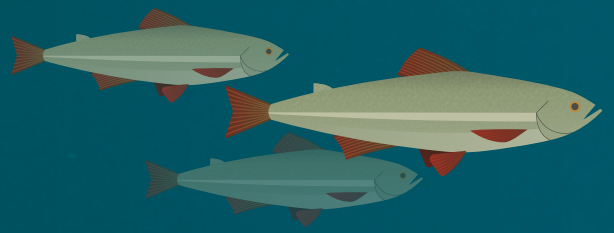
RIVER ALIVE!

Curriculum Guide

Grades: 9-12

Subject Areas: Science, Social Studies, Mathematics, English / Language Arts

CONTENTS



GET TO KNOW YOUR GUIDE

A Brief Introduction

An overview of the River Alive! exhibit and this curriculum guide, and how to get the most out of both.

River Alive!

Welcome!

Welcome to the River Alive! Curriculum Guide. The River Alive! exhibition is part of the Independence Seaport Museum's ongoing efforts to deepen "the appreciation, understanding, and experience of the Philadelphia Region's waterways."

River Alive! features state-of-the-art interactive media and hands-on user directed experiences to bring to life the story of the Delaware River Watershed. Visitors are shown how important the river system has been to the development of the community and the on-going and extensive efforts required to repair it. The immersive experience brings the public closer than ever to the river with exhibits designed to elicit curiosity and appreciation. The exhibit highlights the interaction between people and the river, emphasizing the call to action for protection, restoration efforts, and the difference individuals can make.

River Alive! offers multiple pathways for discovery for all museum visitors and will be especially beneficial to school-aged students and their teachers by providing experiences that teachers can use to build on in the classroom. Through 17 exciting exhibit components, students can freely explore and discover the wonders of the watershed while learning about their own impacts on and relationship to the water. River Alive! cultivates a sense of wonder and a sense of responsibility for the river that runs through our cites, towns and bodies!

Getting Started

Purpose

The purpose of this curriculum guide is to deepen and enhance the student experience and impact of River Alive! through a series of creative activities. This curriculum is designed as a collection of thematic units to guide students through the entire watershed from mountain to coast, diving into each land-use area and unique ecosystem while emphasizing the overall interconnectivity of the whole system. It encompasses different subject areas and is appropriate for a variety of diverse education settings. Basic concepts are introduced for each unit that can be further explored during, before, and/or after a museum visit. The Guide creates connections between the unit lessons with specific exhibits within the exhibition to reinforce primary messaging independent of the order in which the Guide and River Alive! Exhibition are experienced.

The Guide offers an opportunity to inform and/or expand on and deepen understanding of both scientific themes and ideas explored within the exhibition as well as the collective human impact on a vital resource. While implementation of this curriculum is ideally paired with a visit to the exhibit, this resource has been created to also stand alone as an informal educational asset focused on the scientific processes and restoration strategies of a watershed. The information, localized to the Delaware River watershed, supports understanding and empathy in a global context.

Structure

The units are divided by the unique ecosystems along the path of the watershed, starting at the top of the watershed in the mountains and ending at the coast. Each unit connects to create an overarching view of the watershed and reiterating the interconnected nature of the system as a whole. Located in the appendices, each unit additionally has: background information, vocabulary lists, discussion questions, extensions and variations, and a Water Play Activity.

The main activity in the unit facilitates collaborative discussions, incorporates digital and interactive media, and fosters creativity and critical thinking. Three common themes run throughout each unit: cycles of the ecosystems, diversity of living things, and conservation. The repetition of themes highlights the overarching theme of interconnectivity within the ecosystem and with human life. These elements are embedded in the curriculum and come to life through the activities.

In each unit, there will be several “Exhibition Connections” call-outs. This information will help identify areas to make direct connections between the lessons. These connections will help solidify students' understanding of the content at the exhibit or in the classroom.

Finally, each unit contains a Water Play activity, an activity that combines the lessons with the exhibition at the Seaport Museum. These art components come together to form a mobile made of 6 layers, each focused on one of the watershed habitats of the 6 units in this guide. Much like the watershed, the success of the final mobile depends on the stability of each previous layer. Water Play challenges students to think abstractly about the concepts they learn and translate them into a creative installation that students build together.

Users

This curriculum guide can be used by teachers, parents, facilitators, homeschool programs, after- and out-of-school programs, etc. The River Alive! Curriculum Guide is meant for use in both formal and informal education settings.

National Standards Addressed

Common Core Standards
Next Generation Science Standards

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A project by Habithèque with Rosalie Schlenk and Handymakes Studio.

Work Plan

Unit 1 Hello Beautiful Watershed

Lesson 1: **Water is Life** - *1 hour*

The water cycle and water in a global context

Lesson 2: **What is Our Watershed?** - *1 hour*

Watersheds and the Delaware River Watershed habitats

Lesson 3: **We Go Together** - *1 hour*

Watersheds + the water cycle, endangered species

Unit 2 Mountains + Rain = Our Inventory

Lesson: **Let It Soak In** - *1 hour*

Infiltration, percolation, and well water

Unit 3 Beyond Your Wildest Watershed

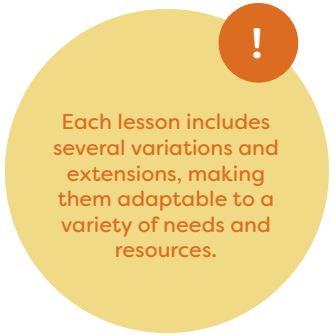
Lesson: **Into the Wild** - *1 hour*

Parts of a river, food webs, and species diversity

Unit 4 River Meets Humans In The Heart of the Watershed

Lesson: **Something In The Water** - *45 minutes*

Importance of agriculture, environmental impact of agriculture, and riparian buffers



Unit 5 Our Urban World Disrupts the River We Need

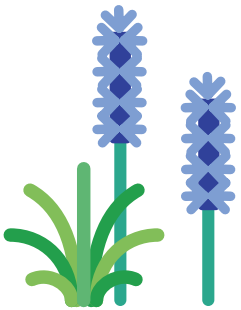
Lesson: **Pollution You Can't Point At** - *1 hour*

Urban impervious, water treatment, and urban water cycle

Unit 6 Fresh Water Joins Salt, An Amazing World Filled With Life

Lesson: **All Paths Lead Here** - *1 hour*

Filtration, scientific indicators of habitat health, and nature-based restoration and preservation



About The Exhibit

1 **River Continuum Wall** - The dynamic 32' long canvas is never the same twice and can be completed with one person or five people playing. As inputs accumulate, brief explanations of the specific threats to water quality and unique strategies for conservation and revitalization in each of the land use areas are revealed and encourage the player to keep going. The wall is "complete" once the players reach a healthy level of biodiversity of land, sky and water.

2 **Rate the Risk to the River** - Rate the Risk to the River is a user generated sculpture that is constantly changing over time. Visitors are asked to consider three simple environmental risks and vote on what concerns them most by placing a peg near their answer. They are able to move pegs between risks, constantly changing the sculpture to reflect the expression of the collective opinion of museum guests in real time.

3 **Watershed Scapes Exploration Wall** - Watershed Scapes Exploration Wall is a long, eye-catching graphic that visually expresses five separate “scapes” that flow together to create the complexity of the Delaware River Watershed. These scapes (Mountain, Wilderness, Farmland, Sub/Urban, Bay/Coastal Plain) define the units outlined in this guide. Visitors see three levels of information for each scape that gives a glimpse into the life and importance of each scape environment, as well as history, industry, and preservation / revitalization challenges and successes.

4 **Nature’s Highway Theater -** Nature’s Highway Theater & Soundscape is an interactive role-playing opportunity that invites visitors to collaborate to tell stories of the river and the animals, plants, and human industries that rely on it. The stage is set with three distinct layers of the watershed as pathways for movement above, along and within the river — sky, land and water. Playful river character costumes are displayed on the adjoining wall for visitors to step into the “shoes” of our “river characters” and then move through one of three river paths to be immersed and part of the river highway scene. A storytelling “narration station” with triggered soundscapes of Evening, Pollution, Rain, Turbidity, a Normal Day, Drought and Spawning activate the set and bring the experience to life.

5 **River Window Installation** - This experience will connect the visitor to the river with an acrylic site-specific art installation that visually interprets the natural forms of water. Four benches are positioned beneath Holosonic speakers to deliver four different audio vignettes that offer voices from the river. Only by sitting on the bench will visitors discover and hear the voices and soundscapes of the river that explore themes incorporated throughout the exhibit.

6 **Water Cycle Puzzle** - The Water Cycle Puzzle is an interactive exploration of the often elusive concept that elicits understanding through gamification. Visitors identify and place key points along the water cycle representing the 12 steps of the Water Use Cycle (a system that mimics the natural water cycle of our world). When all pieces are in the right place, embedded LEDs flash to indicate success. The Puzzle highlights the interconnectivity of the entire system and incorporates human impact on the natural processes through the urban water use cycle.

7 **Plankton Bloom Table** - The Plankton Bloom Table provides an opportunity for the visitor to explore the magnificence and variety of some of our smallest river characters. Visitors work at a round table with a central supply bin to cut out pre-printed plankton shapes from colored, translucent vinyl sheets. They then position their plankton cutouts on a light table to create colorful “blooms” of phytoplankton, zooplankton and diatoms that flow with the water (digital water). By playing with the shapes and layering the different colors, they create an ever-evolving planktonic painting that reveals the often hidden beauty of the microscopic world.

8 **Watershed Theater** - In this sensory and contemplative experience, a group of visitors enter an intimate space in which an immersive video that explores the watershed is presented on a video wall. The visual imagery of this theater space will take visitors out into the watershed, providing them with a bird’s-eye perspective of the diverse landscape. vA poem written in the perspective of the river and soundscape will add a voice to the moving imagery, giving the visitor—especially our urban visitors—a taste of the watershed in its wild state. This intimate space offers a meditative, quiet space for reflection—inviting visitors to relax, enjoy the moment, and share in it together.

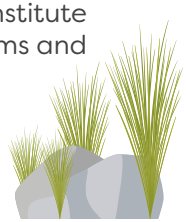
About The Exhibit Cont.

9 **Watershed Map** - The Watershed Map is a visual display of the entire Delaware River Watershed as a contiguous whole contextualized within the geography of the northeast. Visitors are shown a wide range of content about the watershed systems, and our role in it. Two mounted tablets let visitors explore five different "Watershed Trails," each offering a different lens through which to look at the watershed: land, life, history, healing and the nature of water. Visitors are encouraged to leave their own mark by writing a post-it to place anywhere on the map wall.

10 **Currents: Partners & Projects Station** - The Currents exhibit is a sit-down personality quiz. Visitors find their watershed match by answering a simple set of questions. Once a watershed match is made, the visitor is connected to watershed partners based on their own specific interests Printed post-card take-aways with web addresses and other resources are provided to connect with partner organizations after leaving the exhibit.

11 **Watershed 3D Modeling Table** - With the Watershed 3D Modeling Table, visitors are able to design waterways, interrupt and direct the flow of water, and compare how permeable and non-permeable surfaces change the waterscape of the 10' long watershed table with constantly flowing water. At this station, visitors explore the ways humans alter the course of water for development, industry and use. There is a great potential for groups to work together to impact the flow of water in specific ways to create specific outcomes.

