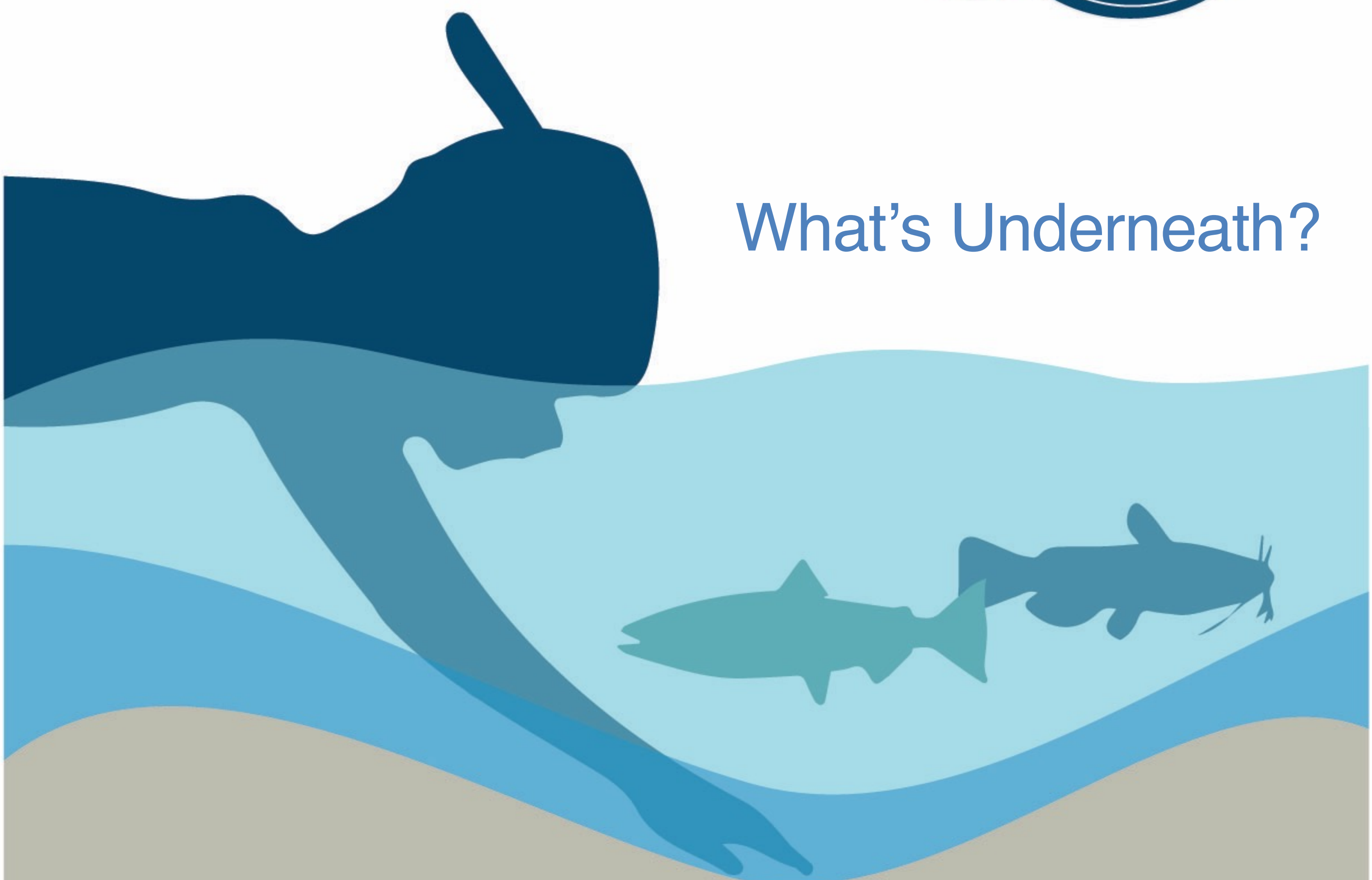
Freshwater Snorkeling Curriculum

What's Underneath?



US Dept. of Agriculture

Forest Service

FS NatureWatch Program

NorthBay

Freshwater Snorkeling

Curriculum

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Introduction: What's Underneath?

"If you want clear water, look for the big green spots on the map"

- *Jeremy Monroe, Freshwaters Illustrated*

Overview

Our national forests provide a number of ecosystem services. Among them, they provide 65 million people with clean water. This curriculum is designed to help students understand their ties to national forests, the importance of forested watersheds for clean water, and the importance of habitat diversity to aquatic life. This learning will lead to a river snorkeling experience where students become connected to life in our streams as they discover how habitat diversity affects species diversity.

About the Curriculum

This multi-faceted curriculum is written for schoolteachers to use with their students prior to participating in a river snorkeling event. Rooted in Next Generation Science Standards, authentic exploration, character education, and contemplative practices, it will prepare students for their river experience. The curriculum is modeled after a core program run by the non-profit institution, NorthBay Education Foundation. NorthBay operates a five-day residential outdoor education program located on the Upper Chesapeake Bay in Maryland. The program uses the environment as a metaphor for life choices. NorthBay's ten-year history has shown this model to be effective in teaching students that the choices they make have an effect on their future, the people around them and the environment.

You will find six lessons in this curriculum: Lesson 1 asks students to identify the national forest closest to them and details the ties they have to that forest. Lesson 2 teaches students about the concept of watershed, and how land use affects water quality. Lesson 3 makes the idea of watershed care relevant to students. Lesson 4 teaches about critical river habitat structures. Lesson 5 prepares students for their river snorkeling field experience and Lesson 6 *is* the river snorkeling experience itself, one that incorporates a contemplative exercise to help connect students to the river.

We want students to form relationships to rivers and the national forests that support healthy aquatic systems throughout our magnificent country. Getting students to experience rivers in intimate ways, like snorkeling in them, will help form those deep emotional bonds that are needed for people to take action to protect the environment. Someday, these students may be called upon to speak for the forests, and the rivers and streams that depend on them.

LESSON 1: NATIONAL FORESTS

OUTCOMES: *Students will*

- Learn which national forest (or natural area) is closest to them.
- Write about real or imagined experiences in their national forest.
- Use fractions in calculations.
- Understand national forests provide important ecosystem services.
- Be encouraged to visit their national forests and natural areas.
- Recognize that national forests and other outdoor places provide the opportunity for us to re-create and rejuvenate ourselves. They will understand the importance of this value, and will understand that the right people in our lives can provide similar benefits.

BACKGROUND

This lesson helps students understand their proximity to forests. Our national forests provide clean drinking water to 1/5 of the nation's population.

ASK

"Have you visited a national forest? What was it like?" If they haven't visited the national forest closest to them, encourage them to talk to their families about getting there. Have students use the Forest Service Locator Map to find their closest national forest: (www.fs.fed.us/locatormap) or the Discover the Forest website (www.discovertheforest.org) to locate a similar, forested area. The site allows the user to find natural areas within 15-100 miles of a zip code entry.

