Chapel Hill Stormwater
townofchapelhill.org/StreamTeam

UPDATED
FALL 2024

STREAM TEAM
VOLUNTEER HANDBOOK

Where community meets science.

Contents


COMING SOON TO A CREEK NEAR YOU

The Beginning: How We Got Here

Welcome to the team!
Stream Team 2.0 is a volunteer water quality monitoring program that helps the Town of Chapel Hill better understand stream health. Volunteers visit stream sites four times a year to test for different water quality parameters. This data helps the Town to identify pollution problems and to monitor the overall health of its streams.

The data from Stream Team 2.0 also helps the Town's Illicit Discharge Detection and Elimination Program (IDDE)[1] by identifying potential pollution issues. For example, in 2013, the conductivity results from Stream Team 1.0 alerted Town staff to the fact that a local pool was discharging directly into the stormwater system.

Volunteers agree to the following:

- **Monitor one of 10 Chapel Hill creek sites** for at least one year in October, January, April, and July
- **Attend two trainings**, one in the fall and one in the spring, to learn how to measure
    - pH,
    - dissolved oxygen,
    - electrical conductivity,
    - temperature, and
    - habitat health
- **Help the Town identify pollution hotspots**
- **Contribute water quality data** to the scientific community.

What are the goals of Stream Team?

- Increase public understanding of water quality by engaging volunteers about water quality indicators, stream health, data analysis, and pollution prevention
- Identify potential pollution hotspots for Town of Chapel Hill Stormwater staff follow-up
- Contribute to scientific studies and research by providing trends and early detection for water quality issues in local streams
- Contribute Tier II data to regional monitoring efforts, such as NC Stream Watch[2], NC Department of Environmental Quality (NCDEQ), Haw River Assembly[3], and Cape Fear River Watch[4].

What are the data tiers for water quality monitoring?

There are three data quality tiers for water quality monitoring with different capabilities and requirements.

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[1] https://www.townofchapelhill.org/government/departments-services/public-works/stormwater-management/water-quality/illicit-discharges#ad-image-0
[2] https://www.deq.nc.gov/about/divisions/water-resources/water-resources-public-information/water-education-programs/water-education-and-outreach/nc-stream-watch
[3] https://hawriver.org/projects/stream-monitoring/
[4] https://capefearriverwatch.org/creekwatchers/

Method Tier	Data Use Examples[5]	Quality Assurance and Quality Control (QA/QC) Requirement	Chapel Hill Example
Tier 1	Education, identifying potential pollution hot spots, targeting restoration projects, highlighting community projects	Quality Assurance Program Plan (QAPP) not required but recommended	Stream Team 1.0
Tier 2	Tier 1 uses, including in basin plans for reporting, tracking performance for interventions	QAPP required, may be approved by DEQ staff	Stream Team 2.0
Tier 3	Tier 2 uses, regulatory purposes	QAPP required	Bug Monitoring

Where you fit in: The QA/QC requirements for Stream Team 2.0 are why it is so important for you to correctly calibrate your equipment the day you monitor.

Who do we contact with questions and feedback?

Email or call Sammy Bauer (Community Education Coordinator) at sbauer@townofchapelhill.org or 919-968-2715.

The main Stormwater office phone number is 919-968-RAIN (7246)

Call 911 in an emergency

What is the history of the program?

Stream Team 1.0 was an educational program started by Wendy Smith that used simple tests to engage volunteers with water quality parameters. Stream Team 2.0 was formed because Stream Team 1.0 volunteers wanted a more challenging program. The increased quality in equipment makes Stream Team 2.0 a complement of the Town's annual Bug Monitoring program[6].

The North Carolina Aquatic Datahub[7] methods manual paved the way for staff to design the Tier 2 program.

[5] How NCDEQ classifies data tiers: https://www.deq.nc.gov/water-quality/planning/tmdl/303d/general/data-tiers/download
[6] https://www.townofchapelhill.org/government/departments-services/public-works/stormwater-management/water-quality/biological-monitoring
[7] https://wrri.ncsu.edu/partnerships/watershed-stewardship-network/support-your-work/nc-aquatic-data-hub/

Who helped develop the program?

A lot of folks made Stream Team 2.0 possible. Here are a few of them:

Chapel Hill Staff and Volunteers		
Who they are	**What they do**	**How they helped us**
Stream Team 1.0 Volunteers		They suggested we increase the quality of our equipment and better connect the data with the broader community.
Wendy Smith	Former Community Outreach Coordinator	Wendy created and administered Stream Team 1.0, the foundation of this program. She was a skilled program manager and volunteer motivator.
Morgan Flynt	Stormwater Program Support	Morgan spent 400 hours during the Summer of 2023 revamping stream team and completing the tasks needed for it to be an approved tier 2 monitoring program.
Allison Weakley	Stormwater Analyst	Allison is the first Quality Assurance Manager for Stream Team. She also administers the Tier 3 monitoring program. Her knowledge of QAQC was crucial in upgrading the program from tier 1 to tier 2.
Sammy Bauer	Community Education Coordinator	Sammy is the first program manager of Stream Team 2.0. They picked up the majority of duties for kicking off stream team 2.0 after Morgan's summer internship ended. Sammy's communications efforts recruited over 90 stream team applicants for the first stream team monitoring season!
Rebecca Buzzard and Katelyn Robalino	Community Connections Team	Rebecca and Katelyn provided insight throughout the development of Stream Team 2.0 that made it possible to build equity and accessibility into the program.
Christina Strauch	Public Information Officer	Christina finalized and deployed all of our recruitment materials, including a rather fun Instagram reel. Christina's hard work pushing out the materials all over Town is directly responsible for such a big turnout of applications
Paloma Baca	Stormwater Intern	Paloma volunteered her time in the Summer of 2023 to digitize and distribute Wendy's tier 1 data to NC Stream Watch, NCDEQ's portal for tier 1 volunteer monitoring data.
Outside Help		
Who they are	**What they do**	**How they helped us**
Lauren Daniel	NC DEQ Water Education Programs Coordinator	Lauren Daniel played a crucial role in developing this project. Lauren created the Volunteer Programs StoryMap that houses volunteer training information, displays data volunteers collect, etc.
Cam McNutt	NC DEQ Environmental Program Consultant	We worked closely with Cam to create the volunteer training manual, Quality Assurance Program Plan (QAPP), and the process for uploading volunteer data to the NC Aquatic Datahub.
Georgia Department of Natural Resources' Adopt a Stream		The habitat assessment and related training materials are adapted from this program.

The Sites: Where We're Going

To select these sites, we asked the following questions:

1. **Are these sites representative of the water body as a whole?** → These sites are in a typical location within the water body and are not unduly influenced by any local factors, such as point sources of pollution. No sites should be chosen that are directly below a culvert, for example. Sites should be distributed across the Town subwatersheds.
2. **Are these sites accessible?** → The sites are in a safe and secure area that is easy for volunteers to access. None of these sites are on private property.
3. **Do these sites complement the Town's Tier 3 Bug Monitoring program?** → Six of the sites are also monitored during Bug Monitoring. More frequent monitoring at these sites would be helpful in identifying sources of pollution in these areas.

Where are the 10 monitoring sites?

Below is a map of the sites, followed by brief site profiles:

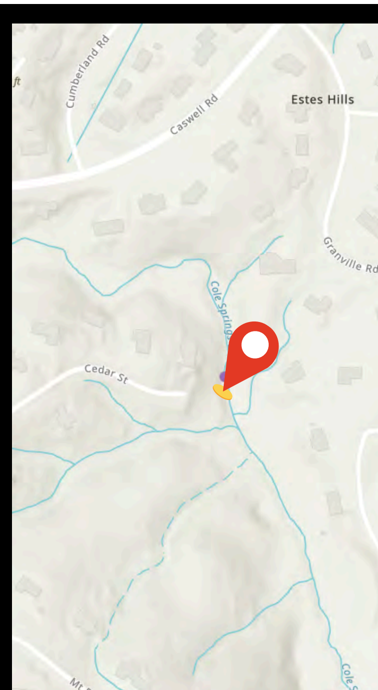
- Site 1: Cole Springs Branch near Cedar Street
- Site 2: Crow Branch below Ashley Forest Road
- Site 3: Schoolhouse Creek at Library Drive
- Site 4: Booker Creek at Martin Luther King Jr. Blvd
- Site 5: Jolly Branch below Chapel Hill High School
- Site 6: Bolin Creek at Umstead Park
- Site 7: Dry Creek at Silver Creek Trail
- Site 8: Booker Creek at Willow Drive
- Site 9: Fan Branch near Scroggs Elementary
- Site 10: Bolin Creek near Community Center

For an interactive site map, scan the QR code or go to https://bit.ly/StreamTeamMap

1- Site Map

Cole Springs Branch near Cedar St

SITE 1

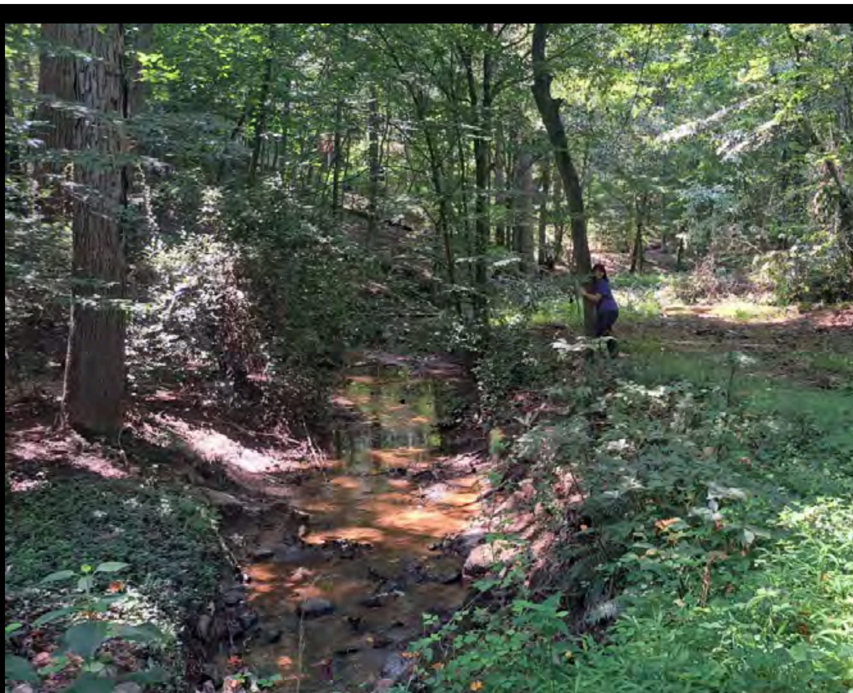


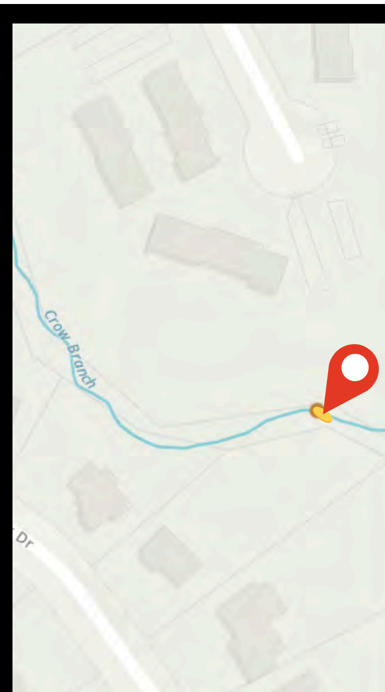
- **Location**: 35.9305188558, -79.0448993588
- In the Middle Bolin Creek subwatershed of Bolin Creek, this site is tucked into a neighborhood.
  - **Nearest bus line**: G, NS, NU, T
  - **Park** near the end of the road. The neighbors should know you're coming.
- **Site midpoint:** The rocky riffle just upstream of the sewer pipe.
- Also a Bug Monitoring site.

Bug photos from macroinvertebrates.org

Crow Branch below Ashley Forest Road

SITE 2



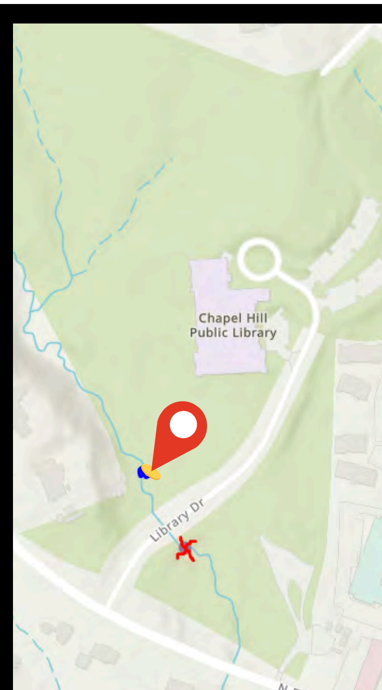


- **Location**: 35.9448132, -79.0539692
- In the Crow Branch subwatershed of Booker Creek, this site is tucked into a neighborhood.
    - **Nearest bus line**: HS, NS, T
    - **Park** in the small parking lot at the end of the Ashley Forest Road. The neighbors should know you're coming.
- **Site midpoint**: The tree that Morgan is hugging in the first photo. You can use any riffle upstream of the culvert.

Bug photos from macroinvertebrates.org

Schoolhouse Creek at Library Drive

SITE 3

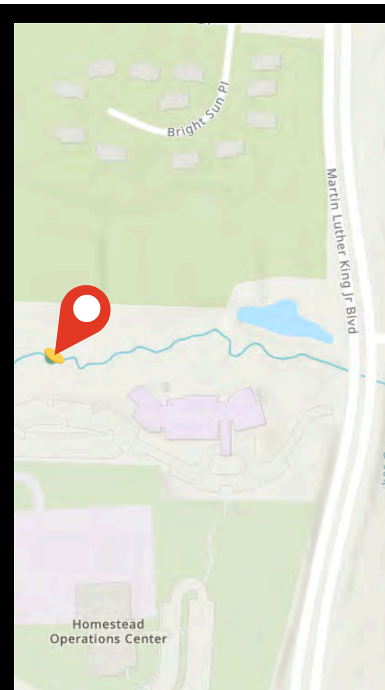


- **Location**: 35.93055899280, -79.03611498830
- In the Middle Bolin Creek subwatershed of Bolin Creek, this site is at the Chapel Hill Public Library!
    - **Nearest bus line**: 400, 405, CL, D, F
    - **Park** at the Library
- **Site midpoint**: Should be marked with pink tape. This site tends to have low flow, so you may have to move to find the closest riffle. Any riffle in the park upstream of Library Drive should be fine.
- Sometimes a Bug Monitoring site.

Bug photos from macroinvertebrates.org

Booker Creek at Martin Luther King Jr. Blvd

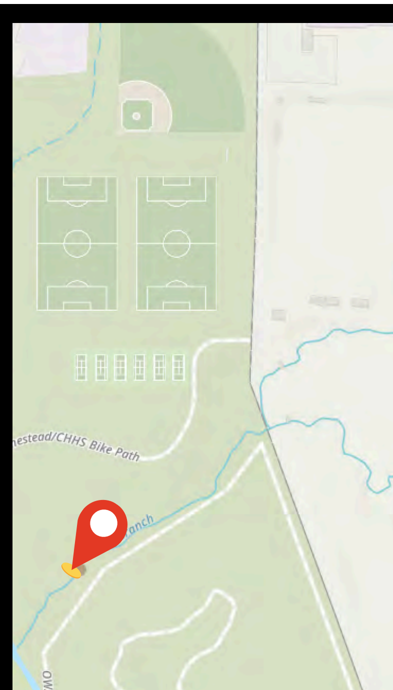
SITE 4



- **Location:** 35.9528124005, -79.0603068391
- In the Booker Headwaters subwatershed of Booker Creek, this site is near the Homestead Aquatic Center and Park
    - **Nearest bus line**: HS
    - **Park** at United Church of Chapel Hill. They know you're coming.
- **Site midpoint**: The tree should be marked with pink tape. Morgan is hugging it in the photo; notice the distinct rock on the right. This one is tougher to find, so use a GPS with the coordinates.
- Also a Bug Monitoring site.

Jolly Branch below Chapel Hill High School

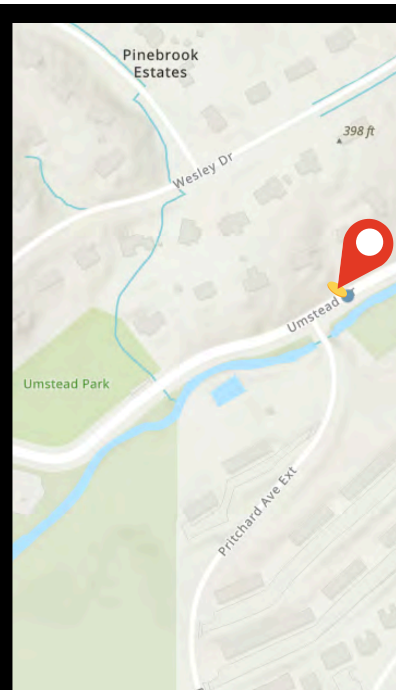
SITE 5



- **Location:** 35.941715405, -79.0829810986
- In the Horace Williams subwatershed of Bolin Creek, this site is in Carolina North near Chapel Hill High School.
  - **Nearest bus line**: HS
  - **Park** at CHHS. **If you park here, we must submit your monitoring days to the district before every monitoring session.**
- **Site midpoint**: The tree should be marked with pink tape (see above). This one is tougher to find, so use a GPS with the coordinates.
- Also a Bug Monitoring site.