12 **Watershed Artifacts** - Watershed Artifacts creates an investigative area where visitors can sit and examine a series of artifacts with simple viewing devices. Future programs will invite visitors to observe and draw the artifacts. And future partnerships with the Academy of Natural Sciences of Drexel University and the Wagner Free Institute of Science will expand on this experience with special programs and presentations off-site and within the River Alive exhibition.



13 **Watershed Data Visualization** - The Wetland Data Visualization is an interactive multimedia station that creates a connection between the abstract concept of "water sensor data gathering" and the revitalization efforts underway throughout the watershed by scientists working in the region and beyond. Visitors will explore three land-use areas including Headwater Non-Tidal River, Tidal Freshwater and Estuary. This component will help visitors better understand the current and ever-changing status of the watershed by exploring why scientists monitor salinity, oxygen and water bugs. The exhibit activities highlight the real threats to the health of freshwater systems and how scientists use collected data over time to strategize preservation and revitalization approaches.

14 **Citizen Science Lab (with Water Quality Testing & "Watershed Wellness" Data Visualization Station)** - The Citizen Science Lab acts as both a staffed demonstration and experimentation area, and a counter where visitors can measure water quality factors on their own and input the data in an ongoing "citizen science" experiment. A rolling Water Sensor Experiment Cart can be pulled out of the lab and taken outside onto the boardwalk or elsewhere in the museum. Visitors will also have the opportunity to connect this interactive experience with the major themes of the exhibition through science-based public programming and by looking through a microscope.

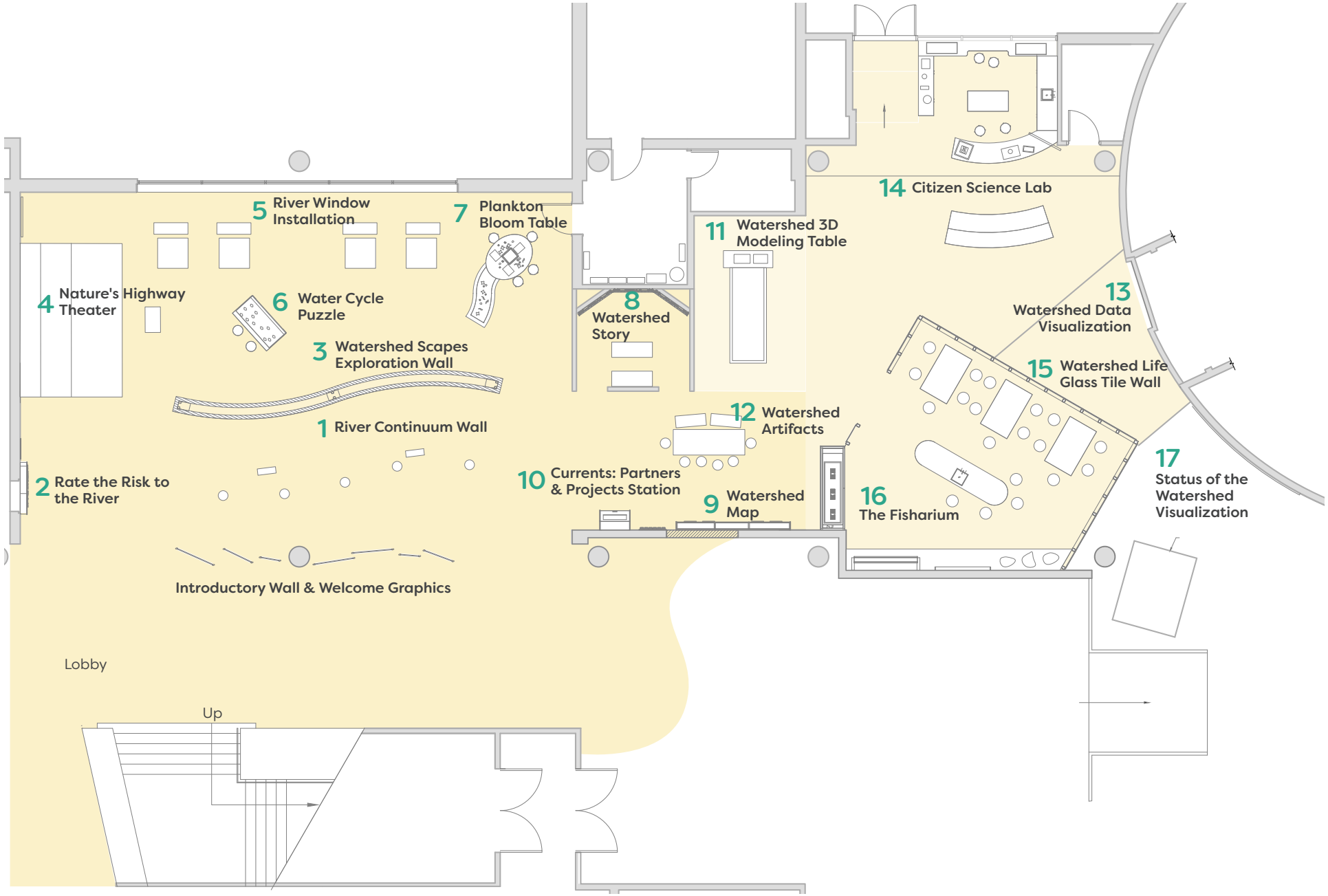
15 **Watershed Life Glass Tile Wall and Rubbing Experience** - The Watershed Life Glass Tile Wall submerges visitors in an underwater experience of the Delaware River, providing a magnified view of the river's native ecological system. Sandblasted on the glass surface are different components of life in the river: native wetland plants, fish hiding among their roots, micro-crustaceans and microorganisms in a harmonious whirlwind. The panels have a deeply sandblasted surface, allowing visitors to create their own rubbings and drawings to take home to remember the extraordinary architecture of these creatures. There will be bins mounted to the wall stocked with paper and pencils for visitors to use to make rubbings.

About The Exhibit Cont.

16 **The Fisharium Classroom** - The Fisharium is a distinctive classroom and lab space that will be open to the public or closed for special programs and presentations. It is themed around fish and floating wetlands as essential to freshwater habitats, and important filtering systems and nurseries for the river's youngest members. This space is alive with programming, presentations, demonstrations, horticulture and live tanks that show how aquatic vegetation, fish and other river species each have an important part to play in the dynamic freshwater river system.

17 **Status of the Watershed Visualization** - As visitors leave, they will see a large wall graphic that shows a variety of statistics about biological and conservation topics related to the watershed and Delaware River. The graphic data visualizations will show powerful comparisons, such as the amount of natural space being preserved versus the amount being developed. These comparisons create a strong message of how much work has been completed, as well as highlighting the vital work that still needs to be done to protect and revitalize the watershed.

Exhibit Map


1 River Continuum Wall
2 Rate the Risk to the River
3 Watershed Scapes Exploration Wall
4 Nature's Highway Theater
5 River Window Installation
6 Water Cycle Puzzle
7 Plankton Bloom Table
8 Watershed Story
9 Watershed Map
10 Currents: Partners & Projects Station
11 Watershed 3D Modeling Table
12 Watershed Artifacts
13 Watershed Data Visualization
14 Citizen Science Lab
15 Watershed Life Glass Tile Wall
16 The Fisharium
17 Status of the Watershed Visualization
Introductory Wall & Welcome Graphics
Lobby
Up

HELLO BEAUTIFUL WATERSHED

Unit 1

An exciting introduction to the water cycle, watersheds, and our relationship to both.

Unit 1 - Overview

Bird's-Eye View

This unit is designed to jump start critical thinking about water. Students will understand water as both a simple necessity of everyday life and a complex resource spanning space and time. Introducing new perspectives around the processes involving water will lead to thoughtful connections across lessons and for the rest of the curriculum guide.

Key Objectives

Hello Beautiful Watershed introduces basic concepts surrounding water while also encouraging students to dive deeper and explore the nuances of this precious resource. The lessons in this unit will have students:

- Compare experiences with water in a global context
- Define the stages of the natural water cycle
- Identify how the urban water cycle mimics a natural system to meet the needs of people
- Identify the state of water in each phase of the cycle
- Explore the different ways water moves through the environment
- Define a watershed and its characteristics
- Identify the 5 major habitats along the Delaware River Watershed
- Connect aspects of the water cycle to different watershed habitats
- Identify key wildlife in each of the watersheds, noting areas of overlap
- Explain the impact of humans in these habitats

Guiding Questions

- What is the value of water?
- Where does water come from?
- What do we use water for?
- What drives the water cycle?
- What phases can water be found in during the cycle?
- How does water move through the earth?
- What's in a watershed?
- What is the interaction between the natural water cycle and the watershed?
- How does the river change from mountains to the coastal areas?
- What role do people play in watershed habitats?
- How can we be better understand watershed inhabitants?

Curriculum Connections

Next Generation Science Standards (NGSS): National

HS-LS1-5 From Molecules to Organisms: Structures and Processes

- Students discover that photosynthesis transforms light energy into stored chemical energy, along with a release of oxygen.

HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

- Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.

HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

- Students explore evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Unit 1 - Overview (cont.)

Curriculum Connections (cont.)

HS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics
- Students investigate the cycling of matter and flow of energy in aerobic and anaerobic conditions in a habitat.

HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics
- Students discover the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics
- Students evaluate the evidence about complex interactions in ecosystem that maintain organism populations in stable conditions, and how the ecosystem alters with changing conditions.

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics
- Students investigate the possibilities and effectiveness of methods to reduce the impacts of human activities on the environment and biodiversity.

HS-LS4-5 Biological Evolution: Unity and Diversity
- Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.

HS-LS4-6 Biological Evolution: Unity and Diversity
- Students discover solutions to mitigate adverse impacts of human activity on biodiversity.

HS-ESS2-5 Earth's Systems
- Students explore the properties of water and its effects on Earth materials and surface processes.

HS-ESS3-3 Earth and Human Activity
- Students discover relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-4 Earth and Human Activity
- Students evaluate solutions that reduce the impact of human activities on natural systems.

Pennsylvania State Standards/Common Core

3.1.12.A1
- Students explore the ways organisms must derive energy from their environment or their food in order to survive.

3.3.10.A5
- Students explore the processes of the hydrologic cycle.

4.1.10.A
- Students evaluate possible causes of population fluctuations, the idea of "carrying capacity" in an ecosystem, and how different factors threaten organism survival.

4.1.12.A
- Students analyze the significance of biological diversity in an ecosystem, causes of biodiversity loss, and management laws meant to effect biodiversity.

4.1.10.B
- Students explore the consequences of interrupting natural cycles.

Unit 1 - Overview (cont.)

Curriculum Connections (cont.)

4.1.12.B
– Students consider solutions to problems caused by interrupting natural cycles.

4.1.10.C
– Students discover how energy is converted from one form to another as it moves within a food web.

4.1.12.C
– Students explore human impacts from industrial, agricultural, and commercial enterprises on energy flow and the health of an ecosystem.

4.1.12.D
– Students analyze the effects of new and emerging technologies on biodiversity within an ecosystem.

4.1.12.E
– Students consider solutions that address human impacts on ecosystems over time.

4.2.10.A
– Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.

4.2.12.A
– Students examine the ways laws and regulations regarding land use management impact on the water quality and flow within a watershed.