If possible, schedule a field trip to explore the forest closest to your school.

EXPLAIN

Show students the national forest closest to their school.

ACTIVITY

Have students virtually explore their forest. Have them search the internet for information about their forest. A good source of this information would be the U.S. Forest Service website for your state or region (http://www.fs.fed.us). Ask "What kind of geography does your forest have? What kind of ecosystems? What kinds of animals and plants can you find there? What types of activities can you do there?" Have students write in their journals about a real or imagined visit to their national forest. Descriptions of the geography and ecosystems should be interwoven into their journal entries. Ask them to download one of the forest maps or recreation guides. This activity will be most productive using the national forest websites versus a local natural area found on the Discover the Forest website, since online resources for non-Forest Service sites will not be as consistent.

EXPLAIN

Tell students that our national forests are amazing places for each of us to enjoy and are vital to sustaining diverse populations of wildlife and fish. They provide the opportunity for us to connect with the people important in our lives while enjoying a worthwhile experience in nature. They also provide natural resources that are important for the survival of the planet. Ask students what they need to survive from day to day. Some examples might include oxygen/clean air, food, clean water and soil. Tell students that one of the things we need to survive is clean drinking water, which is one of the many things national forests provide by protecting and maintaining forested watersheds. In fact, 1/5 of the United States population depends on national forests for clean drinking water.

ACTIVITY

Ask students to calculate how many people in the United States depend on our national forests for clean water based on the fraction mentioned above. Furthermore, if 60% of all forested land in the U.S. is privately owned, how important is the individual landowner to ensuring that clean water is available for everyone by protecting that forest?

CHARACTER CONNECTION

National forests provide refuge and recreation for us. Think about the word ‘recreate’: re-create, renew, regenerate, restore. Outdoor spaces, like our national forests, give us the opportunity for re-creation and renewal. Re-creation and renewal are some of the most important services forests provide. People in our lives can similarly help us. Who in your life provides re-creation and renewal for you? For whom do you provide re-creation and renewal?

LESSON 2: WATERSHED

OUTCOMES: *Students will*

- Understand what a watershed is.
- Understand how a watershed works.
- Design an experiment to model healthy and unhealthy watersheds.
- Understand the importance of forested watersheds.
- Understand how healthy watersheds act as water filters.
- Understand how humans need the right filters in our lives.

BACKGROUND

A watershed is the area of land that drains into a water body. What we do on land directly affects the water quality of the closest water body in a watershed. In fact, the cleanliness of the water in a watershed depends on how well the land in it is managed. Forested watersheds produce the cleanest water. When it rains, the rainwater in a forest percolates through the soft forest leaf duff and soil and does not directly run off to the local stream. As rainwater percolates through the soft forest soil, it is filtered. When rain falls on an agricultural watershed, more water runs off directly to local streams and carries soil, fertilizers and agricultural chemicals with it. When rain falls on a suburban or urban watershed, any water that lands on impervious surface - a hard surface that doesn't allow the rain to soak in - runs off and carries any contaminants that are on the surface with it. Oil, antifreeze, brake dust (which is high in heavy metals) coming from vehicles, and fertilizers are all carried in the water, which runs rapidly to the local creek. Since the water coming from impervious surfaces runs with high velocity, it scours soil and turns the water muddy. Students can watch a 50-minute webcast explaining watersheds and their relationship to clean water at the FreshwaterLIVE Distance Learning Adventure website: https://freshwaterlive.org/webcast-info/webcast

Sediment Pollution

When soil is washed into water it is called sediment. Cloudy water is called turbid, and turbidity is a measure of how cloudy the water is. Sediment has different impacts. One is that sediments can smother bottom habitat in aquatic environments. Many fish lay their eggs on clean gravel along the stream bottom. Deposited fine sediment- sand, mud and silt - can eliminate that habitat needed for fish to reproduce. Fine sediment also buries cobble, which are larger rocks, and what was a really diverse habitat with lots of nooks, and crannies that provided habitat for a number of species becomes a sand or mud flat with little habitat diversity. Low habitat diversity negatively impacts ecosystems because it reduces biodiversity.

Some fish species use eyesight to feed. When they can't see due to cloudy, turbid water, they can't eat, and they must try to move to places that have cleaner water. Other types of animals also depend on clean water to survive. Hellbender salamanders are the largest salamander in North America and are declining in number partly because of increased sedimentation. *The Last Dragons* is an amazing film by *Freshwaters Illustrated* that shows the plight of the Hellbender and how the U.S. Forest Service is working to protect them. Students will have the opportunity to see this movie in Lesson 3: Who Cares?

Nutrient Pollution

Nitrogen and phosphorus wash into our rivers from agricultural and suburbanized land. These nutrients come from animal waste, human sewage, pet waste, lawn fertilizers, and car exhaust. Septic tanks do nothing to reduce the nutrient levels of human sewage, and sewage treatment plants often don't reduce nutrient loads. Excess nutrients in water sources can make excess algae grow.

Algae are an important food source for streams and 50% of the food needed for a river's food web often comes from algae. Too much algae results in turbid water and low oxygen levels that can choke fish and other aquatic organisms. Phytoplankton, or single celled algae, live for a short duration then die. When they die, bacteria decompose the dead algae and use up available oxygen in the decomposition process, which results in oxygen levels too low to support life, especially in deeper, slower moving, sections of the stream. This process is called *eutrophication*.

Other Pollutants

Contaminants that wash into rivers and streams from suburbanized and urbanized landscapes include heavy metals and petroleum products. These can be directly toxic to stream life. The good news is that planting trees, installing rain gardens, green roofs and other engineered green infrastructure can make a big difference in the life of a stream. Each of these practices controls runoff and absorbs or transforms contaminants, all of which restore water quality.

Pedagogy Sidebar - Claim Evidence Reasoning

In this lesson, students are asked to evaluate different graphs and make scientific statements based on their evaluation. Claim Evidence Reasoning (CER) gives students structure in making scientific statements or claims from evidence and reasoning. The following explains the CER process and provides a rubric for what would be considered an excellent CER statement.

Claim Evidence Reasoning (CER) is a format for writing about science. It allows you to think about your data in an organized and thorough manner.
Claim: Statement that answers a question or explains a problem - What do you know?
Evidence: Information that supports your claim - How do you know that?
Reasoning: Explanation of how your evidence supports your claim - In what ways does your evidence support your claim?

CER Rubric	**Excellent**
Claim	• Concise statement (1-2 sentences) • Relates directly to the question and hypothesis • Focuses on only the most important features of the experiment
Evidence	• At least 1 paragraph • Several data sources used to explain claim, including observations and accurate measurements • Clear connections to question and hypothesis
Reasoning	• At least one paragraph • Illustrates how experiment fits into the “big picture” • Incorporates background knowledge, and makes connections to show science concepts studied in class, to draw conclusions about experiment
	• Proofread for spelling and mechanical errors • Proper heading on paper • Each section clearly labeled

SHOW

Show students this photo (Photograph 1):

ASK

“Do you notice how the two streams are different colors, and how they have different turbidities?”