Bolin Creek at Umstead Park

SITE 6

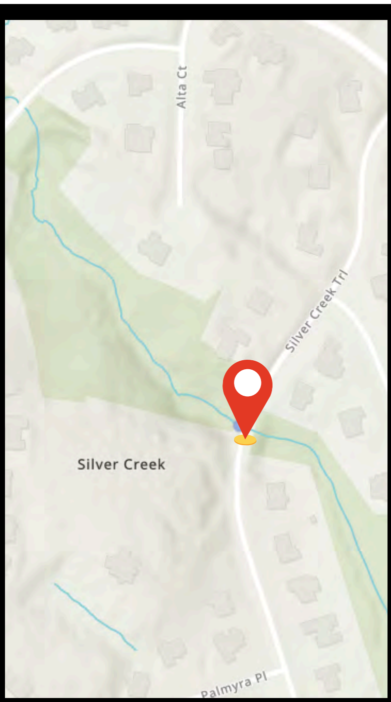


- **Location:** 35.922823, -79.059967
- **This site is accessible for mobility devices!**
- In the Middle Bolin subwatershed of Bolin Creek, this site is along the Bolin Creek Greenway downstream from Umstead Park.
    - **Nearest bus line**: N
    - **Park** at Umstead Park and follow the Greenway downstream
- **Site midpoint**: The concrete ramp leading to the stream. It's a little way past the greenway tunnel under Pritchard Ave Ext with the mural.

Bug photos from macroinvertebrates.org

Dry Creek at Silver Creek Trail

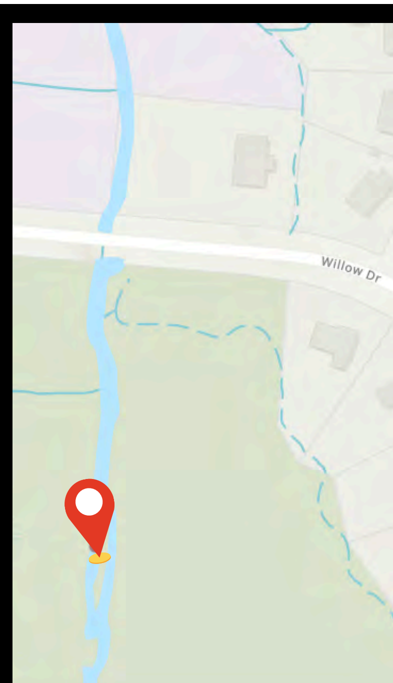
SITE 7



- **Location:** 35.922823, -79.059967
- In the Lower Booker Creek subwatershed of Booker Creek, this site is along the Dry Creek Trail near East Chapel Hill High.
  - **Nearest bus line**: T
  - **Park** along Silver Creek Trail. The neighbors should know you're coming.
- **Site midpoint**: Should be marked by pink tape. The riffle just upstream of the Silver Creek Trail culvert should work well.

Booker Creek at Willow Drive

SITE 8

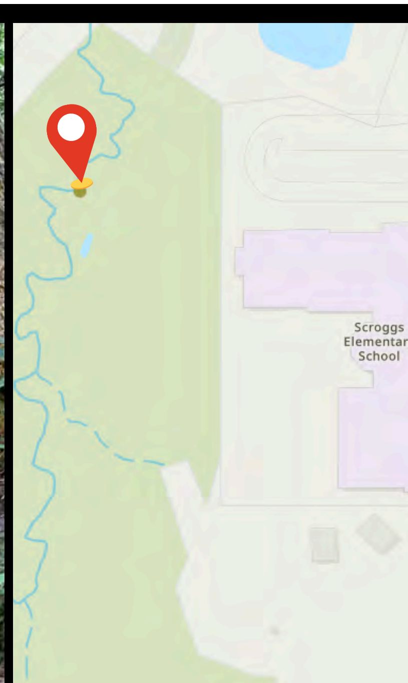


- **Location:** 35.929099, -79.021458
- In the Lower Booker Creek subwatershed of Booker Creek, this site is tucked into a neighborhood.
  - **Nearest bus line**: A, F
  - **Park** along Willow Drive. The neighbors should know you're coming.
- **Site midpoint**: Should be marked by pink tape. This one is tougher to find, so use a GPS with the coordinates. Walk along the OWASA easement and find the best riffle.
- Near a Bug Monitoring site.

Bug photos from macroinvertebrates.org

Fan Branch near Scroggs Elementary

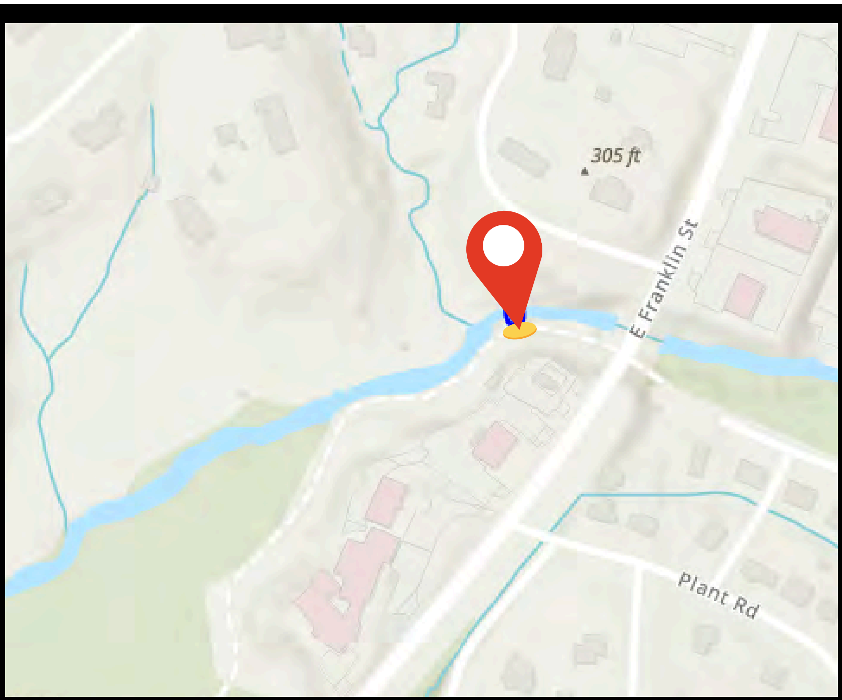
SITE 9



- **Location:** 35.879425, -79.069781
- In the Wilson Creek subwatershed of Morgan Creek, this site is along the Fan Branch trail near Scroggs Elementary.
  - **Nearest bus line**: NS
  - **Park** at Scroggs Elementary (or nearby). **If you park at the school, we must submit your monitoring days to the district before every monitoring session.**
- **Site midpoint**: Should be marked by pink tape. Use any riffle near this spot. This one is tougher to find, so use a GPS with the coordinates.

Bolin Breek near Community Center

SITE 10



- **Location:** 35.927839, -79.035669
- In the Lower Bolin Creek subwatershed of Bolin Creek, this site is along the Bolin Creek Greenway upstream of the Community Center.
  - **Nearest bus line**: 400, 405, CL, D, F
  - **Park** at the Chapel Hill Community Center and walk up the Greenway
- **Site midpoint**: The riffle just downstream of the big sewer pipe.
- Also a Bug Monitoring site.

The Parameters: What We're Measuring

Stream Team 2.0 measures **temperature**, **dissolved oxygen (DO), pH**, **electrical conductivity**, and **habitat**. Staff chose these parameters to complement that Town's annual Bug Monitoring program.

What follows is a basic overview of the parameters. The habitat assessment happens once a year in the spring, so you will receive more information in the March training.

Stormwater's Watershed Education video series[8] includes several of these parameters:

- Temperature[9]
- Dissolved Oxygen[10]
- Electrical Conductivity[11]
- pH[12]

Watershed Education videos

Temperature (°C)

The temperature of water affects biological functions of aquatic organisms, chemical processes, and physical properties of water. Different species of aquatic organisms, from microbes to fish, depend on specific temperature ranges for livability and health. Species will move in a waterway, if they can, until they find an area within their optimal temperature range. If organisms cannot escape high or low temperatures, the species will become stressed and die. Fish are especially vulnerable to temperature abnormalities during their reproductive stages.

Temperature affects:

- oxygen content of water (oxygen levels decrease as temperatures increase)
- the rate of photosynthesis of aquatic plants
- the metabolic rate of aquatic organisms and bacteria,
- the sensitivity of organisms to toxic wastes, parasites and diseases, and
- suspension and dissolution of particles

Causes of temperature change include: weather, removal of shade-producing stream bank vegetation, water impoundments, industrial discharges of cooling water, urban stormwater runoff (especially from hot parking lots), and groundwater inflows to the stream.

Dissolved Oxygen (DO)

- **Typical Levels: 5 – 11 mg/L or ppm**
- **Concerning range: below 4 mg/L**
- **Report immediately: 0 mg/L**

[8] https://www.youtube.com/playlist?list=PLr0THsJ38Jk-203RYQcxAm0_K-J1vSgA2

[9] https://youtu.be/4UdhT3YkMxM?si=OZeoWzEItx2KVNSc
[10] https://www.youtube.com/watch?v=KE8xYFE2hmA&ab_channel=ChapelHillGov
[11] https://youtu.be/5zQejvjaG7g?si=e57I2aiV_rR0XiI3
[12] https://www.youtube.com/watch?v=jmXLkdwfmLI&ab_channel=ChapelHillGov

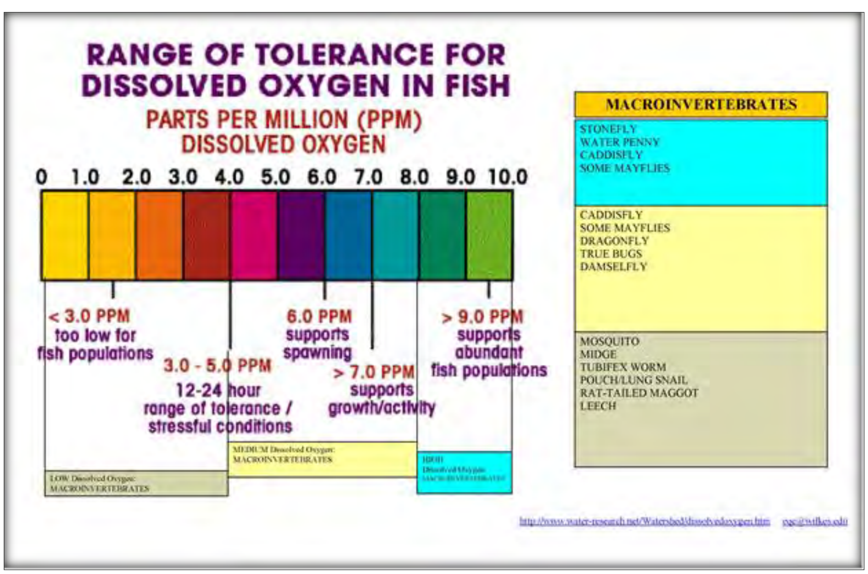
Dissolved oxygen **(DO)** refers to the concentration of oxygen gas incorporated in water. Because aquatic animals breathe through gills, they need dissolved oxygen to live. Aquatic plants, algae and bacteria also require oxygen for respiration. Oxygen is diffused into water from the atmosphere and when water bubbles over riffles in streams. Oxygen is also produced by aquatic plants, algae, and phytoplankton as a by-product of photosynthesis. Once dissolved in water, the oxygen is distributed by the actions of currents and turbulence within the waterbody. Cold water can hold more dissolved oxygen than warm water.

Stream systems produce oxygen, but they also consume it. Respiration, or use of oxygen, occurs by plants at night, by aquatic animals, and by bacteria decomposing organic material. Various chemical reactions within water will also use oxygen. The amount of oxygen used for these processes is called the biochemical oxygen demand, or BOD.

If more oxygen is consumed than is produced, dissolved oxygen levels will decline and organisms sensitive to changes in dissolved oxygen will be impacted to varying degrees. Some organisms can simply move away to a more oxygen rich habitat, but others may weaken or die.

The amount of oxygen required varies according to species of aquatic organisms and their stages of life. Dissolved oxygen levels of at least 6-7 ppm are usually required for spawning, growth and activity of fish. Levels between 3 and 5 ppm are stressful to most aquatic organisms, with levels below 3 often too low to support fish or less tolerant aquatic macroinvertebrates.

High levels of bacteria from sewage, decomposing organic matter, and high water temperatures can cause dissolved oxygen to decline, and will affect the ability of plants and animals to thrive.



Why does rainfall data matter?

If it has not rained within 48 hours, we are likely seeing a baseflow of groundwater. Due to soil composition, groundwater flow can impact our readings for different parameters.

If it has rained within 48 hours, we are also seeing stormwater runoff flowing in the streams. Since much of Chapel Hill is developed, this means we may find evidence of water pollution.

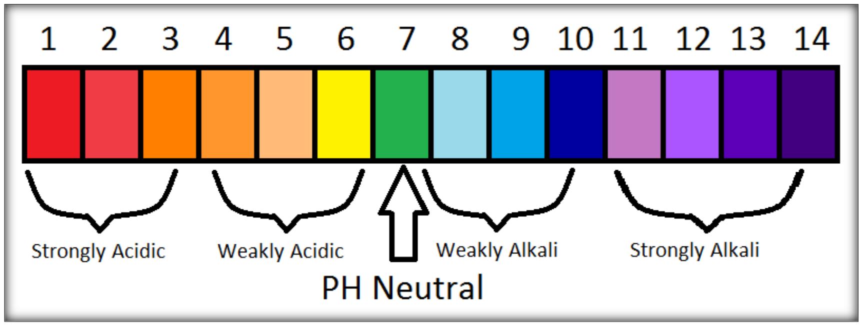
In drought conditions, finding riffles may be challenging.

Volunteers record the past 72 hours of rainfall.

pH (The Power of Hydrogen!)

- **Typical range: 6.0-9.0**
- **Report immediately: below 6.0 or above 9.0**

pH is a measure of acidity or alkalinity. The pH is measured on a scale of 1 to 14; 1 being the most acidic, 14 being the most alkaline, or basic, and 7 being neutral. pH is a way of measuring the concentration of hydrogen ions (H+) in water - at a higher pH there are fewer free H+ ions (more alkaline) and lower pH levels have more free H+ ions (more acidic).



2- The pH scale

A change in one pH unit equals a tenfold change in the concentration of H+. For example, there are ten times fewer H+ ions at a pH of 8 than at a pH of 7 (one pH unit), where a pH value of 9 has one hundred times fewer H+ ions as a value of 7 (two pH units).

A pH below 4 or above 10 will kill most fish, and very few animals can tolerate waters with extreme pH levels. Most aquatic animals and plants have adapted to life in water with a pH range of 6.5 to 8.5. Acidic waters can reduce the hatching success of fish eggs, irritate fish and aquatic insect gills, and damage membranes.

Heavy metals, such as copper, lead and zinc can leach from soil particles under acidic conditions, and may be ingested by aquatic organisms, with varying effects. Bio-accumulation seems to occur only with mercury. Phosphorus can also be more readily released, contributing to overgrowth of aquatic plants and low oxygen levels.

Natural factors can cause pH values to fluctuate. Rain, biological decomposition of organic matter, and respiration of plants at night contribute carbon dioxide to water to form carbonic acid ($CO_2 + H_2O \rightleftharpoons H_2CO_3$), a very weak acid. Photosynthesis of plants and algae during the day removes the carbon dioxide from the water. These processes, as well as geology, tend to naturally balance changing pH and is called *buffering capacity*.

When radical changes in pH occur, we start looking for human influence.

Electrical Conductivity

- **Typical range: 100-300 uS/cm**
- **Concerning range: 300+ uS/cm**
- **Report immediately: 700+ uS/cm**

Electrical Conductivity is a measure of the ability of water to pass an electrical current. It is measured in microsiemens per centimeter (µS/cm). Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge), or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity.

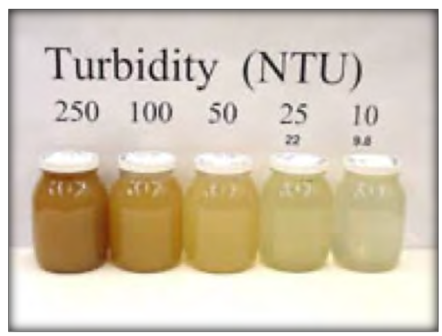
Conductivity in streams and rivers is affected primarily by the geology of the area through which the water, including groundwater contribution, flows. Areas where surrounding geology is composed of materials that ionize when washed into water, i.e. clay soils, tend to have higher conductivity. Conversely, when surrounding geology is primarily composed of materials that do not ionize when in water, i.e. granite bedrock, streams tend to have lower conductivity.

Streams supporting good biological health are typically in the conductivity range of 150-500 µS/cm. Conductivity outside this range can indicate that waters are not suitable for certain species of fish or macroinvertebrates. Streams and rivers tend to have relatively constant ranges of conductivity. Once a typical range is established for a stream, it can be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity can be an indication that a discharge or other source of pollution has entered the stream.