4.2.10.B
– Students examine how human interactions like land use impact wetlands and their surrounding environments.

4.2.12.B
– Students consider the effects of policies and regulations on wetlands and their surrounding environments.

4.2.10.C
– Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.

4.2.12.C
– Students investigate the effects of policies and regulations on water quality.

4.3.10.B
– Students explore the environmental consequences of human extraction and use of natural resources (e.g., mining).

4.2.12.C
– Students investigate data and ways that point and non-point source pollution can be detected and eliminated.

Unit 1 - Lesson 1: Water Is Life

Introduction

The water cycle is a self-sustaining, closed loop process encompassing 12 stages, providing us with the safe, clean water for our daily use. Human activities have impacted the water cycle to establish new stages, part of the water use cycle. In order to maintain the finite amount of water in this system, we must realize our influence and act responsibly.

Every living thing relies on water to survive each day, yet water is a finite resource. How is there enough water to go around? How is human water use different?

Teacher Prep

- Print the water card set, enough so each student will have 1 card
- Queue up videos on projector
    - Why Care About Water?
      Video - 3 minutes
    - River Water Harvesting in Ethiopia
      Video - 1 minute
    - Our Water Cycle
      Video - 2 minutes
    - CoCoRaHS Water Cycle
      Video - 7 minutes
- Gather sticky notes, 3 colors for each group
- Make sure there is enough blackboard space, flat wall space, or large sticky pad easel sheets for students to work on
- Sharpies for each group

Procedure

1. Introduce the first activity by telling the class they are going to work together to solve a mystery. Explain that they will each be given a clue that will help them find the answer. Distribute the Water Mystery Cards to class. Each card has part of a phrase describing a quality of water without using the word.

2. Have students read their own card at first and try to determine what "it" is on their own. After a minute, let students talk with each other to figure out what the cards are talking about. At this time, students can also identify their card's match, completing the phrase.

3. Once the class has reached the solution, play the National Geographic video and the Water.org video:

    - Why Care About Water?
    - River Water Harvesting in Ethiopia

4. In small groups or as a class, have students discuss their reactions to these videos. What connections can they make with their mystery cards? How did it change their perception of water? Did they realize the role water played in their own lives? How does that differ from other people's

Unit 1 - Lesson 1: Water Is Life (cont.)

experience? Ask students to step outside their comfort zones and think about the global context of water and how it connects all living things.

5 Show the first water cycle video, introducing the basics. Tell students to pay special attention to how humans are involved.

— Our Water Cycle

6 Break up the students into small groups. Each group should have 3 colors of post-its, sharpies, and wall / board space or a large sticky sheet. Have students work in their groups to create a visual diagram of the water cycle using the post-its. The different colors should represent the different phases of water in different stages (ex. Yellow for liquid, blue for vapor, etc.). Students can use labels, but encourage them to illustrate the stages to portray what's going on. Have students arrange the diagram on the board or sticky sheet, drawing arrows between the stages. If working on a wall, use additional post-its to draw connections. When students have completed their diagrams, regroup for the next video.

7 Play second video for students. This video gives more detail to the forces that drive the cycle.

— CoCoRaHS Water Cycle

8 Have students add to their diagrams with the new information from the CoCoRaHS video. What new stages should be added? Where in the cycle do they go? Prompt students to discuss in their groups all of the different ways water moves through the earth in the water cycle. Have students write down as many of the different routes through the water cycle as they can.

9 Let students walk around the class and see each other's diagrams before regrouping to discuss the diagrams and the videos. Have students describe each of the 12 stages of the water cycle and how they interact with one another. What were the differences between the two videos? Record all of the students' tracked paths through the water cycle on the board. Why does water take any one of the paths over another? What other factors are at play? Have students discuss the driving forces behind each component of the water cycle.

Unit 1 - Lesson 1: Water Is Life (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

River Continuum Wall

- Why do we need to focus on the whole river, and not just one part, when it comes to cleanup?
- If water keeps cycling, where does it go once it flows to the bay?
- What happens to this continuum if we pollute the river, or interrupt the cycle to use more than “our share” of the water?

Watershed Scapes Exploration Wall

- How does our river affect water in other regions? What’s the connection?
- If water keeps cycling, where does it go once it flows to the bay?
- If you could choose a river habitat, where would you want to live? Why?

Water Cycle Puzzle

- Where does the water end up?
- In regions that aren’t as urbanized as ours, what do you think the water cycle looks like?
- When it comes to the urban water cycle, where do you think we could have the most impact in helping our river stay clean?

Watershed Map

- How much of the water on our planet is available fresh water for living creatures, including us?
- What does it mean for us when we say, "The amount of water on Earth doesn't change"?
- If our freshwater resources are so limited, how do we make good decisions about water use globally? What's fair?

Unit 1 - Lesson 2: What is Our Watershed?

Introduction

Now that the students understand the water cycle, we are going to move on to the watershed, a vast and expansive system. Watersheds are, at their simplest, a container, creating a path for all the water in a certain region as it moves through the water cycle. We will examine the distinct profiles of watersheds, exploring the relationship between water and land.

We all live in watersheds and make up the vibrant ecosystems along the river, but what exactly is a watershed? Why are they so important?

Teacher Prep

- Queue up videos
  - What is a Watershed?
    Video - 1 minute
  - CoCoRaHS Watersheds!
    Video - 5 minutes
- Print out Watershed Maps for students
- Project large watershed map or large printout at the front of the class

Procedure

1. Ask students to take a moment to think about what a “watershed” is. Have students share their definitions with the class, noting differences in what students include in the scope of their definition. Work together to form a collective definition. Write this on the board to reference after the video. Have students generate a list of questions about watersheds. What is in a watershed? How are they formed? What do they do?

2. Play “What is a Watershed” for students. Tell them to pay attention to what constrains certain areas of particular watersheds.

   - What is a Watershed?

3. After watching the video, have a discussion to develop a refined definition of the watershed. Write the revised definition on the board. Discuss the implications of a watershed crossing a political border, as the video mentions. What does that mean for the watershed? For the people living inside that watershed?

Unit 1 - Lesson 2: What is Our Watershed? (cont.)

4 Next, tell students they are going to explore the watershed they live in. You will need to project the Watershed Map, or produce a large classroom copy of the chart. Each student should also have a copy of the chart with blanks. Note that our watershed crosses state borders. Discuss the map with the students to identify what states are in the Delaware River watershed. How might the states manage the watershed?

5 Next play CoCoRaHS Watersheds video for students. This video gives more detailed information about watersheds and introduces the influences of topography on a watershed.

— CoCoRaHS Watersheds!

6 Have students note the watershed divide on their own maps, outlining the edge of the Delaware River Watershed. Discuss the contour lines shown on the maps. What do they mean? How might their patterns reflect the movement of water in the watershed? Have students consider the topography lines in relationship to the shape of the watershed as well as the state lines. Do the state lines work with the topographic lines?

7 Now we are going to look more closely at the habitats along the river in our watershed. Tell students they are going to play a game to finish the maps and discover the habitats. Hand out the first clue card to a student and have them read the background information aloud, one line at a time. After each line give the students time to think about the answer before continuing to the next line. When a student guesses the correct habitat, continue reading the remaining sentences on the card. On their individual maps, students should label the habitats. Repeat for each of the 5 habitats.

8 As you go through the habitats, or at the end, discuss the relationship of elevation and habitat using clues from the topography lines. Ask students to identify significant changes in grade, and how they relate to each habitat.

9 Review the maps together, noting the sequence of the habitats along the river. Discuss the changes in habitat from one section to the next, down the river. Note a gradual change, and the starker contrast between the coastal area and the mountain top.

Unit 1 - Lesson 2: What is Our Watershed? (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

River Continuum Wall

- What relationship between elevation, water flow, and habitat do you see here?
- Name the habitats that you see here. How are they connected?
- Why do the river habitats vary so much from mountain to sea?

Watershed Scapes Exploration Wall

- How are mountains connected to a seashore hundreds of miles away?
- What relationship between elevation, water flow, and habitat do you see here? Describe how this watershed works.
- If you could choose to live in a particular watershed habitat, which one would you choose?

Watershed Theater

- What kinds of habitats can you discover in our watershed?
- Why are there so many different habitats in the watershed? How and why do they form?
- Are there sights and sounds in our watershed that mean something special to you, or spark a particular memory?

Watershed Map

- What are some ways we're protecting both land and water to keep the watershed functioning?
- When did our watershed first take the shape we know today?
- Why does mountain coal mining matter to the Delaware Bay?

Watershed 3D Modeling Table

- Experiment with the different pieces. What happens to the water?
- How do landmasses shape the flow of water—direct it, block it, etc.?
- What's the relationship between the water cycle and permeability?

Unit 1 - Lesson 3: We Go Together

Introduction

The water cycle and watersheds are intertwined. Their interactions sustain and facilitate one another. We will examine the details of this relationship and specifically the health of the watershed. Humans are a part of the habitats in the watershed, and our actions all play a role in the health and stability of the natural processes we rely on.

Humans have a profound and lasting impact on the watersheds we live in and depend on. We have the power to hurt or help these environments. How can we act as stewards for the river we rely on?

Teacher Prep

- Queue videos
  - Nature Works - To Make Clean Water
    Video - 4 minutes
  - A Watershed Moment
    Video - 12 minutes
  - Our Water Quality
    Video - 1 minute
- Print out the Build a Watershed pieces, enough for class
- Posters for habitat diagrams
- Provide or make sure students bring scissors, colored pencils, and glue
- Ensure access to the internet for research, through computers or phones as needed

Procedure

1. Start with a review of information from previous lessons. Have students describe the water cycle, the watershed, and the different habitats that are in a watershed. Students might already be thinking about how all of these elements are related.

2. Play the Nature Conservancy's video about clean water.
   - Nature Works - To Make Clean Water

3. Return to the conversation about the water cycle and watersheds. How do they support one another? Primarily, focus on watersheds as nature's perfect filtration systems. What does this mean for the health of a watershed?

4. Introduce the assignment: Students will be assigned a watershed habitat along with an endangered river animal. They will research to gain an understanding of how that habitat is suited to the needs for the animal (food, water, shelter, etc.), as well as what changed to cause them to be endangered. They will work in groups to create their own diagram of the habitat. The visual representations should show their animal's habitat, especially the elements relating specifically

Unit 1 - Lesson 3: We Go Together (cont.)

to their river character. For example, a coastal habitat and a heron should show both a shallow stream where they feed and the shrubby growth where they nest.

5 Students can use the provided graphics, but should be encouraged to include additional details by creating their own pieces. Students will give a short presentation about their animal and habitat. Presentations should explain the ecology, interrelationships and importance of their habitat. Specific questions to answer: What are the characteristics of this habitat? What makes this habitat uniquely suited for their animal? Why is their animal endangered? Why is it important to preserve or restore this habitat?

6 Hand out the printed watershed habitat graphics, identifying a specific animal that lives in or near the river (wood duck, heron, bullfrog, etc.) Students can research their animal and habitat using print or electronic resources.

7 Each student (or small group) will give their short presentation, which includes their habitat diagram and educates the other students about the animal that they researched. Allow students to ask questions after each presentation.

8 Play A Watershed Moment and Our Water Quality. These videos outline the human related dangers and threats to the watershed as well as how local efforts have improved water quality.