“Do you notice how the stream on the left is very murky, with zero visibility, but the stream on the right is clearer?”

“Do you wonder why this happens?”

“What could cause the differences in the two streams?”

“What could be done to change them?“

SHOW

Show the 5-minute video that explains how watersheds work using the character, “RD” (Rain Drop): https://vimeo.com/161492410

EXPLAIN

Clean water depends on watershed protection. The river on the left has a watershed that is dominated by agriculture and residential development. The stream on the right has a watershed that is mostly forested. *Land use is the single most important factor that determines the quality of water within and downstream of that watershed.*

SHOW

Show students the following hydrographs, demonstrating the height of a sample river and the related turbidity of the water during the same time period.

Figure 1: Gage Height at Brandywine Creek at Chadds Ford, PA

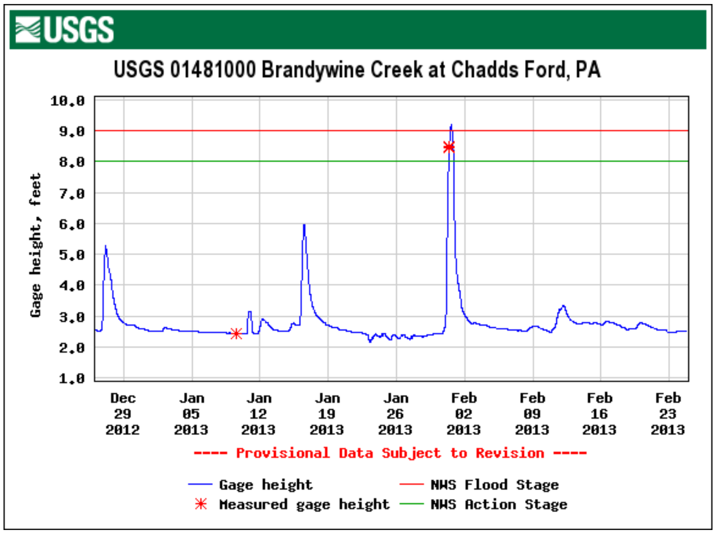
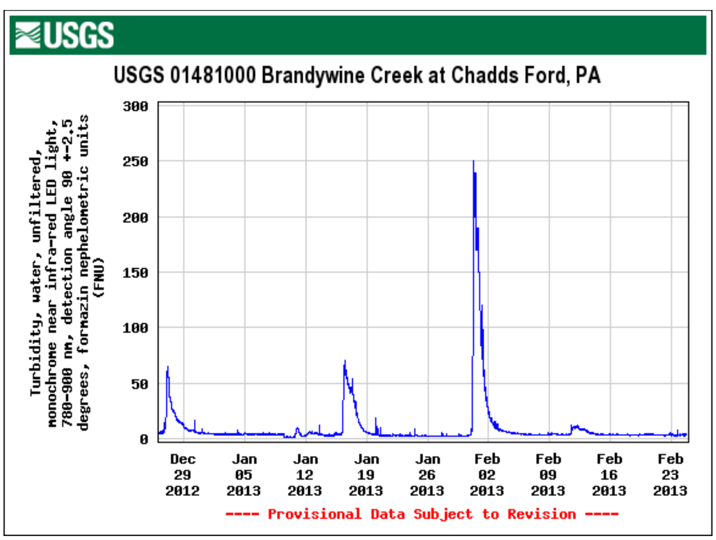


Figure 2: Water Turbidity at Brandywine Creek at Chadds Ford, PA



EXPLAIN

Scientists use hydrographs to measure stream height, flow velocity and other parameters like turbidity. The date is on the x-axis, and the parameter units (like stream height or turbidity) are on the y-axis. Have students study these hydrographs. They are from the same river on the same dates.

ASK

Ask students “What do you notice?”

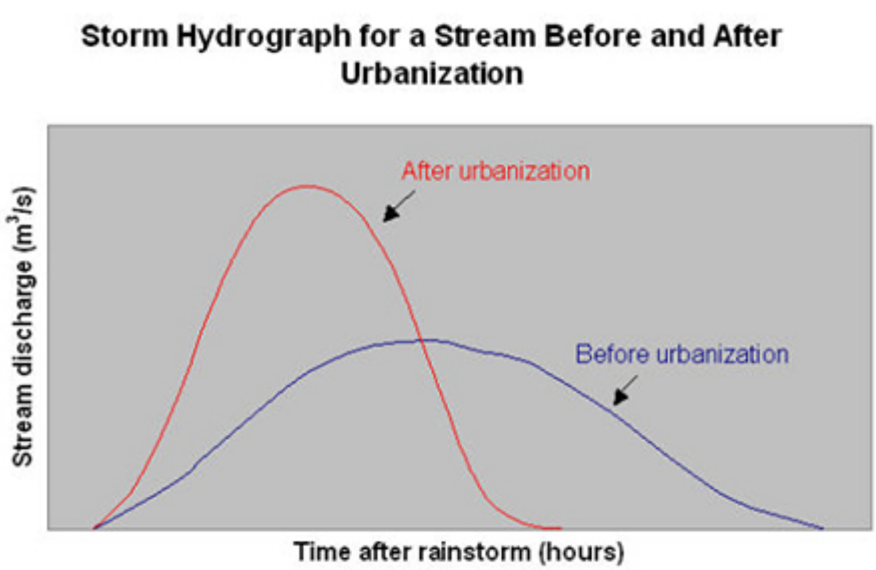
“Do you notice any patterns in the data represented?”

“Do the data represented in the graph follow the same trend?” *Students should note that there is a relationship between river height and turbidity; that when the river rises (flow increased due to runoff) turbidity also goes up.*

ACTIVITY ONE

Have students make a statement, or claim, supported by evidence and reasoning (Claim Evidence Reasoning) based on the data represented in this hydrograph.

Figure 3: Storm Hydrograph



BACKGROUND

This hydrograph is a generic representation of how water runoff is different in urban and forested watersheds. The red line shows that there is much more water runoff in urban watersheds, compared to forested watersheds. The difference is related to impervious versus forested surfaces, and the filtration that occurs when vegetation is present instead of a constructed (concrete or asphalt) landscape.

ACTIVITY TWO

Make a model that represents how different land uses (developed land, agricultural land and forest land) affects water quality.

SHOW

Show the *Try It-Watersheds* 3-minute video that demonstrates a student making a similar model of land use effects on water clarity: https://vimeo.com/158591598

ASK

"How do your results compare to those in the video?"

ACTIVITY THREE

Repeat the same experiment by changing the substrates. What substrate works as the best filter of water as it moves through?