Other Parameters

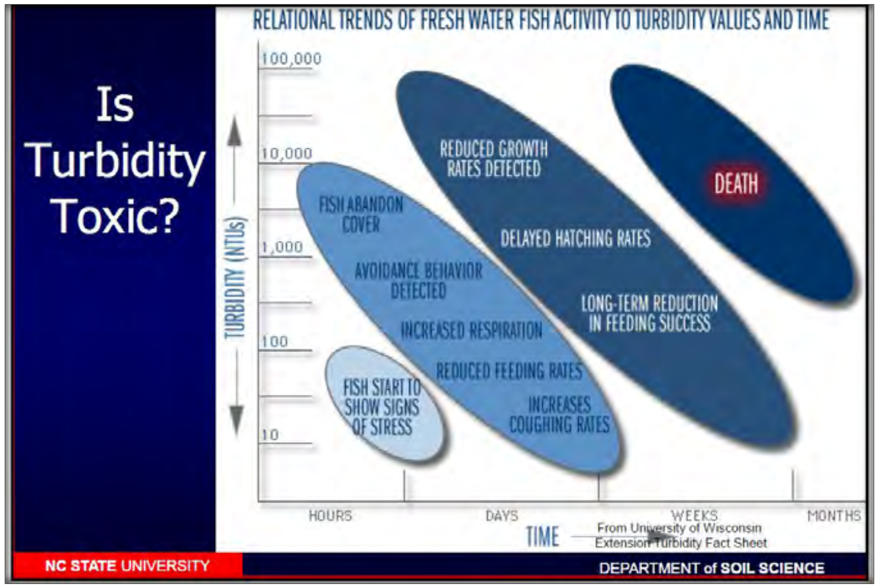
There are several useful parameters that Stream Team 2.0 does not currently measure. This tends to be due to prohibitive equipment costs. What follows is a description of some additional parameters, but there are many others.

Turbidity



Turbidity is a measure of the clarity of water. It is measured in Nephelometric Turbidity units (NTU). Turbidity should not be confused with color, since darkly colored water can still be clear and not turbid. Suspended materials such as clay, silt, organic and inorganic matter, and microscopic organisms, directly affect turbidity by decreasing the passage of light through the water. This reduces or prevents photosynthesis of plants and leads to decreases in the production of dissolved oxygen. High turbidity can also increase water temperatures as the suspended particles absorb more heat than the water could otherwise, which further decreases dissolved oxygen levels since warm water holds less dissolved oxygen than colder water.

[13]Turbid waters can clog gills of aquatic organisms, reduce their resistance to disease, lower growth rates, and inhibit the ability to see and catch food. Lowered growth rates can affect the development of fish eggs and aquatic larvae. As solid particles settle, they can blanket the stream bottom; smothering fish eggs and benthic macro-invertebrates, which are essential for a healthy stream ecosystem. Harmful cyanobacteria (blue-green algae) are favored in turbid waters because they possess flotation mechanisms (McCabe et al., 1985), and can outcompete other plants and algae for light.



Common sources of turbidity include soil erosion, waste discharges, urban runoff, stream bank erosion, bottom sediment disturbance and excessive algal growth.

Turbidity is commonly measured by a meter, measured in Nephelometric Turbidity Units (NTU).

Nitrate (NO_3^-)

Usual Range: < 1 ppm (5 ppm ranks fair, but is cause for concern)

Nitrate is a nutrient needed by all aquatic plants and animals to build protein, and is excreted by living animals. It is released as dead plants and animals decompose. Nitrates in water may also indicate presence of other more serious residential or agricultural pollutants, such as bacteria or pesticides. When nitrates are present in quantities in excess of 10 mg/L, the water supply can pose a potentially fatal threat to infants under six months and to young and pregnant animals through a condition called methemoglobinemia, or Blue Baby Syndrome.

Nitrogen (N) is an essential plant nutrient in the form of NO_3, but in excess amounts can cause significant water quality problems similar to those associated with phosphorus. Together with phosphorus, N in excess amounts can accelerate eutrophication*, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals living in a stream or lake. These changes subsequently affect dissolved oxygen levels, temperature, and other physical and chemical characteristics of streams and lakes.

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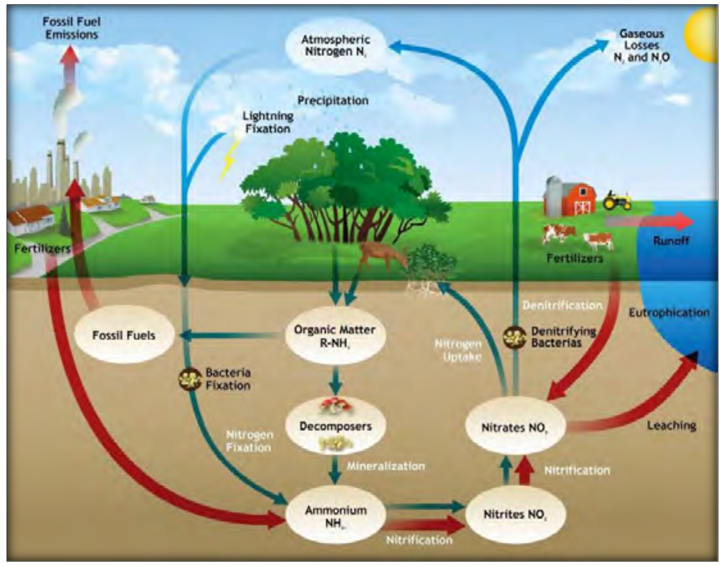
[13] http://www.ncsu.edu/wrri/pdfs/pastevents/lp12012/McLaughlin.pdf

Like phosphorus, nitrogen is classified as organic or inorganic, and there is a similar cycle that regulates the abundance of nitrogen in a stream system. Inorganic nitrogen is used as a nutrient by plants, converted to organic nitrogen which can then be used by animals. Sources of nitrogen include: atmospheric deposition via precipitation, wastewater treatment plants, runoff from fertilized lawns or croplands, failing septic systems, runoff containing animal wastes, power plants, and industrial discharges.



[14]The natural level of nitrates in surface waters is typically low (less than 1 milligram per liter), but the effluent from wastewater or sewage treatment plants can have concentrations that can range up to 30 mg/L. Ammonia, another form of nitrogen, is not detectable with a nitrate test.

***Eutrophication** - "The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication is a natural, slow-aging process for a water body, but human activity greatly speeds up the process." - Art, 1993*

Phosphate (PO_4)

- **Good Range < 1-2 ppm Fair: 4 ppm**

Like carbon, oxygen, hydrogen, and nitrogen, phosphorus is a limiting nutrient for all forms of life, which means that the potential for an organism's growth is limited by the availability of this vital nutrient. It forms part of the structure of DNA and RNA, is needed for energy transport in cells, provides structure to cellular membranes, and assists in giving bones and teeth their rigidity. In short, without phosphorus, we simply could not exist.

Healthy aquatic ecosystems have naturally low concentrations of phosphorus. Too much of it in waterways leads to plant overgrowth, algae blooms (some toxic), and eutrophication. Unlike nitrates, which readily dissolve in water, phosphates tend to attach to soil particles.

Phosphorus (P), like nitrogen and water, cycles through the environment, but does not have a gas phase. Its presence in water has many sources, both naturally occurring and human made - water percolating through phosphorus rich soil and rocks; discharge from wastewater treatment plants; runoff from fertilized lawns and croplands; failing septic systems; runoff containing particles of animal manure;

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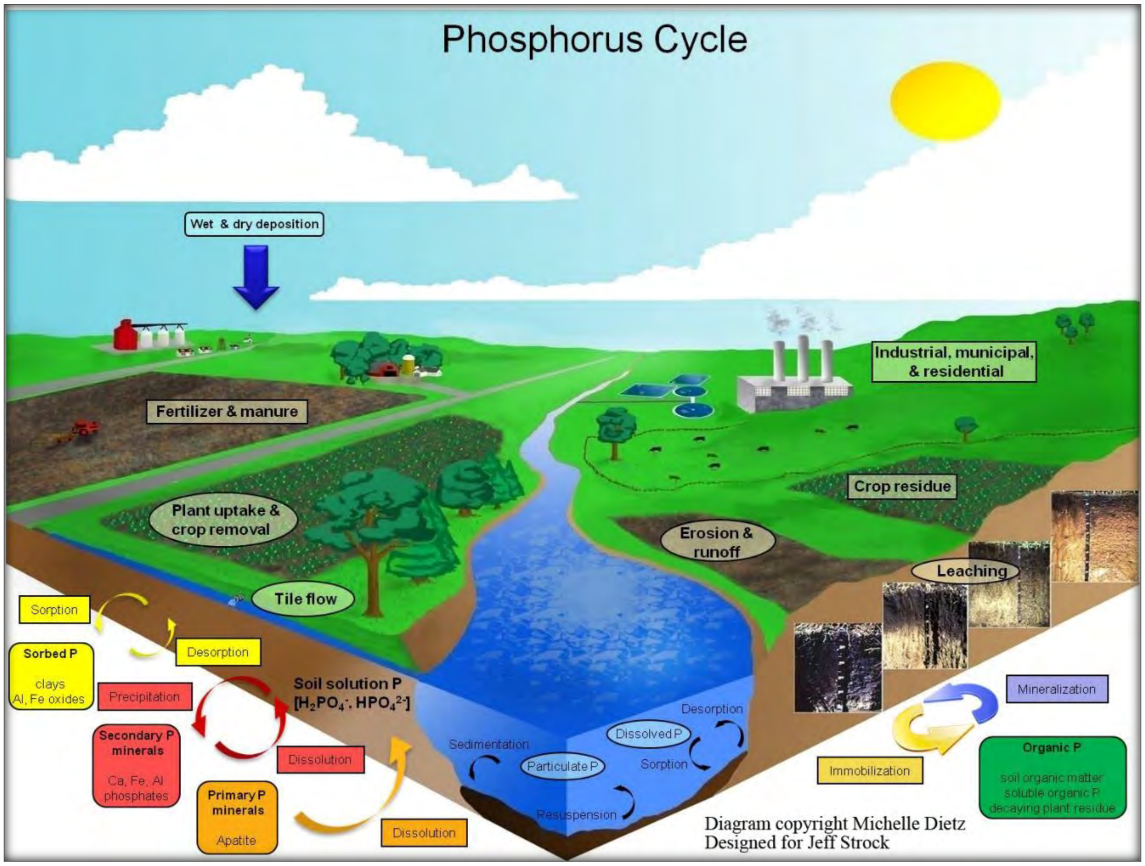
[14] http://imgarcade.com/1/decomposition-cycle/

disturbed land areas; drained wetlands; water treatment; and commercial cleaning preparations.



Significant reductions (25%-81%) in phosphates in NC waterways occurred after the 1988 phosphate detergent ban in NC, according to US Geological Service research.

Heavy Metals

Heavy metals are elements that have atomic weights between 63.5 and 200.5 and have a specific gravity greater than four. Living organisms require trace amounts of some heavy metals to survive, and these metals are known as essential metals. They include cobalt, copper, iron, manganese, molybdenum, vanadium, strontium, and zinc. Though these metals are ubiquitous in the environment, excessive amounts can be harmful to living organisms. There are also certain non-essential heavy metals that are of particular concern for water quality, including: cadmium, chromium, mercury, lead, arsenic, and antimony.

All heavy metals exist in surface waters in particulate, dissolved, and colloidal (evenly distributed microscopic particles in a dispersing solution, i.e. water) phases, though dissolved concentrations tend to be low. Particulate and colloidal phases of these metals may be found bonded to other molecules (hydroxides, oxides, silicates, and sulfides) or as part of silt, clay, or varying types of organic matter. The solubility, or ease with which metals become part of the water column, is predominantly controlled by the pH concentration of water, redox potential (basically indicates how easily chemical reactions are taking place in the water), and the type and concentration of ligands (ions, molecules, or molecular group that binds to a chemical entity to form a larger complex) on which the metals could adsorb (bind to the surface of another particle).

The behavior of metals in natural waters is a function of the sediment composition, suspended sediment composition, and water chemistry. Different types of sediment, i.e. clay versus sand, have varying potential to bind to and subsequently store metals. The water chemistry of a system controls the rate of *adsorption* and *desorbtion* of metals. In the case of water quality, adsorption occurs when metals in the water column bind to the surface of sediment particles, which will generally sink to the bottom and become part of the substrate sediment. Desorbtion occurs when the metals are released from their bond to sediment and returned to the water column. The process of desorbtion allows for the recirculation of metals and potential bioassimilation (use by living organisms). Metals may be desorbed when salinity (salt content) of water increases, when redox potential changes, or pH decreases.

There are both natural and anthropogenic (human-made) sources of heavy metals in surface and ground water, though human-made sources of metals in natural waters greatly exceed natural sources. Natural sources include chemical and physical weathering of igneous and metamorphic rock and soil, decomposition of plant and animal detritus, precipitation or atmospheric deposition of airborne particles from volcanic activity, wind erosion, forest fire smoke, and oceanic spray. Human-made sources include: combustion of fossil fuels, urban stormwater runoff, domestic wastewater effluent, corrosion of water pipes, consumer products, and industrial effluents and waste sludge.

Excess levels of metals in natural waters pose a health risk to the entire biotic community (all living organisms) and the environment. Slightly elevated levels in natural waters can cause changes in tissue structure of aquatic organisms, changes in physiology and circulation of aquatic organisms, changes in biochemistry, changes in behavior, and changes in nearly all facets of reproduction. Many organisms can regulate the concentrations of metals in their tissues. Fish and crustaceans can excrete excess essential metals, but aquatic plants and bivalves (shellfish and mollusks) cannot regulate metal uptake, and subsequently suffer from metal accumulation and eventual metal toxicity.

What can the data tell us about stream health?

The first year of monitoring (2023-2024) focused on gathering **baseline measurements** for the fall and winter seasons.

Our primary analysis will be **looking at changes at each site over time**; we are not comparing the sites to each other. Our goal for the first year was for each team to become familiar with their site and gather baseline measurements that can be used to track changes over time. Comparing sites to each other based on the data collected this season may not be particularly useful for a few reasons.

Why might results differ across sites?

Different sites may show variations in water quality due to several factors. Here are some key factors to consider:

- **Location (upstream vs. downstream):** Upstream sites generally have better water quality compared to downstream sites due to the cumulative effects of pollution sources.

- **Land use (undeveloped vs. developed):** Forested areas tend to have better water quality due to vegetation filtering runoff and reducing erosion, while developed areas can contribute to more stormwater runoff and pollution.
- **Weather conditions (rainfall, temperature):** Heavy rainfall can increase runoff and transport pollutants into streams, while high temperatures can reduce dissolved oxygen levels. Conversely, a very dry fall can result in low flows and low dissolved oxygen levels.
- **Geological Differences (Caroline Terrane vs. Triassic Basin):** Geological differences can make comparing sites to each other challenging. The geological history of North Carolina has resulted in diverse topography, soil composition, and stream substrate materials. Some sites are in the Carolina Terrane (previously called Carolina Slate Belt), while others are in the Triassic Basin. Streams in the Carolina Terrane tend to be steeper with rocky substrates (stream bottoms), while Triassic Basin streams tend to be flatter and sandier. These geological features can impact dissolved oxygen levels, with higher levels in the Carolina Terrane and lower levels in the Triassic Basin.

The Protocols: How to Use the Equipment and Submit the Data

What are the teams responsible for?

There are a few tasks teams must complete in addition to attending training and monitoring sessions. Each team member should sign up to be the leader for at least 1-2 tasks. Some of these items only need to be completed once, whereas others repeat quarterly.

Task	How often?	Who is leading this task?
Send Stream Team staff your team name and bio	Once, due in November	
Decide whether your team will monitor during the first or second half of the month	Once, due in September	
Decide when your team is going to monitor within your assigned batch	Quarterly	
Pick up your team's kit from Stormwater staff	Quarterly, before your team monitors	
Calibrate equipment	Quarterly, the day your team monitors	
Return your team's kit to Stormwater staff	Quarterly, after your team monitors	
Submit data using the Survey123 form	Quarterly	
Conduct a Stream Habitat Assessment	During Spring monitoring	
Send Stream Team staff a short reflection as a team of at least one thing you learned, one memory you'd like to share, and how you'll use this information in the future	Once, due in August	

What are some additional activities teams can do during quarterly monitoring?

Are you finished gathering the required data and want to do more at your site? Here are some optional add-ons to have even more fun in the field.

Activity	Suggested Season, if applicable
Become a **cartographer**: help the Stream Team program by creating more detailed maps of the sites and the data.	Reach out to Stormwater staff anytime if this interests you.
Show off your **photography** skills: become your team's photographer by capturing detailed footage of how your site changes throughout the seasons. With your team's permission, take photos of your team at the site.	Quarterly, starting in the Fall during your first field visit
Become an **ornithologist**: Using Merlin Bird ID, identify the birds you hear while monitoring. Share your results in the field survey question: "Notice any changes since you last sampled this site? If so, please describe." You may hear different birds depending on the season!	Quarterly, starting in the Winter during your second field visit.
Become a **biologist**: track flora and fauna at your site using iNaturalist. Share your results in the field survey question: "Notice any changes since you last sampled this site? If so, please describe." You may see different plants and animals depending on the season!	Summer
Become an **event planner**: Help Stormwater staff plan Spring training activities. You can lead existing portions of the training or plan new, fun activities to engage folks at training.	Winter

How do we stay safe?