— A Watershed Moment
— Our Water Quality

9 Discuss the video with students. Have them share their reactions to the human impact on the watershed. How do the habitats help the watershed? What dangers are they in? What behaviors might we change to help the watershed?

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

River Continuum Wall

- What's our role in the river continuum?
- What happens to this continuum if we pollute the river, or interrupt the cycle to use more than "our share"?
- What are some ways to restore river health for all living beings?

Watershed Map

- Given limited fresh water, how do we make good decisions about water use locally? Globally?
- What are some ways we're protecting both land and water to keep the watershed functioning?
- What are some threats to watershed animals and their habitats?

Water Cycle Puzzle

- What's a consequence for humans when we interrupt nature's water cycle?
- Where could we make changes to work with nature better and have a more positive impact on the water cycle?
- What could you do in your everyday life to work with nature's water cycle?

Watershed Data Visualization

- What happens to water chemistry when we impact the water cycle?
- What are some ways we're using to repair damage to the system?

RIVER ALIVE! Scavenger Hunt: Unit 1

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits.
Carefully explore each stop to fill in the answer to the prompts, and discover even more about our watershed.

☐ River Continuum Wall

What's going on in the river? When we don't take care of our watershed, our wildlife suffers. Work together with your classmates to activate all of the input stations. **How did your station change the continuum wall?**

☐ Water Cycle Puzzle

Solve the puzzle to see how water moves through our watershed. **Which 5 stages are directly caused by human activity (the Urban Water Cycle)?**

☐ Watershed Theater

Take time to experience this entire short film, immersing you in the sights and sounds of the watershed. **Who is telling this story?**

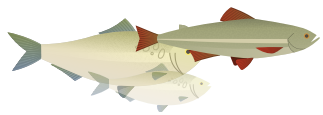
What happens when the land flattens out, and soil and dirt turn into sand and rocks?

☐ River Window Installation

Take a moment to reflect at the River Window Installation. Try sitting on each of the benches and see what secret sounds you discover. **Get up close to the window and draw your favorite water part(s) or pattern(s):**

☐ Watershed 3D Modeling Table

Human activity has a huge impact on the speed and direction of the river. Experiment with some of the objects here to create a flow that twists and speeds up. **Sketch and label the pieces that make up your model. What is the water doing at different points?**



Unit 1 - Wrapping Up

Debrief

By now your students should have a firm understanding of what the water cycle and watershed are all about. Also important, they have been made to consider their own place in the watershed, and think critically about the impact humans in general have on these systems. These concepts are ingrained in the RiverAlive Exhibit, and visiting the exhibit in conjunction with these lesson will create a stronger understanding of our watershed and river.

In the following units we will go deeper into some of the concepts introduced here. We will investigate factors that affect the water cycle in each habitat, like erosion, agriculture, pollution, and the urban environment. By traveling through the watershed, students will discover the wonders of nature, question their responsibility for human impact, and learn how they can work to preserve the health of their watershed!

Additional Resources

Delaware River Basin Interactive Watershed Map
Website - Interactive map showing threats to the watershed due to a variety of pollutants

EPA - How's My Waterway?
Website - Tool to find the health of a local streams, lakes, and other waters and what is being done

How Stuff Works - How Watersheds Work?
Article - Dives into the ins and outs of a watershed

NOAA - Watersheds, Flooding, & Pollution
Website - Multimedia resources and real-world data about watersheds

Philadelphia Water Department Watershed Locater
Website - Provides specific watershed by address within Philadelphia city limits

USGS - Science In Your Watershed
Website - Interactive map of all watersheds in the United States

USGS - Water Cycle Summary
Website - In-depth walk through the water cycle with additional links to concepts

Water Conflict Chronology
Website - A list and interactive map of national and global water conflicts from ancient times to today

MOUNTAINS PLUS RAIN EQUAL OUR INVENTORY

Unit 2

We start our journey along the Delaware River at the top of the mountain.

Unit 2 - Overview

Bird's-Eye View

First things first! This unit explores the first habitat located along the Delaware River: the mountains. The mountainscape plays a very important role in the watershed and the replenishing of our water sources. Students will dig into the details of the processes that give us water and keep the mountainscape healthy.

Key Objectives

Mountains + Rain = our inventory. This lesson explains the meaning of the unit title, each one building on the last to paint a picture of how water moves through the mountainscape to replenish our resources. In these lessons, students will:

- Explain the importance of source waters to the rest of the watershed
- Model an aquifer with different soil types
- Describe the difference between infiltration and percolation
- Explain factors that influence infiltration and percolation
- Understand conditions that cause runoff
- Explain the need for both infiltration and runoff
- Define an aquifer
- Explain their role and how they are refilled
- Describe how human activity affects aquifers
- Define erosion and identify the factors that contribute to it
- Understand the relationship between topography and runoff

Guiding Questions

- Where does the Delaware River begin?
- How does the river start?
- Why are headwaters so important?
- How does water move through the earth?
- Where is the water going?
- How does the watershed clean our water?
- How does human activity affect aquifers?
- What's the relationship between runoff and topography?
- Between topography, soil particle size, rate of precipitation, and runoff?
- What causes flooding?
- How does the water cycle change the shape of the earth?
- What clues do we see today that tell us how much the earth has changed?

Curriculum Connections

Next Generation Science Standards (NGSS): National

HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

- Students discover the cycling of matter and flow of energy among organisms in an ecosystem.

HS-ESS2-5 Earth's Systems

- Students explore the properties of water and its effects on Earth materials and surface processes.

Unit 2 - Overview (cont.)

Curriculum Connections (cont.)

Pennsylvania State Standards/Common Core

3.3.10.A5

– Students explore the processes of the hydrologic cycle.

4.2.10.A

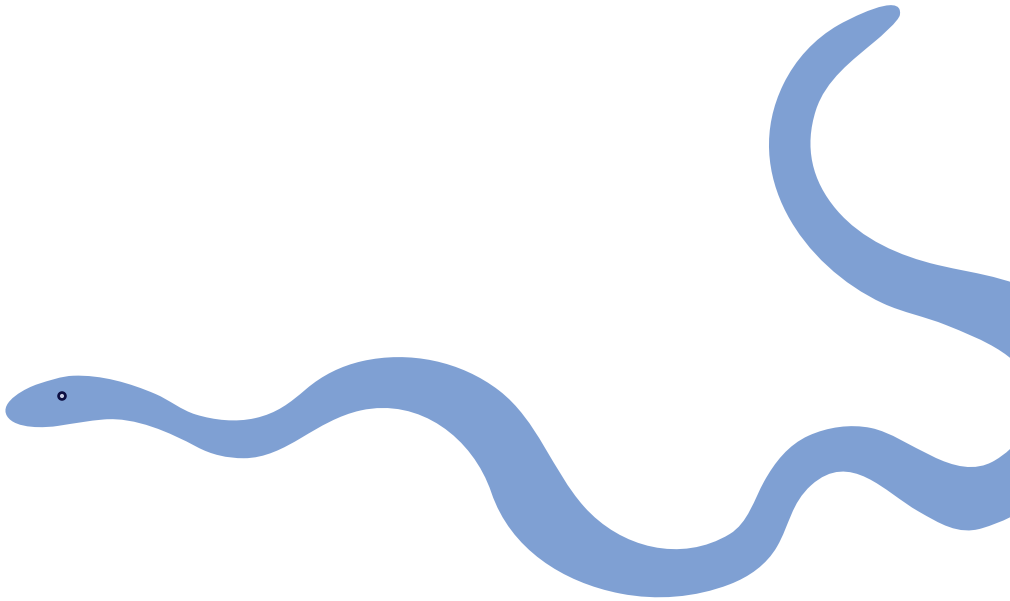
– Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.

4.2.10.B

– Students examine how human interactions like land use impact wetlands and their surrounding environments.

4.3.10.B

– Students explore the environmental consequences of human extraction and use of natural resources (e.g., mining).



Unit 2 - Lesson: Let It Soak In

Introduction

The Catskill Mountains mark the start of a single drop of water's journey through the entire Delaware River watershed. At its source, we can see many of the exciting processes that transport water through the watershed. Much of this movement happens beneath the earth's surface. When it doesn't, it affects the shape of the land. These processes are key in how the watershed naturally manages pollution.

Teacher Prep

- Queue videos
  - What is Groundwater?
    Video - 5 minutes
  - Power of Water Erosion
    Video - 1 minute
- Projection of the Watershed Map
- Collect several clear plastic liter bottles before this lesson. You can prep the bottles by cutting the tops off, or have students do this in class
- Set up stations around the room with the different materials
  - 3-4 different types of soil samples - loam, sandy, clay, and sand from the playground or local park
  - Gravel
  - Sand
  - Water
  - Measuring cup or graduated cylinder (1 per group)
  - Large syringes (basting syringes) (1 per group)

What happens to rainwater after it hits the earth? What factors determine what happens to the rainwater?

Procedure

1. Use the Watershed Map projection to introduce this activity. Point out the Catskill Mountain range on the map. This is there where Delaware River headwaters come from. Explain that headwaters are where the river starts, in our case in the mountains, but they aren't always visible. Headwaters can come from underground springs or marshy areas with melted snow. In the exploration of the Mountainscape, we will learn how water moves through the soil, down into aquifers and up, out into our river.

2. To get started, play the "What is Groundwater?" video. It introduces the processes around water movement that will be explored in the activity.

   - What is Groundwater?

3. Discuss the video with the class. How do aquifers relate to mountain headwaters? How are aquifers refilled? Explain to students they are going to be working in groups to model an aquifer. They will observe how aquifers recharge, how water moves through the soil, and how human activity changes the conditions. Show them a completed model example with all of the layers measured and in the bottle, with the basting syringe inserted. There should be 3 inches of gravel on the bottom, 2 inches of sand, and about 1 inch of topsoil on the top. The basters should be wedged into the gravel, so they don't clog with sand. The topsoil should be built up to almost the edge of

Unit 2 - Lesson: Let It Soak In (cont.)

the bottle on one side, sloping down to the other side to represent a mountain's slope.

4 This experiment will also test different soil types, to see how they affect percolation. Divide the students into teams, each team will be working on an "aquifer." Assign soil types to groups. If possible, have students model more than 1 aquifer so different soil types are being tested by multiple groups. Students can compare results after the experiment.

5 Have students go around the room collecting the items they need to model their own aquifer. They should measure the correct amount of each material at each station, making sure to insert the basters before adding the sand. These syringes represent wells pumping water out for our use. Have students return to their desks after completing the aquifer and adding the food coloring to their water.

6 At their desks, have students start a timer as they very carefully pour the water over their aquifer, so not to stir up the topsoil. As the water saturates the topsoil, it will trickle down into the gravel. They should record how long it takes for the all of the water to move through to the bottom. This demonstrates how rainwater moves through the earth to fill an aquifer. Once the water has settled, have students use a sharpie to mark and label the water's highest point. This is their aquifer's water table.

7 Next, recall how wells work, pumping water up from the aquifer for our use. Students should gently squeeze the baster, replicating a well pumping water out of the aquifer. They should observe and record the change in water level of the aquifer. Then have students squeeze the baster to completely empty it and record the change in water level.

8 Finally have students carefully remove the baster and fill in the hole with more of the same soil. Return the water to the aquifer through the topsoil, pouring from a higher height above the aquifer and at a much faster pace. Record how long it takes for the water to settle. Note the height of the spout, but also have students record what happened to the topsoil with the change in "precipitation" conditions.