CHARACTER CONNECTION

Forested watersheds act as great filters of pollutants and provide clean water for rivers and streams, and subsequently for us. Humans need ‘filters’ to clean out negative influences and help keep us on the right track, just like rivers and streams need the filters a forested watershed provides. Who are the filters in your life? For whom are you a filter?

Vocabulary: Lesson 2

Sediment*:* soil washed into a waterway.

Turbid(ity)*:* the degree of water cloudiness based upon the quantity of sediments suspended in the water column.

Eutrophication: runaway algal growth, also known as an algal bloom. An algal bloom can blanket a waterway, blocking sunlight essential for submerged aquatic vegetation, change pH, and reduce the amount of dissolved oxygen available.

LESSON 3: CARING ABOUT WATERSHED

OUTCOMES: *Students will*

- Understand that their actions affect the environment and the people around them.
- Understand that there are unintended consequences of our actions.
- Develop a sense of caring about rivers and streams and the life they contain.

BACKGROUND

People often need a reason to care about something in order to act on its behalf. This lesson uses the short movie, *The Last Dragons*, by *Freshwaters Illustrated,* to tell the story about Hellbender salamanders, and to inspire in students a sense of compassion for these ugly but fascinating creatures. Who doesn't find a foot long salamander cute and cuddly after all? Hellbender salamanders were once abundant throughout the Appalachian region, from southwestern and south-central New York, west to southern Illinois, and south to extreme northeastern Mississippi and the northern parts of Alabama and Georgia. They need clear, cool streams to survive. Their range and numbers have been shrinking due to declining water quality, largely because of sedimentation. Hellbender salamanders are also impacted when people recreating in streams rearrange rocks on the bottoms to make dams and chutes for their canoes and kayaks.

SHOW

Show students the 10-minute film, *The Last Dragons*: https://vimeo.com/108512185

ASK

"What did you notice in the video?"

"What is causing Hellbender salamander populations to decline?"

"When people move rocks, are they intentionally trying to cause harm to Hellbender salamanders?"

“When people mistreat watersheds, are they intentionally trying to cause sedimentation that kills aquatic life?”

“After watching this video can you see why it is important for us to understand how we can protect the water quality of our rivers and streams on land and in the water?”

EXPLAIN

There are entire communities of amazing life living in our streams that depend on clean water to survive. People also depend on clean water to survive. We need to take care of our rivers and streams while in the water as well as on the land. We are all connected though water. We all need clean water to survive, and we all affect water quality. What we do on land affects water quality, water quality affects those downstream, and we are all downstream of someone else. What we do on land can affect other species and humans on the other side of the world. For example, if I throw a plastic bottle on the ground in my neighborhood, that bottle will flow downhill into the nearest creek where it can negatively affect the living beings in that stream. It may eventually be swept into the ocean where it will negatively affect life there, and it can very possibly wash up on the shores of a distant continent, again impacting life there in different ways. Albatross are ocean-going birds that are significantly declining in number because they ingest plastic that we throw on the ground without thinking, which may end up floating into the ocean. You can make a tremendously positive difference by being good stewards of the land. Taking care of the land around us can positively affect other humans and species a continent away. Water is the big global connector, and this is why it is important that we take care of the land that drains into rivers and streams.

CHARACTER CONNECTION

What differences do you make in the watershed where you live? What do you contribute to the lives of other humans? What do you contribute to the lives of other species? How can your contribution be positive?

OPTIONAL LESSON EXTENSION

A lesson that engages students in an investigation of turbidity on their school yard and in their community that leads to an action plan to remedy erosion is Appendix A.

LESSON 4: RIVER HABITATS

OUTCOMES: *Students will*

- Understand that diverse and complex habitats lead to increased biodiversity.
- Understand why biodiversity is important.
- Be prepared to explore the aquatic diversity of a river through snorkeling.
- Understand the importance of diversity in ecological and human communities.
- Understand that they have a significant effect on the world around them.

BACKGROUND

This lesson teaches students that habitat complexity and diversity leads to increased biodiversity, which is necessary for healthy, resilient ecosystems. It also uses the environment as metaphor for human life and asks some character related questions regarding diversity and our significance to people around us and to the environment. This lesson describes surface features (pools, glides and riffles) local hydraulic conditions and microhabitats, and individual structures such as gravel bars, boulder cascades and woody material. This knowledge will prepare students for their field experience as they explore where different aquatic species are in relation to these habitat features.

Surface Features

EXPLAIN

Review the concept of watershed with students and explain that a drainage network or watershed can be measured in hundreds of miles. A stream *reach*, which is a section of stream with similar hydrologic characteristics, can be measured in hundreds of feet. Stream features can be measured in tens of feet or less. Some examples of features found within a stream reach include pools, glides and riffles. These features can contain smaller structures like *sand bars, gravel riffles, boulder cascades* and *woody material*. All of the features and structures in the stream form a complex, diverse, multilayered habitat, which is important for biodiversity. Different species have different habitat requirements, so a diverse habitat can lead to the best support system for the most species. Biodiversity, or diverse life, leads to stable ecosystems, and it can also mean rich ecosystem services such as air filtration, clean water, and pollination of plants that produce food for human beings. For example, let's say there are seven species of trees in a forest. A disease goes through the forest that kills off one species of tree. There are still six tree species in the forest providing benefits to the forest and humans. Not that the species that was killed by the disease wasn't important, but the general functions of the ecosystem, such as photosynthesis and nutrient cycling, seem to go on without much disruption. We don't even realize what species that depended on the lost tree species are now suffering or declining. Now, let's assume there are only two species of trees in the forest. A disease goes through and wipes out one species. We only have one species left, and although some basic functions still appear to be fine, the system is much more fragile and vulnerable than the more biodiverse and resilient, seven species system. If the remaining tree species also dies, the ecosystem could plummet into a domino effect of subsequent extinctions.

ASK

"Why is diversity important in ecologic communities? Why is diversity important in human communities? What can we do to encourage diversity in both?"

SHOW

Show students this photo (Photograph 2):

ASK

"What do you notice in this photo? Can you identify different habitats?"

SHOW

Show students this photo and ask them what they notice
(Photograph 3):

ASK

"Does it look like the water moves turbulently through these rocks or calmly? How does this spot compare to the spot in the previous photo?"

EXPLAIN

Explain that riffles are areas where coarse gravel or cobble has gathered. Water depths are shallow. The shallow, uneven bottom causes fast water velocities and turbulent flows. The spaces between the cobbles provide lots of habitat for a variety of aquatic organisms.

SHOW

Show students the next photo (Photograph 4):

ASK

"What do you notice? How is this picture different from the previous photo?"

EXPLAIN

Explain that pools and glides are found where the stream bottom has low or reversed slope. Water depths in the pools are the deepest than anywhere in the reach, and water velocities are low compared to other places in the channel. Glides are like pools, only shallower (two to four feet deep compared to over seven feet deep for pools). Pool bottoms often are covered in sediments since the low energy environment allows them to settle out, whereas glide bottoms are often sand and gravel.