Your safety is the most important part of Stream Team! **You are responsible for your own safety.**

Safety Guidelines for Field Work

- Tell someone where you are going and when you expect to be done
- Wear the high-visibility vests so you stand out.
- **Bring any medications you may need with you.**

These are the same guidelines you agreed to when signing your volunteer waiver.

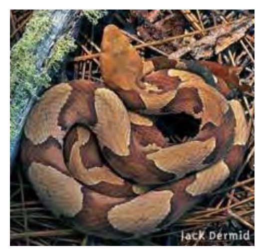
- Wear personal protective equipment, including gloves and goggles, while calibrating equipment for stream water quality monitoring.
- Wear closed – toe shoes or comfortable boots that can get muddy and wet.
- Wear comfortable clothes that will protect you if you walk through brush and

undergrowth. Wear hats or visors for sun protection.

- Use insect repellant and sunscreen. Bring water to drink.
- Wear gloves while picking up litter. They will be provided for you, or you may bring your own.
- **Do not** pick up medical debris, chemical containers or barrels. **Do not** touch any closed, swollen plastic bottles with dark liquid. They may be dangerous. Report to leaders where they are located.
- **Do not** touch living or deceased animals. Animals can carry diseases, and injured or trapped animals may bite.
- ALWAYS use the buddy system. Phone 911 in the case of emergency. If you get hurt, inform supervisors immediately.
- Be observant – look out for snakes, poison ivy and poison oak, and avoid slippery, unstable or steep banks.
- **Do not** enter waterways without permission from the group leader. Always test the depth of the water before entering creeks. Remember that streambeds may have deep pools hidden from view. **Do not** enter the water if you do not know how to swim!
- If working along roads or streets, wear a vest and stay 3-5 feet away from the road. Do not enter traffic or collect litter from bridges.
- Ask someone with heavy gloves to pick up sharp objects. Double bag plastic bags if collecting sharp objects or broken glass and do not overfill.
- **You have the right to refuse to do tasks that make you uncomfortable or that you feel are unsafe.** Ask your leader for a different assignment if asked to do something that makes you feel uncomfortable and report your concerns to the event coordinator.

← Poison ivy

Copperhead snake →



How do we coordinate equipment pick-up and drop-off?

The monitoring seasons are **October, January, April, and July**.

All ten teams share 5 total kits. Your team will have approximately a week and a half to monitor your site.

The schedule may look something like this for any given monitoring month:

- 2nd Friday of the Month prior to monitoring (for the 2023 season, this will be December, March, and June) → **Staff will reach out** with kit pick up and drop off dates/times
- Last week of the month prior to monitoring → **Half the teams pick up kits**
- Monitoring Week 2 → **Those teams drop kits back off by the end of the week**
  - Monday through Wednesday. Staff will need a couple of days to prep the kits for the next groups.
- Monitoring Week 3 → **Second half of teams pick up kits**
- Monitoring Week 4 → **Those teams drop kits back off** after they finish monitoring. This can extend into the month following monitoring, since no one will need the kits immediately.

Pick up and Drop off locations:

- 2nd floor at 208 N Columbia St, Chapel Hill, NC 27514
    - If you drive, park in VISITOR 2 or any spot labeled STORMWATER
- Chapel Hill Public Library (ask the front desk)
- Chapel Hill Community Center (ask the front desk)

What supplies are in the Stream Team kits?

Safety Supplies		
1	Gloves	For calibration
1	Set of goggles	For calibration
4	High-visibility vests	
Equipment		
1	PCTSTestr 50 and manual	For measuring conductivity and pH
1	ExStik DO600	For measuring DO
2	2032 batteries	Backup for the DO meter
Calibration		
1	30 mL bottle of pH 7.0 solution	For calibrating pH
1	30 mL bottle of pH storage solution	For pH meter storage You will use it twice (after calibration and after monitoring)
1	Plastic wash bottle of deionized water	For calibrating pH, DO, and conductivity. Store upright to prevent leaking.
1	30mL bottle of 1413 µS/cm solution	For calibrating conductivity Store upright to prevent leaking
1	Set of hand towels	For cleanup, just in case
Other		
1	Wet erase marker	For kit supply checklist and backup field form
2	30 mL bottles	(1) To store pH storage solution at the stream; (1) To assess water color
1	Work gloves	Optional: Trash cleanup
1	Orange trash bag	Optional: Trash cleanup
1	Field bag	
1	Laminated field survey form	For back up – enter data into digital survey
1	Volunteer Handbook	DO meter manual attached
4	Printed habitat assessments (Spring Only)	
4	Clip boards with pencils (Spring Only)	For habitat assessments

What should we bring with us while monitoring?

- ☐ Smart Phone (Data Keeper will use it to submit your data)
- ☐ Check out the Safety List for what to wear
- ☐ Water bottle and snack
- ☐ Medications you may need (Do you use an epi pen for allergies? Bring that with you.)
- ☐ Your enthusiasm

How and when do we calibrate the equipment?

Since Stream Team 2.0 is a Tier 2 monitoring program, your team's Calibration Lead will need to calibrate your equipment the day you do your monitoring.

For a quick overview, scan the QR code to the right or go to https://bit.ly/Calibration_101.

Video: What is calibration?

We'll start with the simplest equipment and work our way down.

If something is not working with calibration, do not measure for that parameter and mark the error in the Field Survey.

pH: PCTSTestr 50

Video: https://youtu.be/Omshgey6j1w OR scan QR code

Video: Calibrating pH

- When do you do this?
  - o Before you go to the site, the day you monitor.
- What will you need?
  - o Your PCSTestr 50
  - o PH 7.0 buffer solution
  - o Paper towels
  - o Gloves
  - o Goggles
  - o Discard bowl (you supply this)
- What are the calibration steps?
  - o Press ON/OFF to power on the tester.
  - o Remove electrode cap and fill cap to MAX line with pH 7.0 buffer solution.
  - o Dip electrode into cap.
  - o Press CAL/ESC to enter calibration mode. The CAL indicator will be displayed. The upper display will show the measured reading based on the last calibration while the lower display will indicate 7.0, the pH standard buffer solution.
  - o The tester actively reads for about 2 minutes until the measurement stabilizes. A blinking timer icon shows you the progress. Once stable, the timer icon stops blinking. The meter automatically confirms if it finds the buffer and returns to the measurement window, displaying a reading calibrated to the standard buffer solution.
  - o Press CAL/ESC to exit calibration mode.

Conductivity: PCTSTestr 50

Video: https://youtu.be/Omshgey6j1w?t=158 OR scan QR code

Video: Calibrating Conductivity

- When do you do this?
  - o Before you go to the site, the day you monitor.
- What will you need?
  - o Your PCTSTestr 50
  - o 30mL of 1413 µS/cm calibration standard
- What are the calibration steps?
  1. Remove the cap and press ON/OFF to power on.

2. Remove electrode cap and fill cap to MAX line with 1413 µS/cm calibration standard.
3. Rinse sensor with 1413 µS/cm calibration standard over discard container
4. Dip sensor into cap.
5. Press CAL/ESC to begin the calibration.
6. If the reading is within the calibration range, the ✓ icon is displayed when the automatic calibration standard value has been detected.
7. Display automatically returns to measurement window for conductivity.

Dissolved Oxygen: ExStik DO600

For a training video, scan the QR code or go to https://bit.ly/pHPocketPro.

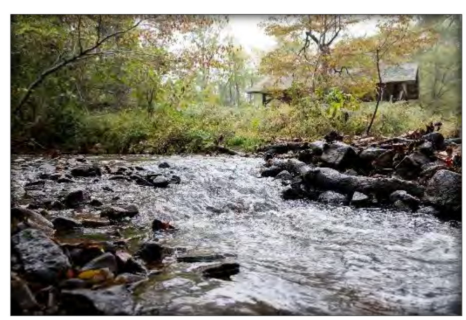
Video: Calibrating the DO meter

- When do you do this?
  - Before you go to the site, on the day you plan to monitor
- What you will need?
  - Your ExStik DO600
  - plastic wash bottle deionized water
- What are the calibration steps?
  1. Remove electrode cap
  2. Moisten yellow sponge with deionized water (should take just a few drops)
  3. Replace cap
  4. Power ON
  5. Hold "MODE" until the unit on the screen is %
  6. Wait for reading to stabilize
  7. Hold "CAL" until "CAL" is shown on the screen
  8. "101.7" will blink on the screen
  9. "SA" will appear on the screen
  10. "End" will appear on the screen. The meter has been calibrated.
  11. If calibration fails, "SA" won't appear. If this happens, remove the cap, clean the electrode w/ deionized water, dry it off, and try again.
  12. If it still doesn't work, electrode needs replacing. Proceed monitoring without taking DO samples. Contact us.

Temperature

- Each meter reads the temperature of the water in addition to its specified parameter. You do not need to do anything differently to calibrate temperature. Just calibrate all 3 meters above.

How and when do we collect samples?



Use the equipment to measure water directly downstream from a **riffle**. Riffles are shallow, faster moving sections of streams, usually with rocks. The pretty riffle on the right is in Bolin Creek at Umstead Park.

Sometimes flow is low, so you may have to move a little from the midpoint of your site.32

Testing for pH

1. Press ON/OFF to power on the tester.
2. Press MENU to enter the setup window. Press HOLD and select Measure. The display shows pH, Cond, TDS, and Salinity.
3. Scroll down by pressing MENU to toggle between pH, Cond, TDS, and Salinity. Press HOLD to select pH.
4. The display shows the selected parameter with a ✓.
5. Dip the electrode directly in the stream, submerging it at least 2-3cm.
6. Stir and let the reading stabilize. The timer icon will blink during this time. Once the reading is stabilized, the timer stops blinking and a ✓ appears.
7. Note the value on your paper field survey. Transfer the result to the digital field survey.
8. Press ON/OFF for 3 seconds to turn off the tester.

Testing for Conductivity

1. Press ON/OFF to power on the tester.
2. Press MENU to enter the setup window. Press HOLD and select Measure. The display shows pH, Cond, TDS, and Salinity.
3. Scroll down by pressing MENU to toggle between pH, Cond, TDS, and Salinity. Press HOLD to select Cond.
4. The display shows the selected parameter with a ✓.
5. Dip the electrode directly in the stream, submerging it at least 2-3cm.
6. Stir and let the reading stabilize. The timer icon will blink during this time. Once the reading is stabilized, the timer stops blinking and a ✓ appears.
7. Note the value on your paper field survey. Transfer the result to the digital field survey.
8. Press ON/OFF for 3 seconds to turn off the tester.

Testing for Dissolved Oxygen

1. Once calibrated, hold MODE until unit is mg/L
2. Remove electrode cap
3. Place electrode in stream riffle
4. Once reading stabilizes, call it out to your teammate
5. Optional rigor: have each teammate do this and record the average of your results.

Testing for Temperature

1. All meters have a temperature reading. Each time you sample a parameter above, note the temperature.
2. Take the average of the temperature readings once you've analyzed all of your samples.
3. Record the average in the field survey.

How and when do we conduct the Habitat Assessment?

The Stream Habitat Assessment Survey begins on page 5 of the Stream Team 2.0 Field Survey. It will first ask whether you've attended the stream habitat assessment training. Once you've attended the training, you will select 'yes' for this question. In case you missed the Spring training or need a refresher on the parameters, we have included detailed information about the habitat assessment and habitat parameters in this handbook, starting with the section called 'The Habitats: Get to Know Our Creeks.'

How do we submit data?

One person on your team will submit your data using the Survey123 Field Survey.
Check your kit checklists for the QR code and link to the field form.

After you submit your data, staff with check for quality assurance and then release the results.

Where do we find the data?

The data will live on the website at www.townofchapelhill.org/StreamTeam in the section titled "What do the data say about stream health?"

This section will expand over time, turning into an interactive dashboard.

Are you an analytics wiz with ideas for how to showcase the data? Let us know and we can build something together!

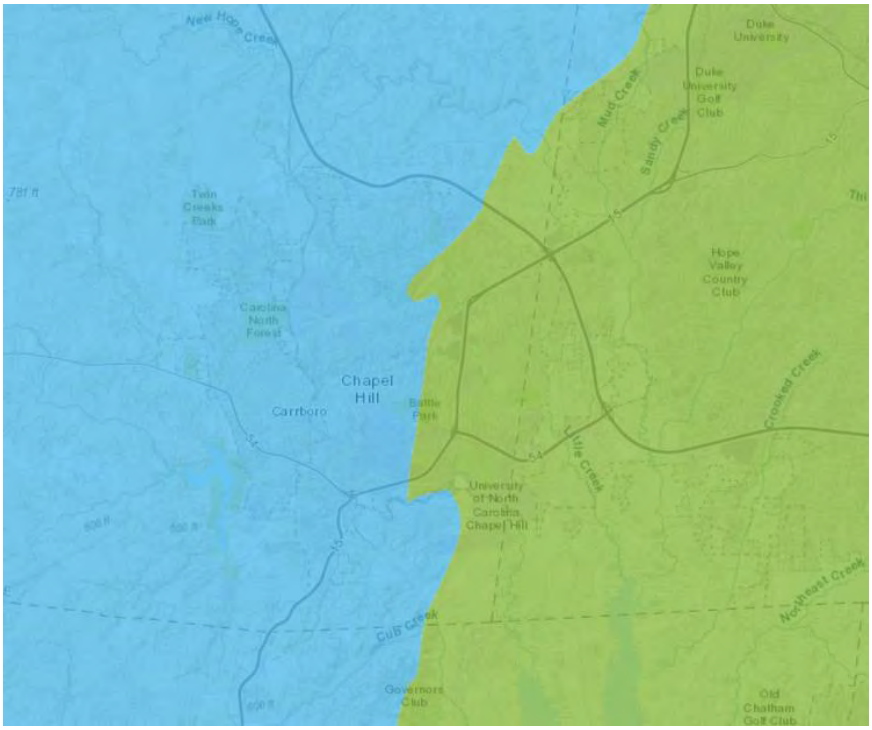
The Habitats: Get to Know Our Creeks

Spring training is dedicated to stream habitats!

What is the local geology?

All three major rock types can be found in North Carolina: igneous, metamorphic and sedimentary. Together these major rock types tell a long, complex and sometimes violent geologic history. To help convey this long geologic history, the state is best described in terms of geological terranes and major geologic elements. A geological terrane is a fault-bounded fragment of the Earth's crust that shares a common geologic history distinguishing it from surrounding terranes or areas.

Chapel Hill is interesting because some parts of town are in the Carolina Terrain, and some are in the Triassic Basin. The state maintains an interactive map shows the entire state's geological terranes, and you can use it to see where your site fits in. Spoiler alert: as of the first monitoring season, all stream team sites are in the Carolina Terrane except for Site 8: Booker Creek at Willow Drive site.



Blue: Carolina Terrane *Green: Triassic Basin*

Scan this QR code to view the full interactive map:

The Geology of North Carolina

Or visit: NC DENR's [Geology of North Carolina](https://ncdenr.maps.arcgis.com/apps/MapSeries/index.html?appid=0a7ccd9394734ff6aa2434d2528ddf12)[15] interactive map

The Carolina Terrane, formerly known as the Carolina Slate Belt, and the Triassic Basin are distinct geological regions that have a significant impact on the characteristics of stream beds in different parts of town.

The **Carolina Terrane** is an area characterized by slightly metamorphosized igneous rocks, or previously igneous rocks that have undergone change due to high heat or high-pressure exposure. These rocks now form slaty or layered rock formations. Streams flowing through this terrane often have rocky and rugged beds, which can affect water flow and erosion patterns. In this region of the Carolina Terrane, rocks are pretty erosion resistant.

On the other hand, the **Triassic Basin** is a geological region associated with sedimentary (rocks formed from layers of sediment that are compacted over time) and igneous rocks (rock formed from hardened magma or lava). Streams in the Triassic Basin tend to have smoother and more sedimentary-based streams. Geographic regions directly influence the nature of stream beds in different parts of town, affecting factors like erosion, water quality, and the types of aquatic habitats that can be found in each area.

Excellent resource about the [geologic history of Chapel Hill](http://www.ncgeology.com/Bolin%20Creek%20Geology/pages/home.html)[16]:

What are the watersheds in Chapel Hill?

A **watershed** is a land area that funnels water down to a common low point. When it rains or snows, water flows from higher elevations down to lower elevations, carrying with it the pollutants on the ground.