8 Have students return to their desks to watch the video about erosion before discussion. They will learn about what they saw in the last part of the experiment.

— Power of Water Erosion

9 As a class, gather to discuss the results of the experiment. Have students compare how long it took for the water to fully seep through their aquifer with the different soils. Not all soils are equal! Discuss the soil types and the role they played. How might different percolation rates in soil be beneficial? (think of the bottoms of rivers / lakes, rice crop enclosures that need to hold water). Returning the water to the soil represents the recharging ability of aquifers. Discuss how using more basters would have affected how quickly the water level would change. What does this mean for increased water usage by humans? Finally, what changes were noted with the increased slope and heavier precipitation? What are the implications for the Catskills? What else could affect runoff (seasonal changes in precipitation, deforestation)?

Unit 2 - Lesson: Let It Soak In (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

Water Cycle Puzzle

- Where does the water end up?
- What are some consequences when we interrupt the flow of water into the ground?
- Where could we make changes to work with nature better and have a more positive impact on the water cycle?

Watershed 3D Modeling Table

- Experiment with the different pieces. What happens to the water?
- What's the relationship between the water cycle and permeability?
- If you were in charge of the city, what would you change to make it more water-friendly?

Watershed Data Visualization

- Why is water treatment important to the entire water cycle?
- What are some ways we can change our environment to get more water into the ground?
- Is there something you could do in your own home or block to help water soak into the ground?

Status of the Watershed Visualization

- Why do riparian buffers matter when it comes to runoff and groundwater?
- Looking at these data, do you think we're on the right track to improving our water situation?

RIVER ALIVE! Scavenger Hunt: Unit 2

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits.
Carefully explore each stop to fill in the answer to the prompts, and discover even more about our watershed.

☐ Watershed Scapes Exploration Wall

Take a closer look at each of the habitat scapes that make up our wonderful watershed. **What's a risk to the river's Mountain habitat? What could you do to reduce that risk?**

☐ Watershed 3D Modeling Table

Experiment with some of the objects here to create a flow that moves forward smoothly, or stops and pools. **What materials cause the change? Describe what makes a healthy flow of water.**

☐ Water Cycle Puzzle

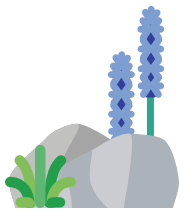
Solve the puzzle to see how water moves through our watershed. **When water sinks into the ground, what is that process called?**

☐ Status of the Watershed Visualization

Investigate the different facts about watershed health. **How many feet of riparian (riverbank) plantings are needed to keep 90% of runoff out of the river? What would you plant to create a beautiful riverbank habitat? Sketch your idea.**

☐ Watershed Map

Investigate the "Water" section of the Watershed Map activity. **How much of the water on our planet is "available" fresh water? How much of that is located underground?**



Unit 2 - Wrapping Up

Debrief

Unit 2 has used the mountains as a setting to investigate the processes that allow the very critical movement of water through the earth. Specifically, we've looked at the Catskill Mountains that are the start of the Delaware River. Precipitation percolates into the earth to refill aquifers and join the river. Our headwaters are formed as water springs from underwater aquifers to start the long journey back to the ocean.

Our exploration into infiltration, percolation, and erosion were framed in the context of the mountain to emphasize their relationship and connection to the shape and composition of the land. Looking at the Catskill Mountains brings these scientific concepts closer to home, as it relates to our very own watershed. We keep returning to the impact human actions have on these cycles, and therefore the habitats. We are a part of these habitats now, and we rely on them just as much.

Moving forward, the next unit looks closer at the anatomy of the river and turns our attention to the cast of characters that rely on the river, ourselves included.

Additional Resources

Catskill Streams - East Branch Delaware River
Website - A wealth of information and links to research about stream restoration, stormwater, and streambank stabilization.

Catskill High Peaks
Website - Detailed information about the 35 peaks in the Catskills that surpass 3,500 feet in elevation

Where the Delaware River Begins
Article - Describes the quiet start of the river

US Aquifer Map
Website - Map and explanation of all aquifers in the U.S.

A Quick Guide to Groundwater in Pennsylvania
Website - A closer look at Pennsylvania's aquifers

Water Table Map of Philadelphia 1980
Website - A historical map of Philadelphia's water table and information about the aquifers the city sits on

National Geographic - Aquifer
Website - National Geographic's encyclopedia entry for aquifer, including related vocabulary

Geohydrology and Ground-Water Resources of Philadelphia, PA
Report - 1991 report on Philadelphia's hydrology, including soil composition charts across several sections of the city

Aquifers
Website - Overview of aquifers and their relationship to local bodies of water

Groundwater and River Flow
Article - About groundwater and its relationship to river flow

BEYOND YOUR WILDEST WATERSHED

Unit 3

We continue moving along the river exploring the wonderful Pennsylvania wilderness and finding some new friends along the way.

Unit 3 - Overview

Bird's-Eye View

Water isn't the only thing moving through the ecosystem. The watershed wildness is home to a diverse cast of land-based river characters who rely on and support the natural process of the watershed. This unit looks at the shape and functions of the watershed through the lens of other animals.

Key Objectives

Finding connections between the inhabitants of the wilderness reinforces the interconnectivity of the entire watershed. In completing this lesson students will:

- Describe the anatomy of a river
- Identify these areas on the Delaware River
- Define an ecosystem
- Describe the wilderness ecosystem in our watershed
- Define the roles of producers, consumers, and decomposers
- Define herbivores, carnivores, and omnivores
- Name examples of producers and consumers found in the wilderness habitat
- Construct a food web
- Follow the flow of energy in an ecosystem
- Draw connections between wilderness organisms and the river
- Describe the impact of an invasive species on an ecosystem

Guiding Questions

- What makes a river?
- What is wilderness?
- What is an ecosystem?
- How are food and energy related?
- How does energy move through an ecosystem?
- What are the four major groups in any ecosystem?
- What roles do each of them play?
- What are some local examples of these organisms?
- How does the river support wilderness ecosystems?
- What happens when an ecosystem is out of balance?
- What can change the balance of an ecosystem?

Curriculum Connections

Next Generation Science Standards (NGSS): National

HS-LS1-5 From Molecules to Organisms: Structures and Processes

- Students discover that photosynthesis transforms light energy into stored chemical energy, along with a release of oxygen.

HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

- Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.

HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

- Students explore evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Unit 3 - Overview (cont.)

Curriculum Connections (cont.)

HS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics

– Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.

HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

– Students discover the cycling of matter and flow of energy among organisms in an ecosystem.

HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics

– Students evaluate the evidence about complex interactions in ecosystem that maintain organism populations in stable conditions, and how the ecosystem alters with changing conditions.

HS-LS4-5 Biological Evolution: Unity and Diversity

– Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.

HS-ESS3-4 Earth and Human Activity

– Students evaluate solutions that reduce the impact of human activities on natural systems.

Pennsylvania State Standards/Common Core

3.1.12.A1

– Students explore the ways organisms must derive energy from their environment or their food in order to survive.

4.1.10.A

– Students evaluate possible causes of population fluctuations, the idea of "carrying capacity" in an ecosystem, and how different factors threaten organism survival.

4.1.12.A

– Students analyze the significance of biological diversity in an ecosystem, causes of biodiversity loss, and management laws meant to effect biodiversity.

4.1.10.B

– Students explore the consequences of interrupting natural cycles.

4.1.12.B

– Students consider solutions to problems caused by interrupting natural cycles.

4.1.10.D

– Students investigate the relationship between habitat changes, plant and animal populations, and corresponding fluctuations in biodiversity.

4.2.10.B

– Students examine how human interactions like land use impact wetlands and their surrounding environments.

4.2.10.C

– Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.

Unit 3 - Lesson: Into The Wild

Introduction

The wilderness is the iconic standard of nature, raw and untouched. It's here we look to investigate the creatures of the watershed. Studying the connections between wildlife and the watershed helps us understand our own relationship with the watershed. They have developed a natural balance and interaction that is self sustaining. Our activities can throw off these balances, to devastating effect.

The ecosystems supported by the river are diverse and interconnected. What exactly are the connections in the wilderness? What kind of change can throw them off balance?

Teacher Prep

- Queue lesson video
  - FuseSchool: Ecology
    Video - 3 minutes
  - Forest Fact Break
    Video - 2 minutes
- Project the Watershed Map
- Print list of forest creatures found in PA wilderness, one for each group
- Print the Shape of the River diagram
- Gather activity materials
- Foam boards, 1 per group
- Push pins
- Yarn or string
- Index cards

Procedure

1. Project the Watershed Map to introduce the anatomy of the watershed. Students should already be able to identify the headwaters of the Delaware Rivers. Identify the river channel, tributaries, and delta along the path down to the ocean. Point out floodplains and discuss the shape of the river bank. Use a beaver as an example of an animal who actually inhabits the bank and can change the channel and shape of the river.

2. In this exercise, students will look beyond a single animal or food chain, and map how the species are interconnected and rely on one another. Play the Fuse School Ecology video.

   - Fuse School: Ecology

3. Go over the information from this video. What is a trophic structure? What is the primary source of energy? How does energy move through an ecosystem? Have students explain the roles of producers, consumers, and decomposers and how they are related. Discuss the differences between consumers: herbivores, carnivores, and omnivores. Thinking more critically, what would happen if the balance of the food chain was thrown off? What factors impact an ecosystem ecology?

Unit 3 - Lesson: Into the Wild (cont.)

4 Now play the Forest Fact Break video, contextualizing the information to the wildness habitat.

— Forest Fact Break

5 Ask students to name local plants and animals that could play a role in the forest river ecosystem. Note animals like raccoons, present in both suburban/urban and forest habitats that eat river animals, or animals that eat river vegetation.

6 Divide students into small groups of 3-4 and give each group the handout list of forest creatures in the PA Wilderness and the Shape of the Riverbank diagram. All of the animals on the list are interconnected through a food web that leads back to the river. Have students identify any of the animals they brought up earlier, noting their role as producer, consumer, or decomposer.

7 Divide students into groups and have them draw each of the plants and animals on index cards to create markers. Give the students time to research information on the animals. On the back of the index card, answers these four questions:

Where do I live?
Where am I on the food chain?
Who / what do I eat?
Who / what eats me?

For example, a raccoon sleeps in trees and comes down to eat, is an omnivore, eats wild fruits, insects, crayfish, frogs, and is eaten by cougars, wolves, or large birds of prey on occasion.

8 Using the push pins, have students organize the plants and animals on the foam board so they can map out the relationships. It might be easier to organize animals by where they live: in the trees, on the ground, or in the river. Use the Shape of the Riverbank handout as a starting point. With what they learned in their research, have students take the yarn and wrap it around the push pins to connect animals and plants. For example, a string would connect wild berries to raccoon to cougar and a raccoon would be connected to wild berries, frogs, mice, etc.

9 Once the food web has been established, ask students to consider how other factors might disrupt the balance of the system. Assign each of the students a disruption card: flash flooding, deforestation, overhunting. Ask students to consider carefully how the impact on a single species would impact the entire web. This could be due to pollution of water, destruction of habitat, loss of food source.