Underwater Features, Local Hydraulic Conditions and Microhabitats

EXPLAIN

There can be localized changes in flow conditions within a reach due to the effects of structures and abrupt channel transitions. Structures such as rocks, gravel bars, woody debris and roots that stick into the channel can cause changes in flow. These form essential microhabitats.

SHOW

Show students this photo as an example of roots and woody debris underwater (Photograph 5):

SHOW

Show students this photo as an example of a boulder cascade underwater (Photograph 6):

SHOW

Show students this photo as an example of a gravel bar underwater (Photograph 7):

EXPLAIN

All of these habitat features affect aquatic life. Anything that affects aquatic habitat, affects aquatic organisms. The health of a stream's aquatic community depends on the habitat characteristics within a reach, which partly depends on the physical features in that reach. The primary biological communities in a stream ecosystem are bacteria, algae/diatoms, macroinvertebrates and fish. The physical features in a stream play an important role in the food web by influencing the spatial and temporal availability of habitat for food, reproduction and predation avoidance.

Food Webs: Fifty percent of the food that fuels a river ecosystem generally comes from outside of the river in the form of leaf litter and other organic debris that falls in or washes into the stream. Streams must have the right features - such as rocks and eddies - to capture this imported food. The other half of the food comes from algae. The microscopic community plays an important role in the ecology of the stream, either through the direct production of food via photosynthesis in the case of algae, or through decomposing organic materials that fall into the stream in the case of bacteria. Algae and diatoms tend to use the hard substrates found in streams. Algal and diatom community richness are vital to other components of the food web such as the benthic macroinvertebrates.

Benthic Macroinvertebrates: Benthic macroinvertebrates are organisms that live on the bottom of streams. ‘Benthic’ means ‘bottom’. ‘Macro’ means ‘big enough to see without magnification’, and ‘invertebrate’ means ‘without a back bone’. Organisms like caddisflies, mayflies, clams and crayfish are benthic macroinvertebrates. This group of animals is very important for stream health and for processing and transforming organic matter into food for other aquatic life. Macroinvertebrates have a variety of lifestyles and feeding modes. *Shredders* decompose large organic particles that fall into streams like leaves and twigs. *Grazers* scrape algae and diatoms from rocks and other substrates. *Collectors* filter fine particles transported from upstream. *Predators* feed on other animals. The more diverse the features of the stream, the more diverse the macroinvertebrate community.

Benthic Macroinvertebrate Diversity: Healthy streams typically have species from several feeding groups and lifestyle modes that inhabit different stream features available within a drainage network. Active filtering collectors, such as clams and several species of mayflies, are found in pools and runs. Passive collectors, such as net spinning caddisflies, are found in riffles. Leaf litter in pools harbor shredders such as amphipods. Shredding stoneflies inhabit leaf packs trapped in riffles and runs. The slow moving water of pools is home to predatory dragonfly larvae, while predatory stoneflies inhabit rifles and runs. Grazers such as snails and many mayfly species exist where there is a hard substrate colonized by algae and diatoms.

Effects of Sedimentation: Sediments fill in the spaces between rocks and pools, which reduces habitat diversity. As the diversity of physical habitat features decreases, the diversity of the macroinvertebrate community decreases. Bottoms composed of fine sediments typically have lower species diversity.

Physical Habitat Characteristics: The physical habitat characteristics that influence the macroinvertebrate community also influence the fish community. A stream that has diverse habitats will likely have a diverse fish community. A stream with little habitat diversity will likely have low fish biodiversity. Different species are adapted to occupy different features in the stream. For example, suckers are well adapted to glean food from soft sediments in pools and runs, while predators like trout and bass use hiding places provided by woody debris and large rocks to ambush prey.

Each feature may be relatively small in size but collectively they influence the stream reach and create a diversity of habitat for a diversity of aquatic organisms. Each individual feature may seem insignificant, but each one is important to the organisms that need it as habitat.

CHARACTER CONNECTION

Events, actions and objects that seem insignificant may have real impacts. We are all connected, human and non-human alike. Your actions that seem insignificant may be very significant to others. Remember the effect people had on hellbenders when they turned over rocks? In what ways are you significant to the people around you? In what ways are you significant to the environment?

SHOW

Show the 30-second video *North Creek Eddy*: https://vimeo.com/157448681

ASK

"What do you notice about this video? Do you wonder how that material is swirling in the water?"

EXPLAIN

Eddies are formed when the main flow is deflected around an obstruction, like a rock. The deflection causes a lower pressure spot on the downstream side of the rock and an area of slack water forms downstream. There is often much less water velocity downstream of the rock than upstream of it. Eddies provide habitat for some organisms.

SHOW

Show the 1-minute video, *Climbers Run Hogsucker*: http://vimeo.com/157448700

ASK

"What do you notice in the video? Do you see that fish vacuuming up sand on the bottom? What do you wonder is happening?"

EXPLAIN

Sand and gravel bars form when sand or gravel accumulate due to water flow. Bars often form in slower water like behind large rocks or on the inside of bends, where water velocities are lower. Bars provide habitat to animals adapted for life on a sandy bottom. For example, hogsuckers vacuum food from sands and gravels.

SHOW

Show the 35-second video, *Passage Creek Bass*: http://vimeo.com/157448687

ASK

"What do you notice about this video? Do you see the fish tail sticking out of the hole in the clay bank? What's going on in that hole?"

EXPLAIN

Clay banks form when the stream cuts down into underlying clay. These clay banks can also provide habitat to a variety of organisms. Crayfish burrow, and fish sometimes carve out homes in them.

SHOW

Show this 4-minute trailer for the movie, *Hidden Rivers*: https://vimeo.com/66103145

ASK

"What do you notice in the video?"

EXPLAIN

Maybe you noticed a lot of different kind of fish. Maybe you noticed a lot of different kinds of habitats. Maybe you noticed both. Generally as habitat becomes more diverse and more complex, the number of species, the biodiversity increases.

CHARACTER CONNECTION

Why is diversity important in human and ecological communities? What happens when diversity is lost? Who and what do we lose? What does the landscape look like? What do human demographics look like? How does the system decline?

Vocabulary: Lesson 4

Reach: the area of a stream you are observing or studying.

Sand bars*:* shifting piles of sand and gravel that accumulate in streams during high water periods. They are often ephemeral, being built up and taken away by changing water flows.

Gravel riffles*:* areas in streams where shallow water flows swiftly over golf ball and smaller sized rocks. These riffles provide important habitat for stream organisms.

Boulder cascades: Areas in streams where water flows over softball and larger sized rocks. Fish and invertebrates inhabit the spaces between the rocks, and these communities of animals tend to contain different species than those communities that develop in gravel riffle habitats.

Woody material: fallen trees and branches in streams contribute to a stream's complexity and create yet another type of habitat that is critical for some stream organisms.