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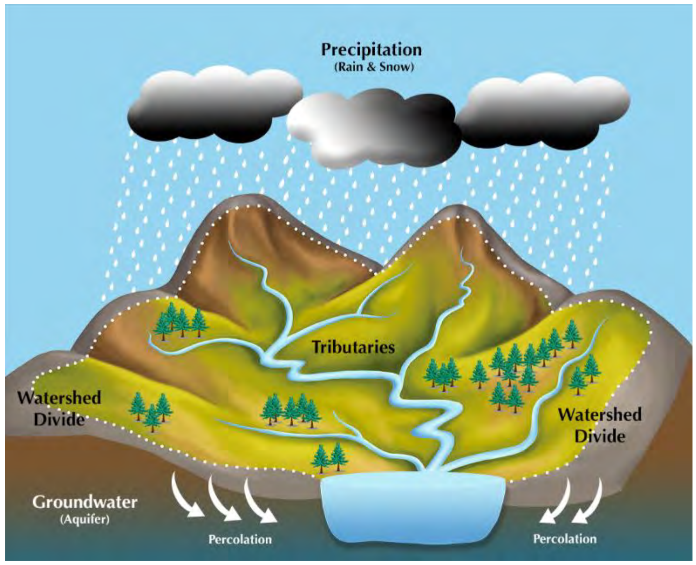
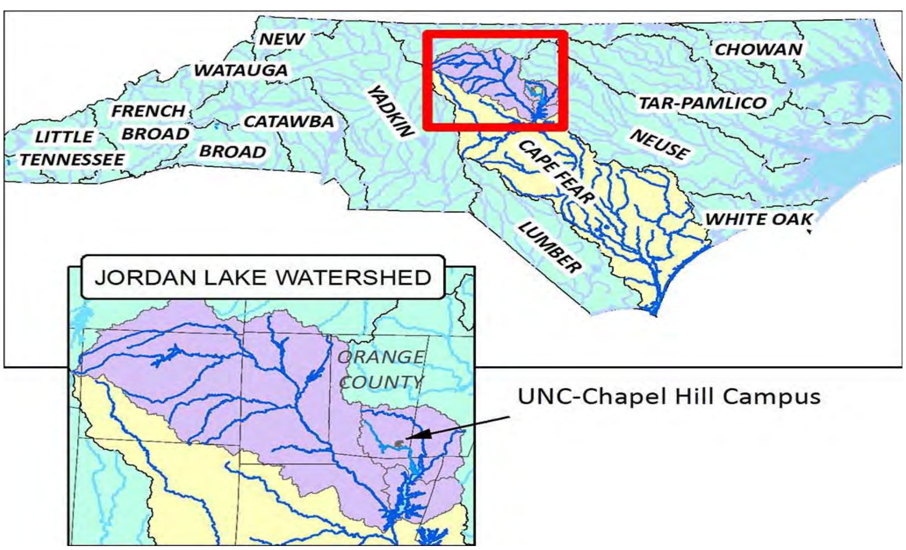
[15] https://ncdenr.maps.arcgis.com/apps/MapSeries/index.html?appid=0a7ccd9394734ff6aa2434d2528ddf12
[16] http://www.ncgeology.com/Bolin%20Creek%20Geology/pages/home.html

A watershed is more than the physical landscape that is defined by ridges with one outlet for water to flow. Watersheds support a variety of resources, uses, activities and values where everything is linked in such a way that eventually all things are affected by everything else. Most importantly, it contains the history of all that went before us and the spirit of all to come.



Watersheds can be as big as an entire river basin or as small as a tiny creek area. In Chapel Hill, we are in the Jordan Lake watershed, which is part of the Cape Fear River Basin.

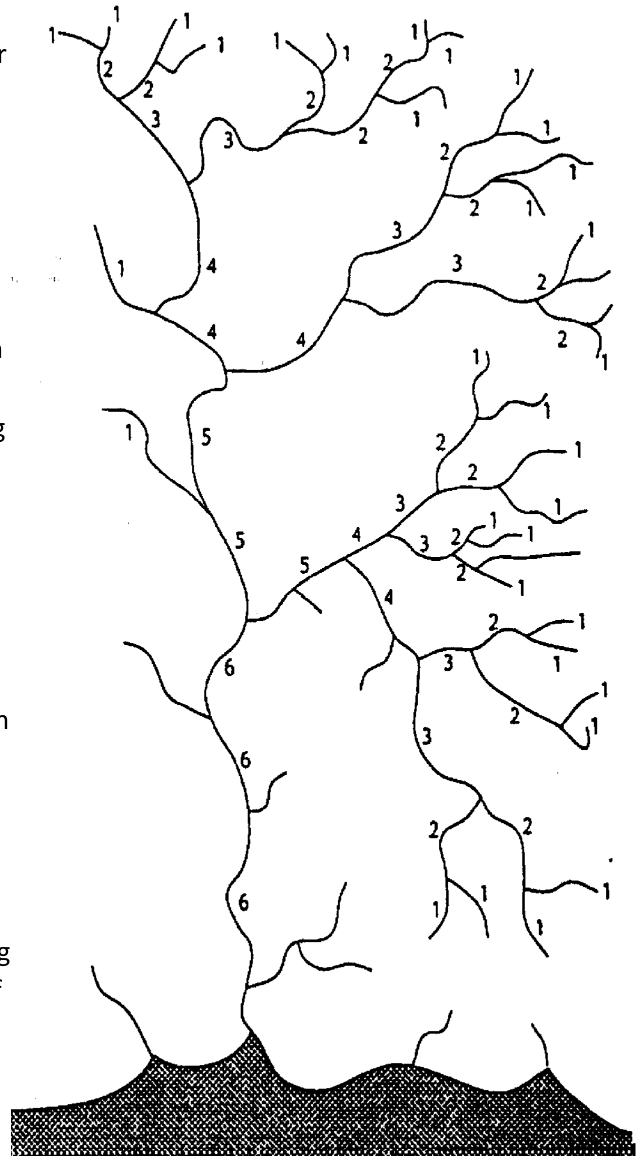


Map credit: UNC EHS

What are the different types of streams?

Stream scientists (that's you!) categorize streams based on the balance and timing of the storm water runoff and baseflow components. There are three main categories:

- **Ephemeral streams** flow only during or immediately after periods of precipitation.
- **Intermittent streams** flow only during certain times of year. Seasonal flow in an intermittent stream usually last longer than 30 days per year.
- **Perennial streams** flow continuously during typical weather conditions. Some of them can dry up during droughts, such as Site 2: Crow Branch below Ashely Forest Road. Base flow is generally generated from the movement of ground water into the channel.



3- River system orders

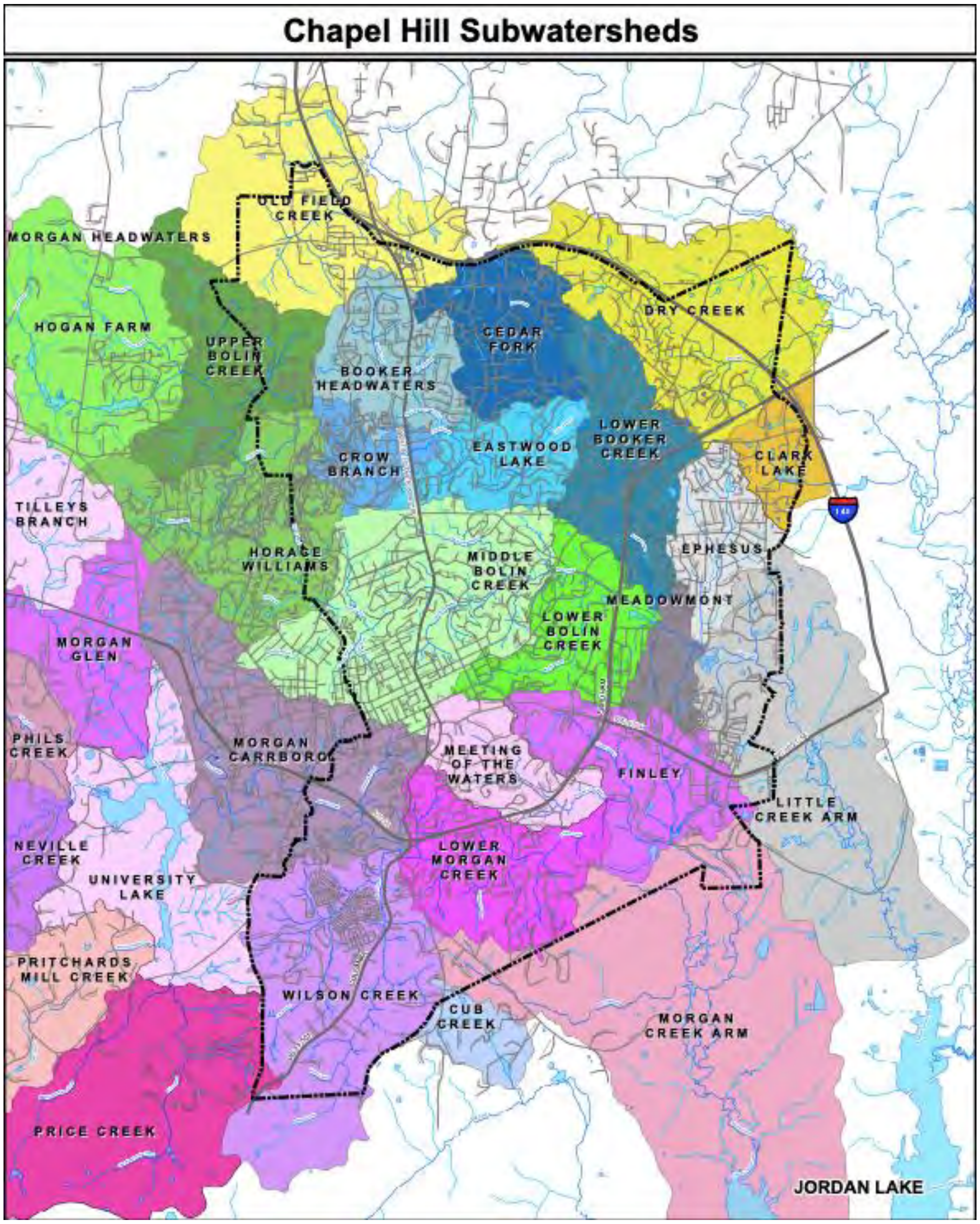
As streams flow downhill and meet other streams in the watershed, a branching network is formed (Figure 3). When observed from above, this network resembles a tree. The trunk of the tree is represented by the largest river that flows into the ocean or Gulf of Mexico. The "tipmost" branches are the **headwater streams**. This network of flowing water from the headwater streams to the mouth of the largest river is called the **river system**.

Water resource professionals have developed a simple method of categorizing the streams in the river system. Streams that have no tributaries flowing into them are called **first-order streams**. Streams that receive only first-order streams are called **second-order streams**. When two second- order streams meet, the combined flow

becomes a **third-order stream**, and so on.

Chapel Hill Subwatersheds

We have several subwatersheds throughout Town. The Stream Team Web Map[17] includes a Town subwatershed layer. You can toggle on this layer to see which subwatershed your site calls home.



4- Chapel Hill Subwatersheds (Purple is Morgan Creek, Green is Bolin Creek, Blue is Booker Creek)

How do streams work?

A healthy stream is a bustling environment, providing shelter and food for wildlife and birds. Vegetation grows along its banks, offering shade, slowing down the flow of water during rainstorms, and filtering

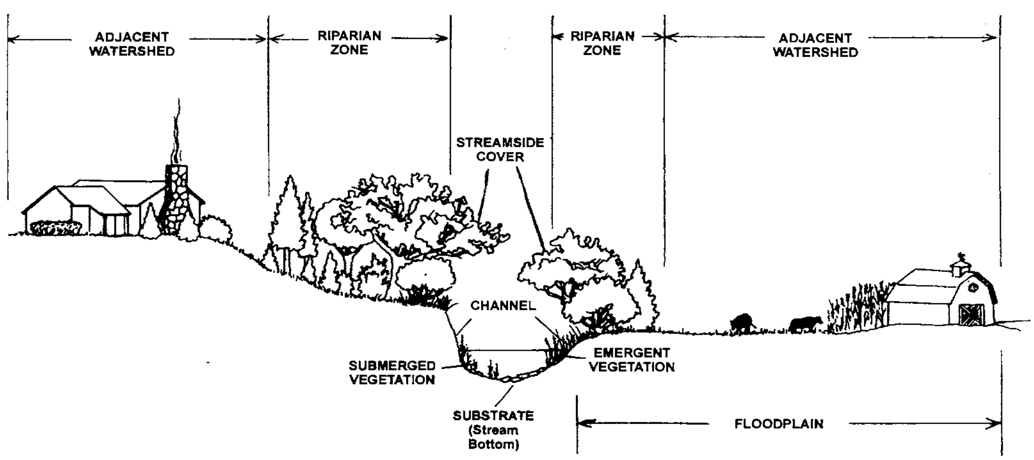
[17] https://www.arcgis.com/apps/mapviewer/index.html?webmap=369688669db54137b6bbcb05243e0d4d

out pollutants. The stream itself is home to fish, insects, and other small creatures, each with specific needs such as oxygen, shelter, food, and breeding grounds.

Streams are dynamic systems that play a vital role in the hydrological cycle. A few of their key functions are:

- **Water Collection:** Streams act as channels that collect water from various sources, including precipitation (rain and snowmelt), runoff from surrounding land and impervious surfaces, and groundwater discharge.
- **Transportation:** The collected water flows downhill due to gravity, transporting it across the landscape. As streams flow, they can erode and transport sediment (soil particles, rocks), shaping the landscape over time.
- **Habitat Creation:** Streams provide diverse habitats for a variety of aquatic plants and animals. Different species thrive in different sections of the stream, depending on factors like water depth, flow velocity, and substrate type (rocky, sandy, etc.).
- **Filtration:** As water flows through a stream, it interacts with the streambed and banks. This natural filtration process helps remove pollutants and debris, contributing to cleaner water downstream.

However, human activities have a significant impact on these stream characteristics. We alter streams by building dams, diverting water, dredging, and discharging waste. We also develop land in the surrounding areas, engaging in activities like farming, mining, deforestation, and grazing livestock. It's important for volunteers to understand that the condition of the land surrounding the stream directly affects its habitat.

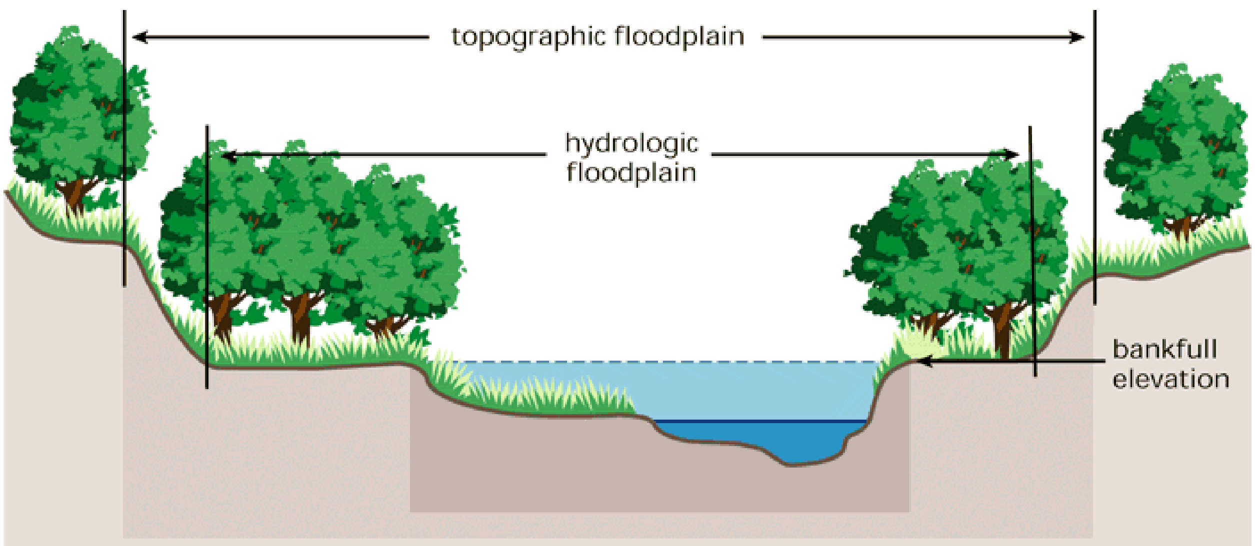


5- Components of a stream and the surrounding land

These activities can dramatically affect the many components of the living stream environment (Figure 1.1). These components include:

- The **adjacent watershed** includes the higher ground that captures runoff and drains to the stream.

- The **floodplain**[18] is the low area of land that surrounds a stream and holds the overflow of water during a flood (Figure 6).
    - The **hydrologic floodplain** is defined by bankfull elevation
    - The **topographic floodplain** includes the hydrologic floodplain and additional floodplains that extend to a specified elevation corresponding to a particular flood frequency, such as the 100-year flood.
- The **riparian zone (buffer)** is the area of natural vegetation extending outward from the edge of the streambank. The riparian zone serves as a protective barrier against pollutants that flow into a stream through runoff. It also helps prevent erosion, provides habitat for stream organisms, and contributes nutrients to the stream. A well-functioning stream system typically has a healthy riparian zone. However, the quality of riparian zones can be compromised when there are roads, parking lots, cultivated areas, bare soil, rocks, or buildings near the streambank.
- The **streamside cover** includes any overhanging vegetation that offers protection and shading for the stream and its aquatic inhabitants.
- The **bankfull** line is defined as the water level, or stage, at which a stream is at the top of its banks and any further rise would result in water moving into the floodplain.



6- Components of the floodplain and bankfull

- The **stream bank** includes both an upper bank and a lower bank.
    - The **lower bank** normally begins at the normal water line and runs to the bottom of the stream.
    - The **upper bank** extends from the break in the normal slope of the surrounding land to the normal high water line.
- **Stream vegetation** includes emergent, submergent and floating plants.
    - **Emergent plants** include plants with true stems, roots and leaves with most of their vegetative parts above the water.

[18] https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=637#

- **Submergent plants** also include some of the same types of plants, but they are completely immersed in water.
- **Floating plants** (e.g., duckweed, algae mats) are detached from any substrate and are therefore drifting in the water.