10 Regroup as a class to discuss how each of the disruptions affected the mountain ecosystem. The interconnected nature of the animals living there was impacted by humans and natural events alike. Ask students what all of these animals have in common. Emphasize all living organisms need clean water for survival, some animals even eat other organisms that live in the river. If the river waters are not drinkable or able to support life, all of the species would suffer.

Unit 3 - Lesson: Into the Wild (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

River Continuum Wall

- What's the connection between one river character and another?
- What happens to diversity when river health improves?
- What's our role in the river continuum?

Watershed Scapes Exploration Wall

- How do different plants and animals rely on the varied habitats of our watershed?
- Where is the richest variety of life found in the watershed? Why?
- What happens to diversity when these habitats are damaged?

Nature's Highway Theater

- How do the many different creatures in our watershed rely on each other?
- All kinds of creatures live in the watershed. What's a story you'd tell about the life here?
- What's your relationship to Nature's Highway? Tell your story.

Plankton Bloom Table

- What happens when the "small stuff" disappears?
- Have you ever seen a plankton bloom? Describe the sight—or smell—of it. What did you think about it?
- In your own life, how do small things affect bigger ones? Can you connect that to this bigger idea of the food web?

Watershed Theater

- How does diversity define the watershed and its wonders?
- What kinds of habitats can you discover in our watershed?
- Are there sights and sounds in our watershed that mean something special to you, or spark a particular memory?

Watershed Map

- What are some threats to animals and their habitats in our watershed?
- What are some ways we're protecting both land and water to keep the watershed healthy and protect life?
- Given the topics highlighted here, where would you focus restoration efforts if you were in charge?

Watershed Artifacts

- What can you discover about diverse life just by looking at a few butterflies?
- How are these creatures different? Why do you think that is?
- Talk about another group of diverse but related animals, like birds or trees. How many have you seen?

Watershed Data Visualization

- What does EPT stand for?
- Why does the diversity of tiny life have such a big impact on animals higher up the food chain?
- How can we help improve the watershed to support more diverse life?

Unit 3 - Lesson: Into the Wild (cont.)

At the River Alive! Exhibition (cont.)

Status of the Watershed Visualization

- What are two connections between different species that you can draw from this data?
- Look at the data on oysters. Why do you think they're in trouble now?
- What are some things you can do to support diverse life in the watershed?

Watershed Life Glass Tile Wall & Rubbing Experience

- Name some of the plants and animals shown in this mural.
- How do the organisms shown here connect to and rely on each other? What's the web?
- If you took out this plant or animal, what would happen to the web? How?

RIVER ALIVE! Scavenger Hunt: Unit 3

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits.
Carefully explore each stop to fill in the answer to the prompts, and discover even more about our watershed.

☐ River Continuum Wall

What's going on in the river? When we don't take care of our watershed, our wildlife suffers. Work together with your classmates to activate all of the input stations. **What appeared first? What appeared only when the environment was cleaned?**

☐ Nature's Highway Theater

Grab a costume and take center stage! Explore the different river scenes and fly, swim, or walk like your character. **Find the pollution scene. What is one set of animals that can be most destructive to river life?**

☐ Plankton Bloom Table

The diversity our watershed relies on starts with creatures so tiny we can't even see them! But balance is everything. **What happens when there's too many phytoplankton?**

☐ Watershed Artifacts

Take a closer look at pieces of the watershed. The smallest inhabitants are still incredibly complex. **Which butterfly could be mistaken for royalty?**

What do these flies look like, and why? Which fishing fly is most different from the others?

☐ Watershed Life Glass Tile Wall

Be sure to collect a rubbing of the Watershed Life Wall. Imagine being submerged in the river and seeing all of these creatures up close. **Write a 5 sentence story about a plant or animal on the wall.**

Unit 3 - Wrapping Up

Debrief

It's important to keep in mind that we are not the only ones living in, and dependant upon, the watershed. We are surrounded by a vibrant and diverse ecology of wild creatures, great and small.

Diversity along the watershed strengthens the health of the whole systems and helps to maintain a natural and self-ustaining balance. A healthy watershed is a key part of this balance. We've seen how interconnected the watershed wildlife is, and how a disruption in one area can be felt throughout the ecosystem. We are also a part of the living watershed and need to consider the effects of our activities. From deforestation to overhunting, when we threaten the health of the watershed, we threaten our own water security.

In the next lesson, we will explore the impacts of a very particular human activity that keeps our population fed: agriculture.

Additional Resources

Crash Course: Ecosystem Ecology
Video - 10 minute video about the connections across environments

FuseSchool: What is Biodiversity?
Video - 4 minute video introducing importance of biodiversity

TED-Ed: The Threat of Invasive Populations
Video - 5 minute video taking a broad look at invasive species and why they can become a problem

UNESCO Learning to Protect Biodiversity
Video - 3 minute video on how to increase biodiversity through education for sustainable development

American Rivers: What Makes A River?
Website - Breakdown and description of the parts of a river

Forests to Faucets
Website - A project using GIS to track areas most important to surface drinking water and the role forests play in protecting them

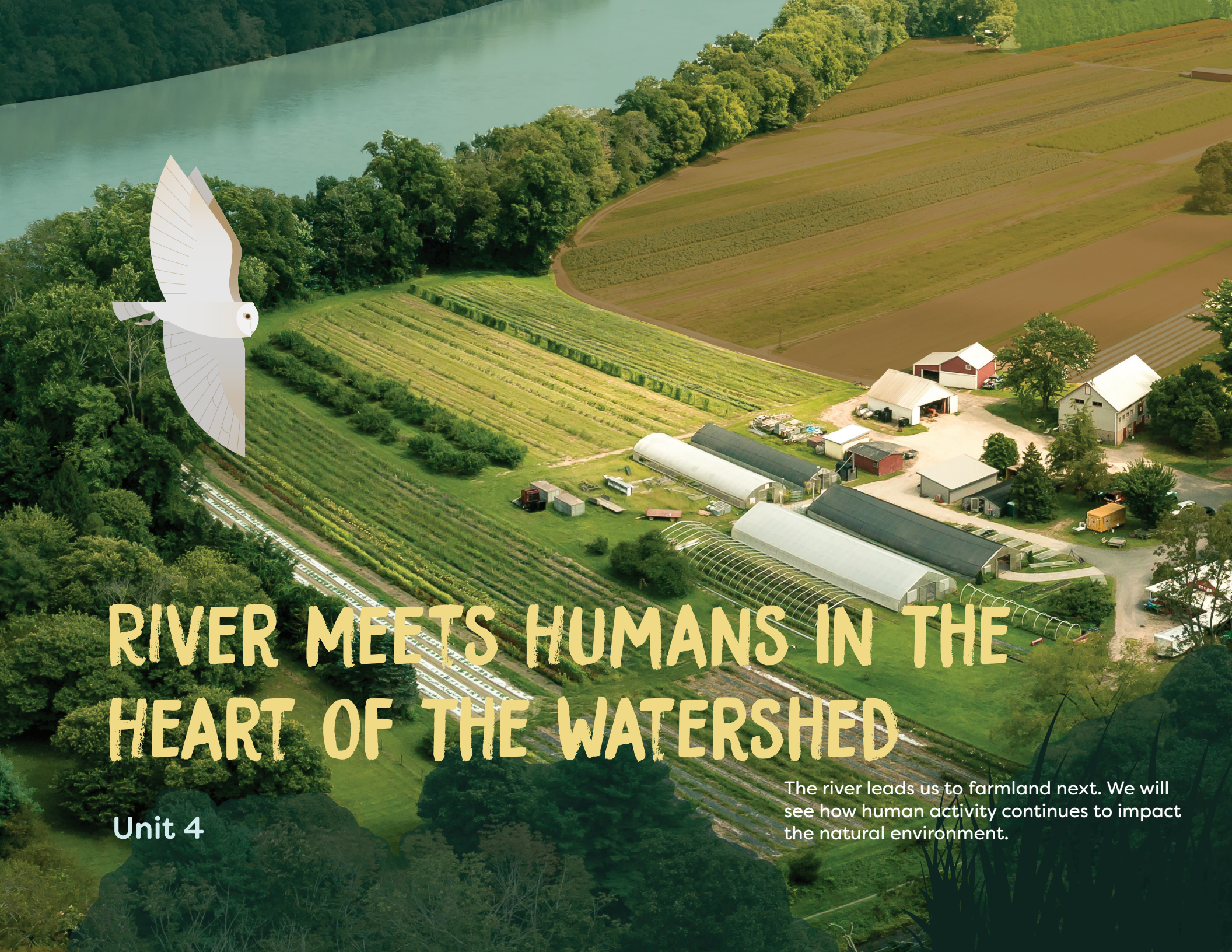
Ecology Without Wilderness
Article - An excerpt from Rambunctious Garden: Saving Nature in a Post-Wild World

10 Surprising Wild Animals Spotted in Philadelphia
Article - About wild animals around in the city

Peregrine falcons in Philly City Hall Nest
Article - About the nesting of falcons on city hall with podcasts and video

Philadelphia Water Department - Biological Resources
Website - Detailed inventory of wildlife found in Philadelphia

PA Fish & Boat Comission - Pennsylvania Fishes
Website - List of watershed fish species, native and introduced with notes to status as threatened or endangered



RIVER MEETS HUMANS IN THE HEART OF THE WATERSHED

Unit 4

The river leads us to farmland next. We will see how human activity continues to impact the natural environment.

Unit 4 - Overview

Bird's-Eye View

The agricultural habitat is the first landscape we've encountered that is defined by the activities humans are using it for. The implementation and practice of agriculture has changed this environment. But there is still much room for improvement in how our farms fit into the watershed and keep it healthy, rather than damaging it.

Key Objectives

The agricultural scape gives us the opportunity to look in depth at the relationship between human activity and the watershed. In this lesson students will:

- Explain the importance of agriculture
- Describe the resources that go into daily food production and consumption
- Identify high resource crops
- Describe the impact of poor agricultural practices on the watershed
- Interpret trends in environmental data
- Define a riparian buffer and its location in a watershed
- Explain the effects of riparian buffers on the river

Guiding Questions

- Where does our food come from?
- How much of our water resources to we devote to growing our food?
- How are these resources being used?
- What are the environmental costs of agriculture?
- What happens when rainwater moves through contaminated soil?
- How do riparian buffers work?
- What is their role in increasing water quality?
- Why aren't there more riparian buffers along the river?
- What are the limitations of plant and soil filtering pollutants?

Curriculum Connections

Next Generation Science Standards (NGSS): National

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

- Students investigate the possibilities and effectiveness of methods to reduce the impacts of human activities on the environment and biodiversity.

HS-LS4-5 Biological Evolution: Unity and Diversity

- Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.

HS-LS4-6 Biological Evolution: Unity and Diversity

- Students discover solutions to mitigate adverse impacts of human activity on biodiversity.

Unit 4 - Overview (cont.)

Curriculum Connections (cont.)

HS-ESS3-3 Earth and Human Activity

— Students discover relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-4 Earth and Human Activity

— Students evaluate solutions that reduce the impact of human activities on natural systems.

Pennsylvania State Standards/Common Core

4.1.10.A

— Students evaluate possible causes of population fluctuations, the idea of "carrying capacity" in an ecosystem, and how different factors threaten organism survival.

4.1.12.A

— Students analyze the significance of biological diversity in an ecosystem, causes of biodiversity loss, and management laws meant to effect biodiversity.