Stream Macroinvertebrate Feeding Strategies: Lesson 4

Shredders decompose large organic particles (> 1 mm) like leaves, flowers, and twigs that fall into streams.

Grazers scrape algae and diatoms from rocks and other substrates.

Collectors filter fine particles (< 1mm) transported from upstream.

Predators feed on other animals.

LESSON 5: AQUATIC DIVERSITY AND FISH BEHAVIOR

OUTCOMES: *Students will*

- Be prepared to identify major fish groups and the microhabitats where they may most likely be found within a stream.
- Be ready to describe the types of fish behaviors (related to obtaining food, shelter, and/or reproductive needs) that might be observed during the freshwater snorkeling trip.
- Be able to discuss why some fish groups may be more or less present than others in a particular area of a stream.

BACKGROUND

This lesson is designed to help students prepare for the aquatic biodiversity and fish behaviors they will observe underwater, once they are in the river. All aquatic animals have the same needs as their terrestrial counterparts: food, shelter, and reproduction. In this lesson we will learn about some of the behaviors that might be observed during a snorkeling trip to a freshwater stream.

SHOW

The Freshwater Snorkeling PowerPoint with embedded videos to demonstrate the beauty of freshwater life and complex feeding, territorial and reproductive behaviors of various underwater species. Explain that our rivers are much more than conduits for water. They contain amazing, intricately interdependent life and these videos give us a glimpse of what can be seen beneath the surface.

http://www.northbayadventure.org/Freshwater Snorkeling Curriculum Lesson.pptx

(Notes: There are presentation notes in the slideshow. Please note that this slideshow may take 15 minutes or longer to download, depending on your internet speed. The file is 1.6 GB, approximately the size of a movie one would download from the internet.)

EXPLAIN

Where animals can be found is most often dictated by physical needs for food, shelter, and reproduction. The major fish families and their habitat preferences are described below:

BASS

Features: Two dorsal fins; forked tail; long slender body
Schooling: Solitary, except striped bass
Habitat: Deep pool, near cover
Feeding: Insects/crayfish/fish

SUCKERS

Features: Single dorsal fin; mouth below snout; lips fleshy
Schooling: White sucker and redhorse always school; hogsucker is solitary
Habitat: Redhorse in water column of deep pool; hogsucker near bottom in glides and riffles
Feeding: Insects sucked from the bottom

MINNOWS

Features: Single dorsal fin; mouth at end of snout; small body lacking spots
Schooling: Always in schools; mixed species
Habitat: Stoneroller and riffle minnow in fast riffles near stream bottom; shiners in glides up in water column

Feeding: Stonerollers and riffle minnows eat insects and algae scraped or sucked off rocks; shiners and chub eat insects and detritus floating in the water

TROUT

Features: Single dorsal fin (plus adipose fin); body streamlined with spots

Schooling: Usually solitary but may occur in loose groups

Habitat: Water column of pools and glides; absent when water temperatures exceed 75 degrees F.

Feeding: Aquatic and terrestrial insects

FRESHWATER MUSSELS

Features: Some mussels have developed sophisticated ways to lure fish, not to eat, but to transport their glochidia, which are early stage larvae in the mussel life cycle. The mussels put out very life-like lures to draw fish in close. The fish grasping at the lure triggers the mussel to release the glochidia, which settle into the fishes' gills and body.

Habitat: Rivers with clean gravel bottoms.

Feeding: Filter feeders. Mussels use two siphons when feeding. Water enters one, (incurrent), and food particles are absorbed in the mussels' digestive systems. The filtered water exits through the second siphon known as the excurrent siphon.

ACTIVITY

Students are divided into five teams, with each team assigned one group of underwater organisms from the list. (Resources for research and extension activities can be found at the end of this lesson, should students and teachers need more information.) Each team should begin by accurately drawing one species from their assigned family. Students should pay particular attention to where their species' eyes and mouth are located, the position and shape of fins, the body shape and color. They should label key features, and add a few fun facts to their poster. After they have drawn and displayed their species somewhere in the classroom, they complete one of the following ideas to learn more about the needs of their group of organisms and then later, to teach their classmates about their species family. In their projects students should include: what the organism feeds on and how, what type of underwater habitat it needs for shelter and reproduction, what qualities makes the family special and unique.

Idea 1
Write a short story that you will read to your classmates about your organism's life. Be creative while making sure your story is factually accurate. Share.

Idea 2
Develop a short fact-based cartoon about a day in the life of your species. Be creative while making sure your cartoon is factually accurate. Share copies with your classmates.

Idea 3
Develop and perform for your classmates a rap that is factually accurate. Share copies of the lyrics with your classmates.

Idea 4
Make a puzzle using the fish picture and key facts. Take it apart so classmates in different groups can put it back together.

Idea 5
Make a 2-minute short video about your species group to share with classmates.

Idea 6
An idea generated by your students!

Ideas contributed by 6th grade boys from Seed School in Baltimore, MD.

Resources

Adobe Spark in the Classroom for multi-media presentations https://spark.adobe.com/edu

Fish Schooling Simulation to Teach Tradeoffs in Animal Behavior:
http://ecoed.esa.org/index.php?P=FullRecord&ID=558

National Forest Service FreshWater Live Resources:
https://freshwaterlive.org/resources/lesson-plans

National Park Service Freshwater Mussel Fact Sheet
https://www.nps.gov/sacn/learn/nature/upload/musselfactsheet.pdf

United States Fish and Wildlife Service. America's Mussels: Silent Sentinels
https://www.fws.gov/midwest/endangered/clams/mussels.html

LESSON 6: SNORKELING ACTIVITY PREPARATION

OUTCOMES: *Students will*

- Be prepared to experience river snorkeling.
- Be prepared to develop a research question through snorkeling.

BACKGROUND

This lesson is designed to help students prepare for their time in the river. We have found that introducing students to their snorkeling adventure before the actual trip makes their time outside much more meaningful. This lesson will prepare students for their snorkeling adventure by showing them what to expect, and by prompting them for a research question that can be answered while snorkeling.

EXPLAIN

Science begins with making observations. Dr. Mary Powers, a river ecologist from UC Berkeley, says that anyone can make scientific discoveries. It just takes someone making observations in a systematic way. Dr. Shigeru Nakano an ecologist from Japan, and Dr. Kurt Fausch, a fish biologist from Colorado, changed how we think about the interactions between stream and forest ecosystems by observing two species of char, (a fish in the same family as trout and salmon) while snorkeling. They also formed bridges between two cultures (Japan and the United States) to establish a community of scientists dedicated to understanding how river ecosystems work and what we can do to protect them. *RiverWebs* is a movie about their work.

SHOW

The 3-minute *RiverWebs* trailer: https://www.youtube.com/watch?v=fs1AZrhhXtw

ASK

"Can you think of a research question related to habitat and biodiversity you can answer by making observations while snorkeling in a river?"