- The **channel** of the stream is the width of the stream at bankfull discharge.
- **Pools** are distinct habitats within the stream where the velocity of the water is slower and the depth of the water is greater than that of most other stream areas (Figure 7). A pool usually has soft bottom sediments.
- **Riffles** are shallow, turbulent, swiftly flowing stretches of water that flow over partially or totally submerged rocks. This is where you can hear the sound of the water moving.
- **Runs** or **glides** are sections of the stream with a relatively low velocity that flow gently and smoothly with little or no turbulence at the surface of the water.
- The **substrate** is the material that makes up the streambed, such as clay, cobbles or boulders.

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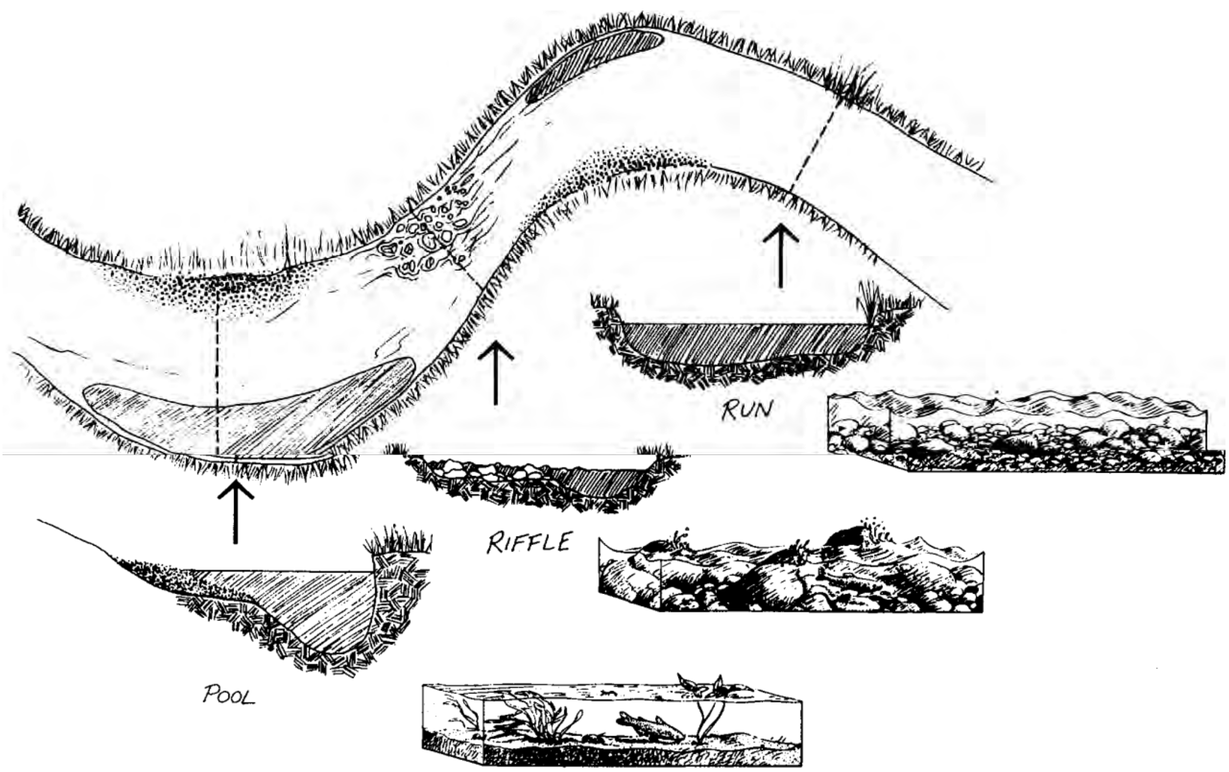
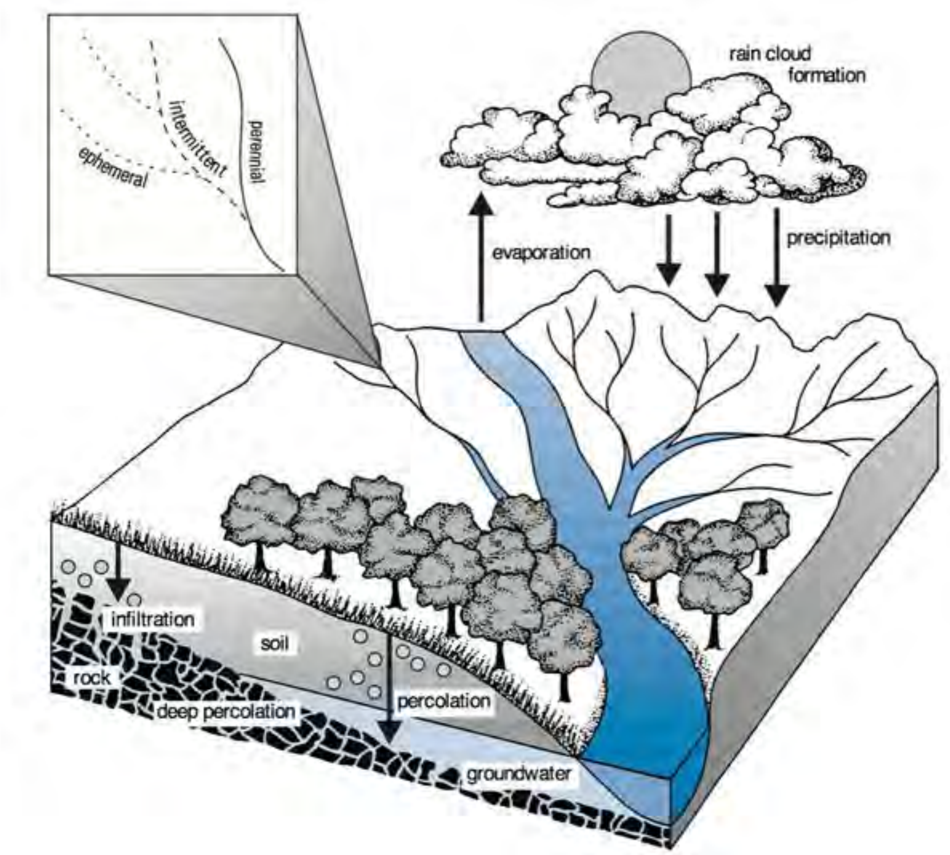


7- Components of a Stream System

Streams are influenced by the surrounding land and human activities. The characteristics of a stream, such as its speed, temperature, and clarity, are determined by the land it flows through. The vegetation in the riparian zone of a stream acts as a protective barrier, providing shade and adding organic material to the water. It also helps to stabilize the streambank and prevent erosion. However, if human activities damage the riparian zone, the stream and its inhabitants, including aquatic insects, fish, and plants, will also be negatively affected.



Source: N.C. Cooperative Extension

Stream Processes

Understanding stream health often involves looking at these processes:

- **Erosion:** Streams naturally erode their banks and beds, creating various channel features like pools, riffles, and meanders. However, excessive erosion can be detrimental to stream health.
- **Deposition:** Sediment carried by the stream eventually settles out in areas of slower flow, creating features like sandbars and deltas.
- **Meander Formation:** Streams often wind and turn as they flow, creating meanders. These meanders help dissipate energy during high flows, reducing erosion.

Read more about stream processes here: https://content.ces.ncsu.edu/natural-stream-processes.

What are urban stream stressors?

Urban development can significantly impact the health of nearby streams. These impacts, called stressors, can degrade the overall quality of the water and habitat for aquatic life. Here are some key urban stream stressors to be aware of:

- **Increased impervious surfaces:** Paved areas like roads, sidewalks, and rooftops prevent rainwater from naturally soaking into the ground. This leads to increased stormwater runoff, causing rapid fluctuations in stream water levels and increased erosion.

- **Pollution:** Urban areas generate a variety of pollutants that can wash into streams through storm drains or directly from spills. These pollutants include:
  - **Sediment:** Erosion from construction sites and developed areas can cause excessive sediment to enter streams, smothering aquatic life and harming their habitat.
  - **Chemicals:** Fertilizers, pesticides, and other household chemicals can contaminate streams, impacting water quality and harming organisms.
  - **Trash:** Debris can clog streams, disrupt natural flow, and introduce harmful toxins.
- **Habitat alteration:** Stream channelization (straightening and widening channels), bank stabilization with riprap, and removal of riparian vegetation (plants along the streambank) all reduce habitat diversity and complexity, impacting the types of plants and animals that can thrive in the stream.
- **Invasive species:** Non-native plants and animals introduced into urban areas can outcompete native species for resources and disrupt the natural balance of the stream ecosystem.

These stressors can have a cascading effect, impacting the entire stream ecosystem.

A Guide to Basic Visuals

While the full habitat assessment protocol is only required each Spring, volunteers will observe and answer questions about the basic visuals of their site every time they monitor. These questions will require volunteers to make observations about:

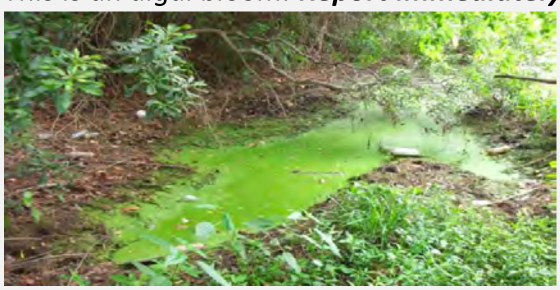
- Water flow/water level
- Water clarity
- Water color
- Water surface
- Water odor
- Trash

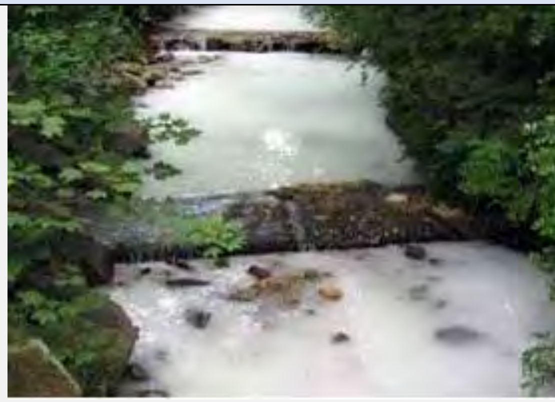
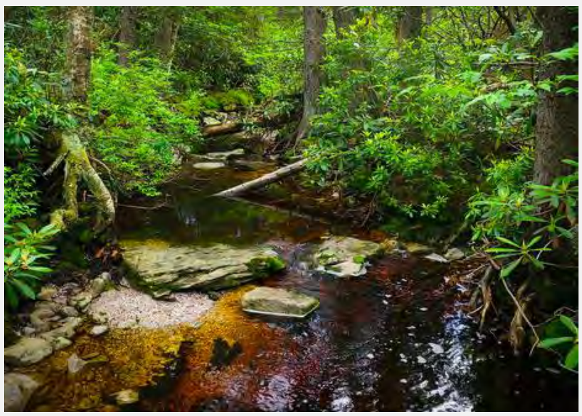
The sections that follow provide photos and explanations of how to answer and when to be concerned about the water color and water surface indicators.

Water Color

Description	What Might This Look Like?	When Should I Be Concerned?
Brown/Muddy	*This stream is brown because it is full of **sediment**.*	Brown, muddy streams are a sign of **sediment pollution**, so turbid streams are always concerning and important to note these observations. We should be especially **concerned** if we see a lot of sediment when it **hasn't rained lately** and/or if we

Description	What Might This Look Like?	When Should I Be Concerned?
	 *This stream is muddy because of an **illicit discharge** from a construction site. **Report immediately.*** 	see a **specific source** (i.e. construction site) directly releasing sediment into the stream.
Green	*This stream is green because of a chemical discharge. **Report immediately.***	Streams can be green for several reasons. The three most concerning reasons are: 1. **Chemical discharges** like paint or antifreeze

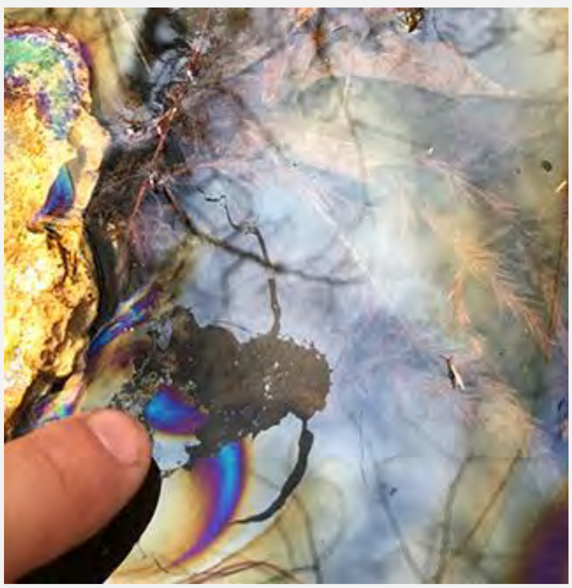
Description	What Might This Look Like?	When Should I Be Concerned?
	 *This is an algal bloom.* ***Report immediately.***  *This stream is green because of algae. Take a photo and submit it in your field survey.* 	2. **Algal blooms**, which are caused by excess nutrient pollution 3. **Algae**, which can grow when there is nutrient pollution and hot air/water temperatures. It is always important to document green streams in your field survey. **If you see an algal bloom or what appears to be a chemical in the stream, call the Stormwater hotline – 919-969-RAIN (7246).**
Milky/White	*Milky, white stream water.*	Milky/white stream water is **unnatural**. It is most often

Description	What Might This Look Like?	When Should I Be Concerned?
		caused by **paint, cement, or wash water.** If you see a milky/white stream, report it immediately to the Stormwater hotline: **919-969-RAIN (7246)**.
Tannic/Tea	Tannic/tea-colored stream water.  	Brown, tea-colored water can be confused with sediment pollution, but it is a bit different. In contrast to brown, muddy streams, **tannic streams are clear and brown.** This can be caused by decaying organic material (plants, leaves, tree trunks). The decaying material sometimes releases **tannins**, which are **naturally occurring chemicals** found in some plants. It is important to note that tannins are acidic, so you can **expect a lower pH reading** if you observe tannic/tea-colored water. While tannins are natural, tannic/tea-colored water is **uncommon in Chapel Hill,** so be sure to note it and **submit a photo** in your field survey

Description	What Might This Look Like?	When Should I Be Concerned?
		if you observe this at your site.

Water Surface

Description	What Might This Look Like?	When Should I Be Concerned?
Clear/Normal	*Clear, normal streams are a sign of* ***good stream health***.  	If your stream is clear and there is nothing unusual on the surface, that's great!
Oily Sheen	*A sheen caused by iron-oxidizing bacteria.*	Everyone's first thought is an oil spill, but that's not always true. **Iron-oxidizing bacteria is natural and common in Chapel Hill.**

Description	What Might This Look Like?	When Should I Be Concerned?
	 *Iron-oxidizing bacteria breaking apart when poked.* 	A bacterial sheen can usually be distinguished from a petroleum sheen by **attempting to break up the sheen.** When a stick is poked in to a b**acterial sheen** or a stone is dropped in to it, the sheen will typically **break into small platelets.** In contrast, a **petroleum sheen** will quickly **swirl and try to reform** after any disturbance. **If you encounter this, report it immediately.**
Algae	*Algae on the surface of the water.*	Algae is caused by **nutrient pollution** and is exacerbated by hot temperatures. If you see algae on the surface of the stream, note it in your field survey and **report it to Stormwater.**

Description	What Might This Look Like?	When Should I Be Concerned?
		
Foam	***Naturally occurring*** *foam gathered on a limb.*  *This may look alarming, but it is also* ***naturally occurring*** *and no cause for concern.* 	Foam can be alarming to see, but it is not always a cause for concern. If you observe foam, **always note it in your survey and submit a photo.** Foam produced from **natural causes** is identified by its **off-white color** and its “fishy” or **“earthen” odor.** Buildups are more prevalent after rainfall. **Human-made foam** is usually a **pure white** color and tends to smell **fragrant** (the product of detergent discharge) or **unpleasant** (the product of sanitary sewer or septic field failures). If you suspect the foam is not naturally occurring, report it immediately to Stormwater and **do not try to remove the foam yourself.**

Description	What Might This Look Like?	When Should I Be Concerned?
	*This is **soap/detergent** foam. If you see this, **report it immediately.*** 	

Stream Habitat Assessment

Stream habitat includes the physical and chemical conditions of this ecosystem and plays a large role in the aquatic life you will find. By conducting completing this section of the field survey, you will be able to qualitatively document the condition of instream habitat and the riparian zone. By conducting assessment on an annual basis with your team, changes over time can be observed, paired with good snapshots upstream, downstream and into the riparian zone on both sides of the channel. The survey rates parameters including channel bottom materials, sinuosity, bank stability, streamside vegetation and many more.

The survey, protocol, and instructions have been adopted from the Georgia Adopt-A-Stream program. An excellent in-depth manual for completing this form can be found on the GA Adopt-A-Stream website[19]:

How To Fill Out the Stream Habitat Assessment Survey

The Stream Habitat Assessment Survey begins on page 5 of the Stream Team 2.0 Field Survey. It will first ask whether you've attended the stream habitat assessment training. Once you've attended the training, you will select 'yes' for this question. Then, you will indicate whether your site is rocky or muddy bottom. Once you provide this information, the stream habitat assessment questions begin. You will answer each question with a number 1-10, and sometimes 1-5. The following sections provide more information about how to answer each question in the survey.