4.1.10.B

— Students explore the consequences of interrupting natural cycles.

4.1.12.B

— Students consider solutions to problems caused by interrupting natural cycles.

4.1.12.C

— Students explore human impacts from industrial, agricultural, and commercial enterprises on energy flow and the health of an ecosystem.

4.1.10.D

— Students investigate the relationship between habitat changes, plant and animal populations, and corresponding fluctuations in biodiversity.

4.1.12.D

— Students analyze the effects of new and emerging technologies on biodiversity within an ecosystem.

4.1.12.E

— Students consider solutions that address human impacts on ecosystems over time.

4.2.10.A

— Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.

4.2.12.A

— Students examine the ways laws and regulations regarding land use management impact on the water quality and flow within a watershed.

4.2.10.B

— Students examine how human interactions like land use impact wetlands and their surrounding environments.

4.2.12.B

— Students consider the effects of policies and regulations on wetlands and their surrounding environments.

Unit 4 - Overview (cont.)

Curriculum Connections (cont.)

4.2.10.C

– Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.

4.2.12.C

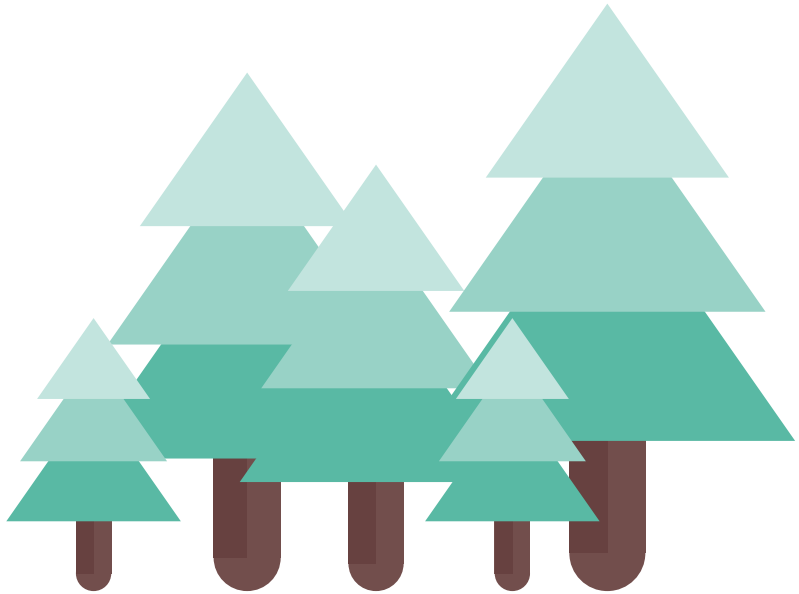
– Students investigate the effects of policies and regulations on water quality.

4.3.10.B

– Students explore the environmental consequences of human extraction and use of natural resources (e.g., mining).

4.5.10.C

– Students investigate data and ways that point and non-point source pollution can be detected and eliminated.



Unit 4 - Lesson: Something in the Water

Introduction

Our food can always be traced back to producers. The plants we eat require fertile land and clean water in abundance. Meat requires even more resources per calorie. In order to feed our growing populations, farms of varying sizes grow fruits, vegetables, grains, and livestock. Their practices are designed to maximize productivity, but don't always consider the effects on the surrounding environment.

Teacher Prep

- Queue lesson videos
  - Human Water Cycle: Agriculture
    Video - 5 minutes
  - Riparian Management: Increasing Biodiversity on farms
    Video - 2 minutes
- Print pollutant case study, 1 per student
- Gather materials
  - Blank paper, students might need more than 1 sheet
  - Graph paper
  - Rulers, 1 per student

The impact of our agriculture on the watershed relates to both land use, water use, and potential pollutants. What resources are needed to grow our foods? When can agriculture endanger the health of our watershed?

Procedure

1. Ask students to consider: What is agriculture? What is needed to support agriculture? What resources? Specifically, have students discuss the role of water in agriculture. How is it used? This lesson explores both our reliance on agriculture and the effect it can have on our watershed.

2. Students are going to create a food map. They will document a single meal, breaking down the contents and identifying the resources used at each step. As an example, break down a relatively simple meal: Peanut butter and jelly sandwich. Starting with this at the center, the three components branching off are peanut butter, jelly, and bread. Just taking the bread, the branches coming off of that component are flour, salt, eggs, water, yeast. Flour and yeast also require water in their production. The eggs are laid by chickens, who require water and are fed a mixture of grain, which in turn requires more water to be grown. All of these maps should end up with producers at the lowest level, requiring sun and water. Have students highlight or mark every place where water is a necessary resource on their map. Visualizing the hierarchy of elements shows the complexity of a simple meal, and gives an idea of just how much goes into making the food we eat every day.

3. Have students choose a meal they want to map out. The more ingredients, the more detailed the map and the more resources

Unit 4 - Lesson: Something in the Water (cont.)

used. Give students time to flesh out their charts, tracing their food back to primary sources and noting the resources required at each step. Students might need to research a breakdown, such as what grains are used in chicken feed.

4 Once the food maps are completed, lead a discussion on what students have found through their food maps. Which foods had the longest chain to break down? Which foods had the least? What can be said about water's role in our food production? Were there any surprising findings?

5 Now that students have an understanding of the amount of resources that go into a single meal, it's time to take a step back and see how the agricultural infrastructure in place is or is not working.

— Human Water Cycle: Agriculture

6 Discuss the implications of the video. Why is so much of our water used on agriculture? Reference student food maps to identify where water is being used. What supporting activities does the video discuss where water is used? What practices are farmers and scientists using to safeguard the watershed? How is tech being used in agriculture?

7 Now students will explore the impact our agriculture can have on the watershed. Hand out the case study to students and introduce the next activity. They will be exploring how the installation of a riparian buffer can help a waterway, especially in an agricultural setting. The case presents Rolling Meadow Farms, a local farm that grows sweet corn and cabbage. Farmer John has inherited his father's farm and is looking to make updates to the current state of affairs. As a millennial farmer, he wants to improve the local environment as much as possible, and plans on replating the riparian buffer on the river that runs through his property. He has collected data from before and throughout the installation.

8 Students will be creating graphs to represent the trends in the data collected. Have students create bar graphs and line graphs, whichever is most relevant to plot the soil content, annual flood level, fish population, and vegetation coverage. Have students pay attention to patterns across the data.

9 Ask students to share their graphs and discuss what the changes mean. What changes can be seen? What contaminants were originally found? At what pace are the changes happening? How are they related to the increasing riparian buffer vegetation coverage? What could this mean about the impact of riparian buffers? What does this mean for the inhabitants downstream from the farm?

10 Close the lesson with the Biodiversity Landowners' Guide video about Riparian buffers and biodiversity on farms. This can also be related to the biodiversity concepts in Unit 3.

— Riparian Management: Increasing Biodiversity on Farms

Unit 4 - Lesson: Something in the Water (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

Rate the Risk to the River

- How does what we choose to eat pose a risk to the watershed?
- Which risk would you focus on to impact river health the most? Why that one?
- If you could add a risk to this exhibit, what would it be?

Plankton Bloom Table

- Have you ever seen a plankton bloom? Describe the sight—or smell—of it. What did you think about it?
- What causes plankton blooms?
- What are some choices that you can make, personally, that would help reduce the pollution that causes plankton blooms?

Watershed 3D Modeling Table

- Experiment with the different pieces. What happens to the water?
- What's the relationship between permeability and riverbank/riparian borders?
- What would you change to make farming more friendly to the river's flow?

Watershed Map

- What are some organizations working to make agriculture more river-friendly?
- Describe one way that riverbanks are being repaired to improve water health.
- What are some long-term consequences of agriculture?

Status of the Watershed Visualization

- Why do riparian buffers matter when it comes to runoff and groundwater?
- What's the cost differential between restoring a riverbank versus preserving it in the first place?
- Looking at these data points, how do you think our watershed is doing?

RIVER ALIVE! Scavenger Hunt: Unit 4

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits.
Carefully explore each stop to fill in the answer to the prompts, and discover even more about our watershed.

☐ Rate the Risk

We all have different concerns about the watershed. Let your voice be heard by casting your vote on the wall! **Which concern did you vote for? Why?**

☐ Plankton Bloom Table

Look at the different shapes, and imagine floating in an invisible world filled with all these wonderful organisms. **In a few sentences, describe what it's like to be a beautifully geometric plankton.**

☐ Watershed Map

Investigate the "Land" path of the Watershed Map activity. **Who is working to improve the relationship between agriculture and the river? How are they doing it?**

☐ The Fisharium

Look around the Fisharium and try to identify some of the plants and animals in the aquaria on the wall. **How to the floating wetlands support the hydroponic plants next to it? What could this teach us about new agriculture practices that are more river-friendly?**

☐ Status of the Watershed Visualization

The Delaware River watershed is lucky to have people and organizations devoted to keeping it clean and healthy but there is always work to be done. **Why is land development a process that still has room to improve?**

Unit 4 - Wrapping Up

Debrief

While we depend heavily on agriculture and devote a wealth of resources to it, this lesson reveals the negative impact humans can have on the watershed when we aren't careful. Pollutants aren't the only problem. The impact of livestock and removal of natural riverside barriers to increase farmable land exacerbate erosion, pollution, and decrease in biodiversity.

But it's not hopeless. We've seen how farmers can take actions to safeguard our water and promote biodiversity on farmlands. We are extracting directly from the earth in this habitat. We need to consciously maintain the balance of the ecosystem.

The next lesson centers on another primarily human habitat, this one even more explicitly so. The urban environment represents a different kind of relationship with the watershed, although our responsibility here remains the same.

Additional Resources

CIAT Website
Website - Interactive maps that explore the origins of our food crops and their current production areas

Radical Cartography
Website - Maps of the United States showing crop and animal distribution

Americans Love Spices. So Why Don't We Grow Them?
Article - NPR article about American spice imports

Protecting Water Quality from Agricultural Runoff
Handout - Summarizing impact of farming practices

Riparian Buffers for Wildlife
Article - From Penn State University giving a breakdown of the parts of a riparian buffer and outlining the benefits

Riparian Buffers: Types and Establishment Methods
Article - From the University of Arkansas describing all the different kinds of riparian buffers

OUR URBAN WORLD DISRUPTS THE RIVER WE NEED

Unit 5

As we continue, we learn about the relationship between the river and the City of Brotherly Love.

Unit 5 - Overview

Bird's-Eye View

The urban / suburban world is another habitat defined by human settlement and activity. Distinctly different from any of the other habitats, the urban scape presents new obstacles for water to move through the hydrological cycle. In turn, we have developed methods and technologies to keep water moving.

Key Objectives

This unit looks at the water management systems introduced to the watershed by humans. Students will:

- Define impervious and pervious surfaces
- Identify surface type from a map
- Calculate surface area
- Calculate stormwater runoff
- Describe our stormwater management systems
- Identify potential sources of stormwater pollution
- Determine new ways to improve soil infiltration
- Describe the steps water treatment plants take to remove pollutants

Guiding Questions

- What makes urban habitats so different from the rest of the watershed?
- Why do urban areas affect runoff?
- How do we manage runoff in urban areas?
- What are the weaknesses in these systems?
- How are pollutants introduced to the river?
- Are there any natural pollutants?
- How can we remove pollution from our water?
- How can we stop pollutants from getting into our water?