EXPLAIN

We will compare different habitats during your snorkeling adventure. These videos will help prepare you for your snorkeling adventure.

SHOW

The 6.5-minute film, *A Deeper Creek*: https://vimeo.com/103358996
The 2.5-minute film, *CJR & NorthBay Deer Creek Snorkeling:* https://vimeo.com/151201196

EXPLAIN

These videos give you an idea of what your snorkeling expedition will be like. You will explore and experience river life from its perspective. You will view the river from a perspective most people have never seen or understand. You will be getting fully into the river, so bring a bathing suit and a towel! Also, it is very important that you have shoes on your feet that can get wet, and that will stay on your feet, like water shoes. Flip-flops and crocs don't work because they tend to float off. Bring a change of clothes. A private place to change and bathrooms will be available. All snorkeling equipment will be provided.

ASK

"What did the kids in the videos get out of their experiences in freshwater snorkeling?"

SNORKEL DAY

EXPLAIN

You are going to go on an incredible adventure to explore a river underwater. Freshwater snorkeling is an amazing way to observe stream life and better understand the role of biodiversity in aquatic ecosystems. You will likely get into the river twice. The first time is to make observations of the patterns, abundance, diversity and distribution of life in the stream. The second time is to just experience, and become connected to, the stream in an experiential way.

EXPLORE

Once you are in the stream, identify the different habitat features you reviewed in class. Look to see if you can notice any patterns of where different fish species are located. While you are snorkeling, look for benthic macroinvertebrates, in addition to fish. See if you can notice any patterns to where different benthic macroinvertebrates are located. Make observations to provide data to answer your research question. Share your findings with a classmate.

CONTEMPLATE – STREAM SNORKELING

Snorkeling a stream can be inherently contemplative. What we mean by this is when you go into a stream and look underwater, you can settle into the movement of the stream and just watch the life of the stream unfold around you in its environment, on its own terms. As a way to help you get into this contemplative way of observing stream life, be intentional in how you gear up and approach the creek. Put on a snorkel mask and goggles and walk silently to the stream. Before entering the water, take a long slow look at the stream. Pay careful attention to what it does, and how. When finished looking, enter the stream slowly, quietly. Settle down into it as gently as possible and proceed through the following guided observations.

Becoming the Stream

Relax into the water to become the stream. Not part of it, rather, as best as you can make yourself into the stream itself. Merge with it to become a single flowing entity.

Sensory Observations

Next, feel the current moving you, the water surrounding you with light pressure on your skin. Notice the light changing, the colors, the cobbles tumbling, the debris swirling by, fish nibbling on your mask/toes.

Touch a leaf, a cobble, a turtle, a fish.

Listen to underwater sounds. What do you notice?

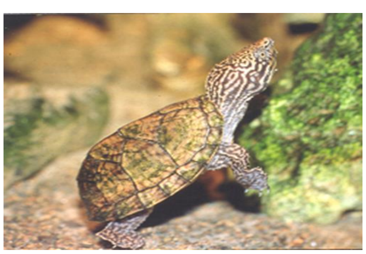
From Another Animal's Perspective

Find an animal to observe. Moving with intention, observe and try to understand life from the animal's perspective, the perspective of an animal living in the stream environment. The following objectives will help you observe animals that make the river their home. They were developed for the Conasauga River on the Cherokee National Forest, so some of the specific kinds of animals may be different from the ones in the stream you are snorkeling.

(Teachers Note: you can place these objectives on small cards with five on each side - so that each participant can have their own or work in groups of two or three. Instruct students to go back into the stream and find each of the objectives. The pictures (answers) and more information are on the pages that follow).

Objective 1.	Observe the tadpoles; catch them if you can.
Objective 2.	Observe the hogsuckers; watch them “vacuum” the stream bottom.
Objective 3.	Observe the large drum and redhorse; listen to them “sing”.
Objective 4.	Observe the tiger-striped Mobile logperch; watch it flip stones with its nose.
Objective 5.	Observe the large schools of stonerollers; watch them scrape algae off rocks.
Objective 6.	Observe a redbreast sunfish; see if it is guarding a nest site.
Objective 7.	Observe a bass; how would you fish for them?
Objective 8.	Observe the minnows while you are facing downstream in a riffle; they may nibble on your fingers.
Objective 9.	Observe a bronze darter; watch it dart from rock to rock.
Objective 10.	Observe a turtle; be careful, they bite hard.

ITEM	IMAGE	SPECIES	LOCATION	COMMENTS
1		Bullfrog Tadpoles	Shallow water; sitting on the bottom; may be clustered	Fairly easy to catch but handle them gently
2		Hogsucker	Shallow water; on bottom; usually alone but may be found with stonerollers	Suck up organic matter from stream bottom
3		Drum & Redhorse Sucker	Largest fish in the area; in deep pools; usually in large schools	They often make a metallic clicking sound ("singing")
4		Mobile Logperch	In slow current or riffles with coarse gravel bottom; usually alone	Feeds by flipping stones over with its nose
5		Stonerollers	Always in riffles; usually in very large schools	Feed by scraping algae off rocks; often "flash" as they turn in the water

ITEM	IMAGE	SPECIES	LOCATION	COMMENTS
6		Redbreast, Longear, and Bluegill Sunfish	Always in calm water; usually near tree branches or boulders	Brightly colored males guard nests which look like bright, gravelly spots on the bottom
7		Spotted, Largemouth, and Redeye Bass	Always in calm, deep water near tree branches or boulders; usually alone	Many young are present; large fish will seek cover when frightened
8		Many species of shiners	In large, mixed species schools in riffles; up in the water column	Face down stream in the riffle and they will swim close to your face
9		Many species of darters; bronze is the most common	Usually in the fastest riffles perched on rocks	When disturbed they will dart from one rock to another
10		Striped Neck Musk Turtle; River Cooter and Snapping Turtle	Calm water; among rocks or in nooks	They all bite

SUMMARIZE

Gather students in a circle. Invite them to share their experiences of snorkeling. What were they surprised by? Delighted with? Inspired by? Frightened of? What will they tell their friends and families about their stream snorkeling experiences?

EXPLAIN

Streams are affected by what we do on land, and more specifically, by how we manage the water that runs off land. Runoff quantity and quality affects the stream channel at the reach level and at the feature level. Changes at the feature level affect the microscopic life that is the foundation of the stream's food web: bacteria, algae and diatoms. The impacts resonate through the system, affecting macroscopic life like benthic macroinvertebrates and fish. We are all connected.

ACTIVITY

Have students identify the favorite aquatic organism they observed while snorkeling. Ask them to write and illustrate an essay from the perspective of that organism. What does the organism need in order to live a healthy life? What are some of the challenges the organism faces? How does the organism overcome them? How does poor water quality affect their organism? What action(s) will the students take to protect their favorite organisms? Invite students to share their essays.