Rocky versus Muddy Bottom Streams

The Stream Habitat Assessment will ask you to identify whether your site is a rocky bottom or muddy bottom stream. One question in the survey will only apply to muddy bottom streams, whereas others will only apply to rocky bottom streams. Streams in the Triassic Basin are classified as muddy bottom, while Carolina Terrane streams are rocky bottom. **As of 2024, only one stream team site is a muddy bottom stream: Site 8 aka Booker Creek at Willow Drive.**

[19] https://adoptastream.georgia.gov/sites/adoptastream.georgia.gov/files/related_files/document/Visual.pdf

Scoring The Habitat Parameters

Each habitat parameter is rated with a value from 0 to 10, and in some cases (Numbers 8, 9 and 10) you will be asked to evaluate each bank separately, scoring each from 0 to 5. Using the data form, record the score that best fits the observations you have made based on the narratives, drawing, images and description provided in the Spring training.

All team members will complete a paper habitat assessment. You will come to a consensus to determine the final scores and comments submitted in the field survey.

The Habitat Parameters

Stream habitat is evaluated looking both upstream and downstream, and includes: channel bottom materials, streamside vegetation, slope, and other channel characteristics. You may choose a value between 0-10 (total) for each parameter. Note the final three questions ask you to evaluate each bank separately.

All measures should be taken during baseflow conditions. Stream reach is defined as 12 times stream width, bankfull to bankfull.

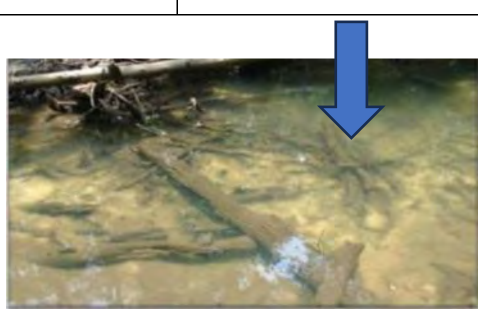
Definition of Terms

Bankfull: The water level, or stage, at which a stream is at the top of its banks and any further rise would result in water moving into the floodplain.

Epifaunal Substrate: What types of submerged materials are on the channel bottom?

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	Excellent -Poor			
1. Epifaunal Substrate **What types of submerged materials are on the channel bottom?**	**Abundant stable** habitat cover for colonization by macroinvertebrates and fish: submerged roots, woody and vegetative debris, cobbles, leaf packs, and undercut banks. 	**Adequate stable** habitat cover for colonization by macroinvertebrates and fish: submerged roots, woody and vegetative debris, cobbles, leaf packs, and undercut banks. 	**Little or no stable** habitat cover available for colonization by macroinvertebrates and fish: submerged roots, woody and vegetative debris, cobbles, leaf packs, and undercut banks; habitat may move during high flows. 	**What did you see?**
	10 9 8	7 6 5 4	3 2 1 0	**Score** ☐



Definition of Terms

Epifaunal substrate: the organic and inorganic material that is available within the stream for organisms to live in or on. Otherwise known as available cover.

Benthic freshwater macroinvertebrates[20]: aquatic animals without vertebrae who live in the bottoms of streams, rivers, lakes, and ponds and are large enough to see with the naked eye (>0.2-0.5 mm)

What to Look For

This parameter looks at the amount of habitat or cover available for critters such as macroinvertebrates and fish living in the water. It looks at the quantity and variety of natural materials in the channel including submerged roots, woody and vegetative debris, cobbles, leaf packs and undercut banks.

Why is it Important?

These types of available cover provide refuges as well as breeding and feeding grounds for aquatic life. An abundance and variety of habitat can support a diversity of organisms and also provide for more stability following a disturbance such as flooding.

How to Score this Parameter

Rated on a scale from 0-10, choose a value that reflects the variety and abundance of habitat materials present ranging from little to abundant' such as submerged roots, woody and vegetative debris, cobbles, leaf packs and undercut banks.

Embeddedness (Rocky and Muddy Bottom Sites)

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	**Excellent -Poor**			
2. Embeddedness *For rocky bottom streams only **Are fine sediments being deposited in riffle/run area?**	Gravel and cobble are **slightly** embedded in riffle area. 	Gravel and cobble are **partially** embedded in riffle area. 	Gravel and cobble are **completely** embedded in riffle area. 	**What did you see?**
	10 9 8	**7 6 5 4**	**3 2 1 0**	**Score** ☐

[20] https://www.macroinvertebrates.org/

Definition of Terms

Embeddedness: The amount of silt and sand that surrounds and covers the gravel and cobbles found in a stream.

Riffle: A shallow section in a stream where water is breaking over rocks, cobble, wood or other substrate in the streamed causing surface agitation.

What to Look For

This is a measure of how much the bottom substrate materials (cobbles, boulders and other rock) are surrounded and covered by fine sediment (silt and sand). The more the bottom is covered in silt and sand, the more embedded it is. This parameter is only to be scored if evaluating rocky bottom streams and in an area where riffles are a natural feature.

Pro tip: pick up a rock on the bottom of the stream. How easily does it separate from the substrate?

Why is it Important?

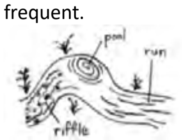
Embeddedness tells us if there is enough suitable habitat available for aquatic life including macroinvertebrates, fish and amphibians. Generally, as cobbles and gravel become embedded, the surface area available to these critters for shelter, spawning and egg incubation decreases

How to Score this Parameter

Rated on a scale from 0-10, choose value that reflects the degree to which cobble and gravel are embedded ranging from slightly to completely. Evaluate this parameter by picking up gravel or cobble out of the streambed with your fingertips, and estimating what percentage of the particle was buried. Observations should be taken in the upstream and central portions of riffles

Riffle/Run/Pool (Rocky and Muddy Bottom Sites)

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	**Excellent -Poor**			
3. Riffle/Run/Pool **Is a diversity of instream habitats available: riffle, runs, and pools?**	Yes, all **three (3)** habitat types (riffle, run, pool) are present and frequent. 	**Two (2)** habitat types are present. 	Only one (1) habitat type present and dominant. 	**What did you see?**
	10 9 8	**7 6 5 4**	**3 2 1 0**	**Score** ☐

Definition of Terms

Riffle: Shallow areas of a stream or river with a fast-moving current bubbling over rocks.

Run: These areas differ from riffles in that depth of flow is typically greater and slope of the bed is less than that of riffles. Runs will often have a well defined thalweg.

Pool: A deeper area of a stream with slow moving water.

Thalweg: The line defining the lowest points along the length of a river bed or valley; the deepest part of the channel.

What to Look for:

In this parameter we are looking at the diversity and frequency of different instream habitat types including riffles, runs and pools.

Why is it Important?

The presence of these different flow regimes and habitat types relates to a stream's ability to provide and maintain a stable aquatic environment through the distribution of nutrients and oxygen, movement of materials and dispersion of energy.

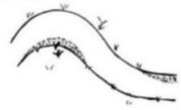
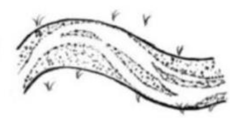
How to Score this Parameter:

Rated on a scale from 0-10, choose a value that reflects the amount of habitat types available ranging from one type as dominant, to all three types present and frequent.

Sediment Deposition (Rocky and Muddy Bottom Sites)

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	Excellent -Poor			
4. Sediment Deposition **Are point bars and islands present?**	**Point bars and islands stable** and of **small** size and frequency with some vegetation. Composed mostly of gravel and cobble.	**Point bars and islands less stable** and of **moderate** size and frequency with some sparse vegetation. Composed mostly of some gravel land finer sediment.	**Point bars and islands unstable** and of **large** size with little or no vegetation. Composed almost entirely of fine sediment.	**What did you see?**

				
	10 9 8	7 6 5 4	3 2 1 0	Score

Definition of Terms

Point Bars: Deposits of sediment on the inside of a meander or bend of stream.

Vegetated Islands: A small islet or sandbar within a river having a grouping or thicket of trees.

What to Look For

This parameter relates to the amount of sediment that has gathered in the channel and the changes that have occurred because of sediment deposits. Deposition can cause the formation of islands, point bars, shoals or result in the filling of pools. Sediment typically comes from bank erosion within the stream and watershed as a result of land disturbance.

Why is it Important?

Deposition of sediments naturally occurs in slow-low flow sections. High levels of sediment deposition create a dynamic and unstable system, making habitat unsuitable for aquatic life by smothering available cover and lowering oxygen levels. This parameter is a reflection of the stability of the point bars and islands.

How to Score this Parameter:

Rated on a scale from 0-10, choose a value that reflects the size and composition, as well as frequency of vegetated islands and point bars in the channel.

Channel Flow Status

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	Excellent -Poor			
5. Channel Flow Status				

How much water is in the stream channel?	**Water reaches base of both lower banks; little** substrate exposed. 	**Some** substrate is exposed and **water partially fills channel.** 	**Most** substrate is exposed and **very little water** in channel. 	**What did you see?**
	10 9 8	**7 6 5 4**	**3 2 1 0**	**Score**

Definition of Terms

Substrate: The mineral or organic material that forms the bed (bottom) of a stream.

What to Look For

This is the degree to which the channel is filled with water during base or average annual flow, and how much, if any, of the stream substrate is exposed.

Why is it Important?

The more water covering available habitat within the substrate, the better for aquatic organisms.

How to Score this Parameter

Use the vegetation line on the lower bank as your reference point to estimate channel flow status. Rated on a scale from 0-10, choose a value that reflects the amount of water reaching the base of both banks from 'very little water" to 'reaches both banks, and look at how much the stream substrate is exposed from 'most to little!'

Channel Alteration

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	**Excellent -Poor**			
6. Channel Alteration **Is the stream channel altered by humans?**	**No evidence** of channelization (straightening) or alterations such as dredging, agriculture, concrete banks, or construction activities. 	**Some evidence** of channelization (straightening) and/or alterations such as dredging, agriculture, concrete banks, or construction activities. 	**Most of stream reach** channelized and/or many alterations present such as dredging, agriculture, concrete banks, or construction activities. 	**What did you see?**

	10	9	8	7	6	5	4	3	2	1	0	Score ☐

Definition of Terms

Channelization: Straightening of a stream channel.

What to Look For

This parameter examines changes in sinuosity and if the shape of the channel and/or the instream habitat have been impacted by alterations. Examples of alterations include: riprap, artificial embankments or stabilization structures, impoundments, diversions, straightening or the presence of dams and bridges.

Why is it Important?

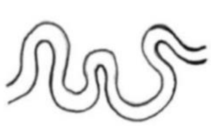
Streams tend to follow a normal and natural meandering pattern. Streams that have been altered typically have fewer natural habitats for aquatic organisms and have an unnatural shape that leads to major differences in energy distribution, structures, and flow regimes.

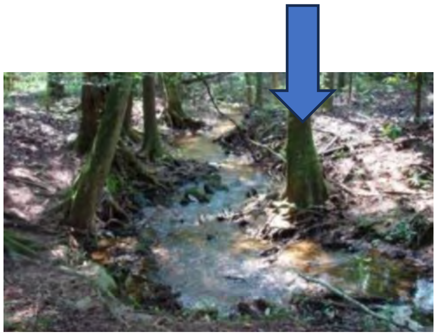
How to Score this Parameter

Rated on a scale from 0-10, choose a value that reflects the occurrence of bends (sinuosity) in the channel ranging from most of the stream reach is channelized to no evidence of channelization? Look for evidence of alterations to score this parameter including: dredging, agriculture, concrete banks or construction activities.

Channel Sinuosity (Muddy Bottom Only)

Complete this question for muddy bottom sites. Skip this question at rocky bottom sites.

Habitat Parameter	**Excellent -Poor**			
7. Channel Sinuosity *For MUDDY BOTTOM streams only **Does the channel have lots of curves and bends?**	Yes, bends in the channel are **frequent**. 	There are **more bends than straight** sections. 	There are **more straight sections** than sections with bends or channel is entirely straight. 	**What did you see?**
	10 9 8	**7 6 5 4**	**3 2 1 0**	**Score** ☐



Definition of Terms

Channel sinuosity: The frequency of bends that occur in a stream.

What to Look for:

This parameter is a measure of how much the stream meanders, or its sinuosity. These meanders or bends can be measured using aerial views and maps of the stream channel. This parameter is only to be scored if evaluating muddy bottom streams.

Why is it Important?

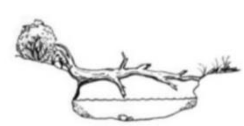
More meanders in a stream provide for a higher diversity of habitat and aquatic critters. The bends absorb energy from higher and faster flows, protecting the stream from excessive flooding and erosion.

How to Score this Parameter:

Rated on a scale from 0-10, choose a value that reflects the occurrence of bends in the channel ranging from 'straight sections to frequent bends.'

Bank Stability (Rocky and Muddy Bottom Sites)

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	**Excellent -Poor**			
8. Bank Stability **How stable are the streambanks?** Determine right/left bank by facing downstream.	**Bank stable**; erosion, scouring, undercutting, or bank failure absent or minimal. Vegetation overhanging the stream is abundant. 	**Bank moderately stable**; evidence of small areas of erosion, undercutting, and scouring, or bank failure present. Moderate amounts of overhanging vegetation present. 	**Bank unstable**; many eroded and scoured areas with undercutting; bank failure present; steep banks. Little over hanging vegetation present. 	**What did you see?**
Left bank	5 4.5 4	3.5 3 2.5 2	1.5 1 0.5 0	
Right bank	5 4.5 4	3.5 3 2.5 2	1.5 1 0.5 0	**Score** ☐

Definition of Terms

Undercutting: A type of erosion which occurs when soils are swept away by the action of the stream, especially on the outer banks of curves. The result is an unstable, overhanging bank.

What to Look For

This parameter is a measure of the potential for soil to detach from the upper and lower streambanks and move into the stream. Here are a couple of indicators of bank stability:

- **Bank Slope:** Steeper banks are more prone to erosion than gently sloping banks. Look for signs of collapse or slumping.
- **Vegetation:** Healthy vegetation with deep root systems helps hold soil in place.
- **Moss:** Presence of moss can indicate some stability, but it's not a guarantee.
- **No plants:** This suggests a highly erodible bank.
- **Bank Material:**
  - **Natural materials:** Look for exposed soil or rock.
  - **Riprap (large rocks) or concrete:** These can be signs of bank stabilization efforts, although not necessarily ideal for ecological health, this can indicate a temporarily stable bank.

Why is it Important?

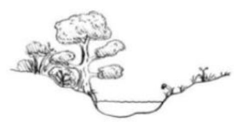
Steep banks, considered more unstable, are more likely to collapse from erosion and cause channel widening than gently sloping banks. Eroded banks indicate scarcity of cover and organic inputs to the stream as well as problems with sediment movement and deposition.

How to Score this Parameter

Rate both the left and right banks separately (facing downstream). Rated on a scale from 0-5, choose a value that reflects the stability of each bank from 'Unstable to stable. Are there any of the following signs of erosion: bare exposed soil, crumbling banks, exposed tree roots and undercutting? Combine these scores when finished for a cumulative score ranging from 0-10.

Vegetative Protection (Rocky and Muddy Bottom Sites)

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	**Excellent - - - - - - - - - - -**	**- - - - - - - - - - - -**	**- - - - - - - - - - - -Poor**	
9. Vegetative Protection Are streambanks covered & shaded by a variety of vegetation? Determine right/left bank by facing downstream.	Most streambank surfaces covered and shaded by a **large variety** of vegetation (trees, shrubs, flowering plants, and grasses). 	Some streambank surfaces covered and shaded by **some variety** of vegetation (trees, shrubs, flowering plants, and grasses). 	Few streambank surfaces covered and shaded by vegetation. **Little variety** of vegetation. Streambank dominated by one type of vegetation (trees, shrubs, flowering plants, and grasses). 	**What did you see?**
Left bank	**5 4.5 4**	**3.5 3 2.5 2**	**1.5 1 0.5 0**	
Right bank	**5 4.5 4**	**3.5 3 2.5 2**	**1.5 1 0.5 0**	**Score** ☐

Definition of Terms

- **Nonnative:** A species living outside its native distributional range, which has arrived there by human activity.
- **Undercutting:** A type of erosion which occurs when fine sediment are swept away by the action of the stream, especially around curves. The result is an unstable overhanging bank
- **Riparian vegetative zone:** The vegetated area along the stream channel.

What to Look For

This is a measure of the amount of vegetation covering the streambanks and the near-stream portion of the riparian zone. It provides information on the ability of the banks to resist erosion.

Why is it Important?

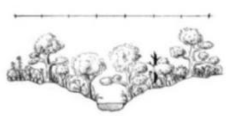
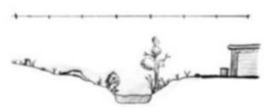
Banks with full plant growth are more beneficial for aquatic life, as the root systems of plants growing in the streambanks help hold soil in place, control erosion/undercutting, provide shade and habitat, and lessen the amount of runoff coming into the waterway.

How to Score this Parameter

Rate both the left and right banks separately (facing downstream). Rated on a scale from 0-5, choose a value that reflects the amount of streambank surfaces covered by a variety of healthy, living vegetation (i.e. trees, shrubs, flowering plants and grasses) from 'few to most' surfaces. Factors to consider when scoring this parameter include the balance of upper/under/lower story cover presence and during which season the assessment is being conducted. Also, please note if any nonnative vegetation is present, if known. You will combine these scores when finished for a cumulative score ranging from 0-10.