APPENDIX: TURBIDITY

OUTCOMES: *Students will*

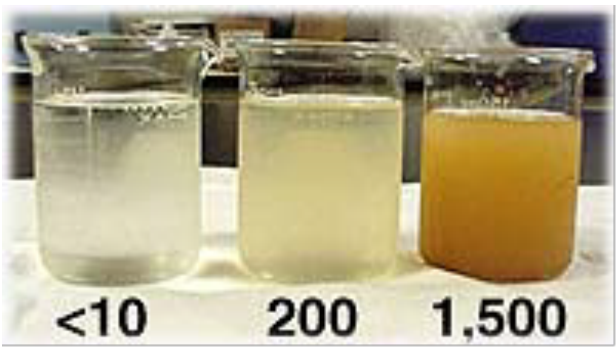
- Understand the water cycle.
- Understand that turbidity causes degraded stream ecosystems.
- Develop a scientific investigation of turbidity around their school.
- Understand how to ask good research questions.
- Understand how to conduct an investigation.
- Conduct short research project that builds knowledge through investigation of different aspects of a topic.
- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners
- Solve problems involving measurement and conversion of measurements.
- Represent and interpret data
- Understand decimal notation for fractions, and compare decimal fractions.

BACKGROUND

Turbidity is a measure of the cloudiness of water. The higher the turbidity, the harder it is to see through the water. Turbidity consists of a number of substances. Mud, silt, sand, small pieces of dead plants, bacteria, aquatic organisms, algae, and chemical precipitates all contribute to turbidity. Turbidity has a number of negative effects on our rivers and streams. Some kinds of fish are less effective at finding food when the water is murky, and muddy water can make it difficult for some fish to get oxygen from the water through their gills. The small particles that make water cloudy eventually settle to the bottom and smother habitat for a number of stream species. Finally, turbidity makes it more difficult to filter and make the water safe for people to drink. Erosion, waste discharge, and urban runoff can add suspended solids to a body of water. Agricultural runoff, in addition to directly increasing suspended solids, can also contribute to the growth of algae. After a storm or flooding, turbidity in surface water generally increases rapidly due to the increase in runoff (Myre and Shaw, 2006).

Turbidity measurements are reported in nephelometric turbidity units (NTU). An average person can begin to see turbidity levels starting at around 5 NTU and greater (Myre and

Shaw, 2006). Lakes that are considered relatively clear in the United States can have a turbidity up to 25 NTU (Nathanson, 2003). If water appears muddy, its turbidity has reached at least 100 NTU. At 2,000 NTU, water is completely opaque (Joyce, 1996). Turbidity tubes can be used to measure turbidity in surface waters (Photograph 8: Sample Turbidities (Howard, 2001):



ENGAGE

Use *Last Dragons* to provide background information on turbidity to students, and to make the issue relevant to students. Discuss how turbidity is measured. Explain that students will design their own experiment about turbidity.

EXPLORE

Guide students through the experimental design process, starting with developing a good research question related to turbidity. Good research questions should be in question form, not be a yes or no answer, be specific to a region or population, ideally will identify the variables to be measured and will discuss the relationship between the variables. Possible research questions include: What areas of our schoolyard produce the most amount of turbidity? How does rainfall amount affect turbidity? Does the turbidity in our local stream change as we move downstream? Does our storm water retention pond reduce turbidity entering the local stream? Have the students develop a sampling scheme appropriate to the question asked, and generate data following the sampling scheme.

Using a Turbidity Tube *(Adapted from Myer and Shaw, 2006)*

Before You Begin:

- Be sure to use a clean bucket or other container to collect water samples.
- Measurements should be taken in daylight, but not direct sunlight. Cast a shadow on the tube by placing yourself between the sun and the tube.
- Do not wear sunglasses when reading the tube.
- If possible, work with a partner to help verify measurements and disk visibility. When measuring, remember highly colored water will register as having a higher turbidity than it actually does.

Measuring Procedure:

1. Dip the container into the water. Be careful not to include sediment from the bottom of the body of water.
2. Rinse the tube with the water that is going to be tested and pour it out.
3. Stir or swirl the water sample in the container vigorously until it is homogenous, introducing as little air as possible.
4. Place your head 10 to 20 centimeters directly over the tube so that you can see the viewing disk while the sample is being poured into the tube.
5. Slowly pour water into the tube. Try not to form bubbles as you pour. *If bubbles do form*, stop pouring and allow any bubbles to rise and the surface of the water to become still.
6. Keep slowly adding water until the pattern on the disc becomes hard to see.
7. Watch the viewing disk closely and add water even more slowly. Stop pouring as soon as the pattern on the disk can no longer be seen. *If you can still see the viewing disk pattern when the tube is full*, record the turbidity value as less than the final measuring mark. (Example: If your tube is full and your highest mark is 5 NTU, write down that the turbidity is "<5 NTU".). Read the turbidity from the scale on the side of the tube. *Remember*: if your turbidity tube does not have turbidity values marked on the tube side, simply measure the water level with a ruler or tape measure and find the corresponding turbidity value in the length to turbidity conversion chart.

Length-to-Turbidity Conversion Chart *(Myre & Shaw, 2006)*
This chart provides the turbidity values (in NTU) that correspond to different lengths measured above the viewing disk. These values can be used to mark the turbidity tube directly or to convert measured values to turbidity units.

Centimeters	NTU (* indicates interpolated or extrapolated values)
6.7	240
7.3*	200*
8.9	150
11.5	100
17.9	50
20.4	40
25.5	30
33.1	21
35.6	19
38.2	17
40.7	15
43.3	14
45.8	13
48.3	12
50.9	11
53.4	10
85.4*	5*

EXPLAIN

Have students evaluate and graphically represent the data in ways that make sense. Use this evaluation to develop a conclusion statement, an inference and a recommendation.

EXTEND

Have students develop and carry out an action plan to reduce the amount of sediments entering our local streams. Evaluate the schoolyard for areas students suspect increase turbidity in the local stream after rains. Sample those locations after rain events using dustpans to collect water running off the site and compare turbidity between sampling locations. This will identify the most serious contributing site to turbidity. Have students develop a plan to install a rain garden or other storm water management practice that will capture runoff from problem sites, thus reducing the sediment load entering the local stream.

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NorthBay

NorthBay is the east coast's premier environmental education and character development program, providing residential and in-school environmental education and character development programs to over 15,000 public school students each school year. The NorthBay mission is to challenge middle school students to realize that their attitudes and actions have a lasting impact on their future, the environment and the people around them by using approved and relevant curriculum, character development, and the outdoors as an integrating context. Please visit us at: www.northbayadventure.org

NATUREWATCH

The U.S. Forest Service NatureWatch Program provides opportunities for nature immersion online, outdoors, and underwater. Check the website for the best information on places to explore, ways to get engaged in citizen science reporting, and what to learn while enjoying what nature has to offer: http://www.fs.fed.us/naturewatch