Riparian Vegetative Zone Width (Rocky and Muddy Bottom Streams)

Complete this question for rocky and muddy bottom sites.

Habitat Parameter	**Excellent -Poor**			
10. Riparian Vegetative Zone Width What is the amount of buffer available? Determine right/left bank by facing downstream.	Buffer present; a large variety of vegetation extends at least **three channel widths** on each side. 	Some buffer present; some variety of vegetation extends **two to one channel width** on each side. Human activities have impacted buffer zone. 	Little or no buffer present; vegetation extends **less than one channel width** on each side. Human activities substantially impact buffer zone. 	**What did you see?**
Left bank	**5 4.5 4**	**3.5 3 2.5 2**	**1.5 1 0.5 0**	
Right bank	**5 4.5 4**	**3.5 3 2.5 2**	**1.5 1 0.5 0**	**Score** ☐

What to Look For

This parameter is a measure of the amount of the vegetation from the edge of the streambank into the riparian zone (buffer).

Why is it Important?

The riparian zone performs many important functions such as removing pollutants from runoff, providing shade to cool the water, controlling erosion by reducing the velocity and volume of runoff and by providing habitat for aquatic life (i.e. organic matter inputs). Depending on the stream size and order, the width of the riparian zone may vary.

How to Score this Parameter

Rate both the left and right banks separately (facing downstream). Rated on a scale from 0-5, choose a value that reflects the width of the riparian zone from less than one channel width to at least three channel widths.' Also, please note if any nonnative vegetation is present, if known. You will combine these scores when finished for a cumulative score ranging from 0-10.

Spotting and Identifying Non-Native Vegetation

Non-native plants come in all forms, including trees, shrubs, vines, grasses, and ferns. Invasive, non-native plants are aggressive survivalists and share these tendencies:

- Grow vigorously
- Survive in a range of conditions
- Reproduce quickly
- Difficult to eradicate

As you answer the questions about vegetative buffers, keep an eye out for non-native vegetation. Your field survey will ask if you spotted any non-native vegetation. You can answer "yes," "no," or "unsure." Here are a few of the most common non-native plants you might spot at our stream sites in Chapel Hill.

Name	Photo	Where it's native	Impact
Common ivy		Europe/western Asia	Outcompetes and displaces native vegetation.
Kudzu		East Asia, Southeast Asia, some Pacific Islands	Fast-growing and outcompetes all native plants, including trees.
Japanese honeysuckle		Eastern Asia	Outcompetes native vegetation for light and below-ground resources.

Chinese Wisteria		China	Climbs up tall trees and shades out smaller trees and plants below.

To learn about nonnative species in the Southeast visit http://www.invasive.org/eastern/ses. NC State Extension also has excellent resources on invasive plants and their impacts: https://content.ces.ncsu.edu/invasive-plants-and-your-forests.

How Do I Interpret My Total Habitat Score?

Add your scores for all parameters. Your total score will fall into one of the four categories: Excellent, Good, Fair, or Poor.

Stream Habitat Score	Excellent (69-90)	Good (46-68)	Fair (23-45)	Poor (0-22)
What does this mean?	A score in this range signifies a thriving aquatic ecosystem with exceptional features that support a diverse and abundant community of life.	A score in this range suggests that the stream is providing valuable ecological services and is relatively resilient to disturbance. It's a positive indication of the overall health of the stream ecosystem	A score in this range indicates that the stream habitat has some limitations in supporting aquatic life, but it's not necessarily in poor condition.	Scores in this range indicate significant limitations in its ability to support aquatic life. A score in this range highlights the need for significant restoration efforts to improve the stream's health.

Habitat scores can change through the seasons and in varying weather and climatic patterns. It is good to have baseline data through the seasons and over time compare the total. It is also good to look at each parameter individually over time.

History of Handbook Updates

- October 2023: The calibration section (and subsequent checklists) were updated to reflect new training videos and a change in the pH calibration protocol.
- Spring 2024: The Habitats: Get To Know Our Creeks section was added. This section includes information about Spring Stream Habitat Assessment protocols, local geology, and clarifications about basic visuals questions. Instructions for calibrating and measuring with the new pH and conductivity equipment was added. Instructions for calibrating and measuring with the old equipment was moved to a section called “Old Equipment Instructions.” There is now a glossary in the appendix.

- September 2024: "What are the team roles?" section was replaced with "What are the teams responsible for?" There are now more team roles with the option for team members to sign up for multiple roles. "What are some additional activities teams can do during quarterly monitoring?" section was added. This section provides suggestions for additional field activities. "How do we coordinate equipment pick-up and drop-off?" section was updated. "What supplies are in the Stream Team kits?" was updated to reflect new conductivity equipment supplies. "Conductivity: PCTSTestr 50" calibration section was corrected – plastic cup is no longer needed to calibrate conductivity meter.

Appendices

Appendix 1: Glossary

The **bankfull** line is defined as the water level, or stage, at which a stream is at the top of its banks and any further rise would result in water moving into the floodplain.

The **Carolina Terrane** is an area characterized by slightly metamorphosized igneous rocks, or previously igneous rocks that have undergone change due to high heat or high-pressure exposure.

Channelization is the straightening of a stream channel.

The **channel** of the stream is the width of the stream at bankfull discharge.

Channel sinuosity is the frequency of bends that occur in a stream.

Deposition happens when sediment carried by the stream eventually settles out in areas of slower flow, creating features like sandbars and deltas.
Dissolved oxygen (DO) refers to the concentration of oxygen gas incorporated in water. It is measured in parts per million (ppm) or milligrams per liter (mg/L).

Electrical Conductivity is a measure of the ability of water to pass an electrical current. It is measured in microsiemens per centimeter (µS/cm).

Embeddedness is the amount of silt and sand that surrounds and covers the gravel and cobbles found in a stream.

Ephemeral streams flow only during or immediately after periods of precipitation. They are part of the river system.

Epifaunal substrate is the organic and inorganic material that is available within the stream for organisms to live in or on. Otherwise known as available cover.

Erosion is the geological process in which earthen materials are worn away and transported by natural forces, such as wind or water, or by human activity, such as construction

First-order streams have no tributaries flowing into them

A **floodplain** is the low area of land that surrounds a stream and holds the overflow of water during a flood.

- The **hydrologic floodplain** is defined by bankfull elevation

- The **topographic floodplain** includes the hydrologic floodplain and additional floodplains that extend to a specified elevation corresponding to a particular flood frequency, such as the 100-year flood.

Habitat is where an organism lives, eats, and/or reproduces.

Headwater streams are the "tipmost" branches in a river system. They are part of the river system.

Heavy metals are elements that have atomic weights between 63.5 and 200.5 and have a specific gravity greater than four.

Illicit discharges (also called **water pollution**) are materials dumped into streams or the stormwater system that have been determined to be harmful to stream water quality or ecological balance.

Impervious surfaces are made of hard materials that prevent rainwater from naturally soaking into the ground. Examples include roads, sidewalks, and rooftops.

Intermittent streams flow only during certain times of year. Seasonal flow in an intermittent stream usually last longer than 30 days per year.

Invasive species are non-native plants and animals introduced into urban areas can outcompete native species for resources and disrupt the natural balance of the stream ecosystem.
A **meander** is a bend in a creek or river.

Nitrate is a nutrient made from nitrogen.

Perennial streams flow continuously during typical weather conditions

pH is a measure of acidity or alkalinity. The pH is measured on a scale of 1 to 14; 1 being the most acidic, 14 being the most alkaline, or basic, and 7 being neutral.

Phosphate is a nutrient made from phosphorus.

Point Bars are deposits of sediment on the inside of a meander or bend of stream.

Pollution is the introduction of harmful materials into the environment.

- **Sediment:** Erosion from construction sites and developed areas can cause excessive sediment to enter streams, smothering aquatic life and harming their habitat.
- **Chemicals:** Fertilizers, pesticides, and other household chemicals can contaminate streams, impacting water quality and harming organisms.
- **Trash:** Debris can clog streams, disrupt natural flow, and introduce harmful toxins.

Pools are distinct habitats within the stream where the velocity of the water is slower and the depth of the water is greater than that of most other stream areas.

Riffles are shallow, faster moving sections of streams, usually with rocks.

The **riparian zone (buffer)** is the area of natural vegetation extending outward from the edge of the streambank. The **stream bank** includes both an upper bank and a lower bank.

- The **lower bank** normally begins at the normal water line and runs to the bottom of the stream.

- The **upper bank** extends from the break in the normal slope of the surrounding land to the normal high water line.

A **river system** is the network of flowing water from the headwater streams to the mouth of the largest river.

Runs or **glides** are sections of the stream with a relatively low velocity that flow gently and smoothly with little or no turbulence at the surface of the water.

Second-order streams receive first-order streams. They are part of the river system.

Stormwater runoff is precipitation, such as rain or snowmelt, that does not soak into the ground.

The **streamside cover** includes any overhanging vegetation that offers protection and shading for the stream and its aquatic inhabitants.

Stream vegetation are plants within a stream and include emergent, submergent and floating plants.

- **Emergent plants** include plants with true stems, roots and leaves with most of their vegetative parts above the water.
- **Submergent plants** also include some of the same types of plants, but they are completely immersed in water.
- **Floating plants** (e.g., duckweed, algae mats) are detached from any substrate and are therefore drifting in the water.

The **substrate** is the material that makes up the streambed, such as clay, cobbles or boulders.

A **thalweg** is the line defining the lowest points along the length of a river bed or valley; the deepest part of the channel.

The **Triassic Basin** is a geological region associated with sedimentary (rocks formed from layers of sediment that are compacted over time) and igneous rocks (rock formed from hardened magma or lava).

Turbidity is a measure of the clarity of water. It is measured in Nephelometric Turbidity units (NTU).

Undercutting is a type of erosion which occurs when soils are swept away by the action of the stream, especially on the outer banks of curves. The result is an unstable, overhanging bank.

A **vegetated Island** is small islet or sandbar within a river having a grouping or thicket of trees.

A **watershed** is a land area that funnels water down to a common low point.

Appendix 2: How do we identify and report pollution?

Remember to check your facts and specific location before calling.

Immediately report incidents that you witness or observe.

- Take a picture to capture the offense. Send this with your report directly to the Town's Stormwater staff. Please include accurate location, time of observation, and description of the situation. Jason Salat is our IDDE contact: jsalat@townofchapelhill.org or call 919-969-RAIN (7246).

- If there is a vehicle involved, try to get the license plate number and description of vehicle.
- DO NOT trespass on private property. Legally, evidence obtained without access permission from the property owner or a search warrant cannot be used against them. Trespassing can be used against YOU, however.
- Raising awareness and educating first offenders is important. Legal action is reserved for repeat offenders or egregious damage.

What are illicit discharges?*

As part of meeting requirements for our Clean Water Act permit (called NPDES Phase II) , the Town must have a program to identify and elimination water pollution (illicit discharges). **Illicit discharges** are materials dumped into streams or the stormwater system that have been determined to be harmful to stream water quality or ecological balance. The Town has an ordinance that defines and prohibits illicit discharges to stormwater systems, including right of entry provisions, penalties, and due process procedures.

Chapel Hill Code of Ordinances Chapter 23, Article 5

Allowed discharges include:

- landscape irrigation/irrigation water/lawn watering
- water line flushing
- diversion of stream flows
- rising groundwater/groundwater infiltration
- uncontaminated pumped groundwater
- discharges from potable water sources
- foundation drains/crawl space pumps/footing drains
- air conditioning condensation
- springs
- individual residential car washing
- flows from riparian habitats and wetlands
- dechlorinated swimming-pool water
- street wash water (this is done after dry sweeping has been conducted)

Discharges of petroleum products and derivatives, and hazardous materials as defined by NCDWQ are explicitly disallowed (illicit). If you suspect anything other than stormwater is being discharged into the stormwater system or directly into streams, please contact us.

***Chapel Hill erosion and sedimentation control ordinance**:
https://library.municode.com/nc/chapel_hill/codes/code_of_ordinances?nodeId=CO_CH5BUBURE_ARTVSOERSECO.

Orange County Erosion and Sedimentation Control performs permitting, inspection, and enforcement in Chapel Hill, with assistance from Town engineering staff. The State inspects local and state government projects.

To report erosion and sedimentation from construction projects in Chapel Hill, please call Steve Kaltenbach, Orange County Erosion Control at 919-245-2580..

Learn more at www.townofchapelhill.org/PreventWaterPollution

Appendix 3: Old Equipment Instructions

In Spring 2024, we replaced the pH and Conductivity meters with multi-parameter meter. However, we still have some of the old pens as back up. In case you have to use the backup equipment, instructions for calibrating are below.

Calibrating

Conductivity: Oakton ECTester

For a training video, scan the QR code or go to https://bit.ly/ECTestr11.

Video: Calibrating the Oakton ECTester

- When do you do this?
  - Before you go to the site, on the day you plan to monitor
- What will you need?
  - Your ECTester,
  - Plastic wash bottle of 1413 µS/cm solution
  - Plastic cup
  - Discard bowl
  - Deionized water
- What are the calibration steps?

1. Confirm the meter is in Auto Calibration mode
   a. Unscrew the cap at the top of the meter. Look at the top with the front of the meter facing you. There are two white, rectangular buttons sitting above the batteries.
      i. The right button = **INC** (increase)
      ii. The left button = **DEC** (decrease)
   b. Hold down INC a press ON. Press INC or DEC to select 'Yes' (to enable auto calibration).
   c. Press °**C/°F** to confirm auto calibration.
2. Confirm 1-point calibration
   a. the display should say YES 1 Pnt
   b. Hold Press **HOLD ENT** to confirm 1-point calibration (The display shows 'CO' for a few seconds and then shows power-up sequence. The tester goes to measurement mode.)
3. Calibrate the tester
   a. Rinse the electrode with deionized water before calibration
   b. Rinse plastic cup with a small amount of deionized water. Add 1413 µS/cm solution to the fill line from the plastic bottle
   c. Make sure tester is in Measuring mode ("MEAS" will be in upper lefthand corner).

d. Rinse the electrode using the <u>wash bottle of 1413 µS/cm solution</u>. Then dip the electrode in the plastic cup with the solution. Swirl gently to create a homogenous sample and allow time for the reading to stabilize.
e. Press INC or DEC to enter calibration mode. The 'CAL' indicator appears on screen.
f. The upper display shows the measured conductivity reading and the lower shows the default conductivity.
g. Tap HOLD ENT to confirm. 'CO' should pop up on the display.

4. Turn meter off.

pH: Pocket Pro pH Tester

For a training video, scan the QR code or go to https://bit.ly/ECTestr11.

Video: Calibrating the Pocket Pro pH Tester

This one can be tricky, so here is an instructional video[21] we found to be helpful.

- When do you do this?
  - Before you go to the site, on the day you plan to monitor
- What will you need?
  - Your pH probe
  - pH 7.0 buffer
  - pH storage solution
  - paper towels
  - a container to discard used solution (you supply this)
  - bottle of deionized water
  - gloves
  - goggles
- What are the calibration steps?
  1. Your probe should be stored in storage solution. Discard the storage solution into your <u>discard container</u>.
  2. Rinse the probe and cap with <u>deionized water</u>.
  3. Dry probe and cap – blot, don't wipe.
  4. Fill cap to fill line with <u>7.0 buffer solution</u>
  5. Turn on the meter
  6. Press the graph button (top half of circular button)
  7. Display will show "7.00" at the bottom of the screen
  8. Wait for a reading to stabilize. It's okay, and expected, for this reading to not be 7.0
  9. Once it stabilizes, press the graph button (top half of circular button) again
  10. To complete calibration, press and hold the graph button until the LCD screen flashes END (this may take many seconds)
  11. The display should say M.
  12. If the display has a graph with a question mark, calibration failed. If this happens, clean the probe and retry?
  13. Refill cap with storage solution

[21] "Hach Pocket Pro pH reader calibration"
https://www.youtube.com/watch?v=VduSgzpzYNo&ab_channel=EndemicEnvironmental

- Check for air bubbles by the sensor. Shake lightly to remove them (they'll mess up your reading).

This is called 1-point calibration, in which we check the meter with just one buffer solution. Since we are measuring pH in fresh water, only 1-point calibration with a pH of 7 is needed.

Measuring

Testing for pH with the Pocket Pro pH Tester

1. Set the power to on
2. Remove the cap from the sensor
3. If the lock icon shows on the display, push the **lock icon** to go to continuous measurement mode
4. Rinse the sensor and cap with deoionized water and blot dry
5. Rinse the cap in stream water.
6. Pour the water sample into the cap to the fill line
7. Put the sensor fully into the cap. The masured valued shows on the top line.
8. To keep the measured value on the display when the sensor is removed from the sample, push the **lock icon**. (The lock icon shows on the display when the measurement is stable)
9. When done with the measurements:
    - Refill the cap with the pH storage solution
    - Put the cap on the tester.
    - Set the power to off.

Testing for Conductivity with the Oakton ECTester

- Push the 'HOLD' button on the meter to set the in-stream measurements before removing from the water.

Appendix 4: Current Equipment Manuals

The manuals for the ExStik DO600 and PCTSTestr 50 start on the next page. The PCTSTester 50 manual is also in the case with the meter.