Curriculum Connections

Next Generation Science Standards (NGSS): National

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

- Students investigate the possibilities and effectiveness of methods to reduce the impacts of human activities on the environment and biodiversity.

HS-LS4-5 Biological Evolution: Unity and Diversity

- Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.

HS-LS4-6 Biological Evolution: Unity and Diversity

- Students discover solutions to mitigate adverse impacts of human activity on biodiversity.

Unit 5 - Overview (cont.)

Curriculum Connections (cont.)

HS-ESS3-3 Earth and Human Activity

– Students discover relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-4 Earth and Human Activity

– Students evaluate solutions that reduce the impact of human activities on natural systems.

Pennsylvania State Standards/Common Core

4.1.10.A

– Students evaluate possible causes of population fluctuations, the idea of "carrying capacity" in an ecosystem, and how different factors threaten organism survival.

4.1.12.A

– Students analyze the significance of biological diversity in an ecosystem, causes of biodiversity loss, and management laws meant to effect biodiversity.

4.1.10.B

– Students explore the consequences of interrupting natural cycles.

4.1.12.B

– Students consider solutions to problems caused by interrupting natural cycles.

4.1.12.C

– Students explore human impacts from industrial, agricultural, and commercial enterprises on energy flow and the health of an ecosystem.

4.1.10.D

– Students investigate the relationship between habitat changes, plant and animal populations, and corresponding fluctuations in biodiversity.

4.1.12.D

– Students analyze the effects of new and emerging technologies on biodiversity within an ecosystem.

4.1.12.E

– Students consider solutions that address human impacts on ecosystems over time.

4.2.10.A

– Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.

4.2.12.A

– Students examine the ways laws and regulations regarding land use management impact on the water quality and flow within a watershed.

4.2.10.B

– Students examine how human interactions like land use impact wetlands and their surrounding environments.

4.2.12.B

– Students consider the effects of policies and regulations on wetlands and their surrounding environments.

Unit 5 - Overview (cont.)

Curriculum Connections (cont.)

4.2.10.C

– Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.

4.2.12.C

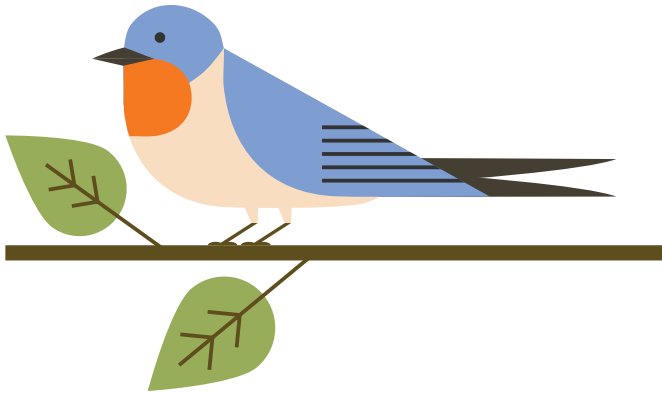
– Students investigate the effects of policies and regulations on water quality.

4.3.10.B

– Students explore the environmental consequences of human extraction and use of natural resources (e.g., mining).

4.5.10.C

– Students investigate data and ways that point and non-point source pollution can be detected and eliminated.



Unit 5 - Lesson: Pollution You Can't Point At

Introduction

The Delaware River watershed has changed dramatically with the settlement of people. Particularly in urban areas, the increase in impervious surfaces that challenge natural stormwater systems also challenge our constructed solutions. All that water carrying pollutants from the urban scape wind up in the river one way or another.

The urban environment is the pinnacle of human occupation on the watershed. What are the specific challenges that arise in urban and suburban habitats?

Teacher Prep

- Queue up lesson video
  - Urban Water Cycle: Water Treatment
    Video - 3 minutes
- Print the Impervious Urban and Suburban maps, 1 for each student
- Rulers for each students
- Calculators
- Calculation sheets
- .75 litres
- 1 liter bottle with cap
- ½ cup of soil
- ½ cup of fine sand
- Funnel
- Measuring Cup
- Collect enough materials per group
  - Clear plastic cups, 4 per group
  - 1 teaspoon of powdered alum (per group)
  - Cheese cloth 5x5 and coffee filter
  - 1 popsicle stick to stir with
  - ½ cup of clean sand, not mixed in
  - ¼ cup of clean gravel / pebbles
  - Water Treatment Worksheet

Procedure

1. Have students compare urban and suburban environments with the past three habitats. What features are different? What's the same? One thing in common is that people inhabit all of these environments. However, what human presence looks like is very different in urban and suburban areas than in the mountains, wilderness, or even farmlands.

2. One of the most visible differences between the previous habitats and the urban habitat is the lack of green space. We have traded grass and soil for concrete and pavement. Have students recall the Unit 2 experiments in percolation and the key role it plays in recharging aquifers. Why might water not drain the same way in an urban area? Guide the discussion towards permeable and impervious surfaces. Introduce these concepts and have students define each of them. Which surface is more prevalent in suburban and urban areas? Urban areas drastically cut the amount of permeable surfaces.

3. Hand out the residential maps to students. Write out all of the surfaces seen on the map on the board. Ask students to identify what surfaces are permeable and what surfaces are impermeable and record on the board.

Unit 5 - Lesson: Pollution You Can't Point At (cont.)

4 Now hand out the urban neighborhood map. Categorize all these surface on the board as well. What are the differences and similarities between the two maps?

5 Have students measure and calculate the total surface area of permeable and impervious surfaces for each map. They can break things down into simple shapes for the calculations. Record how the area of each surface present on the maps as well as the total permeable and impermeable surface areas. Calculate the runoff from a storm that had 1" of rain.

6 Regroup to talk through the findings. Which map had more impervious surfaces? Why? How might that be related to the size of the population? With all of these impervious surfaces, where does the water go? Recall Unit 1's view of the city's sewage and drainage systems. What kind of strain might we see on this particular city's system?

7 Ask students to guess how much of Philly's (or local city) drinking water is groundwater. The correct answer might be surprising, it is none. 100% of the city's drinking water is pulled directly out of the Schuylkill and Delaware Rivers. Moving forward with an understanding of how water ends up in the river and how stress on the storm drains can bring new pollutants into the environment, now we will explore how we might actually clean the water before we drink it.

8 Play the pollution control video for students.

— Urban Water Cycle: Water Treatment

9 Explain that students will be testing out the cleaning process described in the video. Hand out the Water Treatment worksheet and go over each of the stages mentioned in the video: Source water Intake, Raw Water Basin, Chemical Treatment, Flocculation, Sedimentation, Effluent Weirs, Filtration, and Final Treatment. Create the river water, using the funnel to add the soil and sand explaining that they represent sediment from the river and pollutants respectfully. Shake up for 30 seconds to combine mixture.

10 Pour about 1 cup full of the river water into each group's cup. This is their River Water Basin. The first step is chemical treatment. We won't add chemicals to the mixture, but discuss the addition of chemicals to the water. What are the benefits? What are potential drawbacks?

11 Next is coagulation. Have students add alum, to their cup, gently mixing for 1 minute to help with coagulation. Students should observe and record the accumulation of solids as they stir.

12 Next is sedimentation. Have students let the mixture sit for 5 minutes. Observe and record how particles fall and the speed they fall. What are the size of the particles that fall first.

13 Now for the effluent wiers. Have students very carefully pour the next cup, so not to disturb the sediment at the bottom. Their new mixture should look very different from the initial sample. Observe and record these differences.

14 Finally for filtration. Have students work together to hold first the cheese cloth, then the coffee filter over the mouth of the cup as they pour into the next two cups. Record and observe the change in the final water. What is left in the filters?

15 Again, we won't add chemicals to the mixture but discuss the final treatment stage. What do their mixtures look like now. How could they be made cleaner through the chemicals?

Unit 5 - Lesson: Pollution You Can't Point At (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

Rate the Risk to the River

- Which risk would you focus on to impact river health the most? Why that one?
- How does the earth work to protect us, and the river, from risks like pollution?
- If you could add a risk to this exhibit, what would it be?

Watershed Map

- What are some ways Philadelphia is working to improve the relationship between the city and the river?
- What do you think about people outside the watershed using the Delaware's water?
- Look at the map. If you were in charge, how would you balance the water needs of the four states that fall within the watershed?

Water Cycle Puzzle

- Where does our water end up?
- In regions that aren't as urbanized as this one, what do you think the water cycle looks like? Better? Worse?
- When it comes to the urban water cycle, where do you think we could have the most impact in helping our river stay clean?

Watershed Data Visualization

- How does water chemistry reflect water quality?
- Why does water treatment play a big role in supporting river health in an urban area?
- What are some methods we can use to improve river health for everyone?

RIVER ALIVE! Scavenger Hunt: Unit 5

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits.
Carefully explore each stop to fill in the answer to the prompts, and discover even more about our watershed.

☐ Rate the Risk to the River

Consider the risks on the wall, and vote for the one you think is most important. **Now, what's missing? What risk do you think should be on the wall, and why?**

☐ Watershed Map

Investigate the "Health" section of the Watershed Map activity. **What does it mean when Philadelphia calls itself a "Green City"?**

Think about your own home or neighborhood. **What is one thing you could change to make your home more river-friendly?**

☐ Currents: Partners & Projects

Take the quiz and find out which river hero you are! Make sure to dive in and connect with the watershed. **What watershed hero did you make a match with?**

Write the suggested partner or activity you find most appealing.

☐ Watershed Data Visualization

Go through the different explorations of watershed data. **What happens to water chemistry when cities put in more "green" infrastructure?**

Unit 5 - Wrapping Up

Debrief

The urban / suburban habitat is probably the most familiar ones to students. It's the frame of reference we have for how humans inhabit the earth. This lesson brings to light some of the unhappy truths about urban development.

We can't avoid the problems caused by large amounts of impervious surfaces, concentration of pollutants that are spread to the river, and removal of plants and animal habitats. We're managing in some ways, with water treatment and attempts to reduce water usage. But there's a long way to go for these practices to be adopted by everyone living in urban environments.

We've almost reached the end of our journey. The next unit looks at the final stop before the river meets the ocean: coast / bay habitats.

Additional Resources

City of Philadelphia: Treatment Process
Handout - Poster of drinking water and wastewater treatment processes

City of Philadelphia: Water Utility
Website - City of Philadelphia Water Utility page

Philadelphia's Water Story
Handout - Infographic about the stresses on our water system

Philadelphia 2017 Drinking Water Quality Report
Report - Published spring 2018, state of the union on all things Philadelphia water

Nassau SWCD: Stormwater Pollution & Green Infrastructure Solutions
Video - 30 minute video of Nassau County's efforts to control pollution and install a green infrastructure

EPA: Protecting Water Quality from Runoff
Handout - from the EPA about urban runoff

Delaware DNREC: Stella Ellis Stream Restoration
Video - 3 minute video about suburban stream management in response to heavy storm runoff

FRESH WATER JOINS SALT, AN AMAZING WORLD FILLED WITH LIFE

Unit 6

The final step of our journey brings us closer than ever to the river before it flows into the Atlantic Ocean.

Unit 6 - Overview

Bird's-Eye View

The Bay habitat is the last habitat of the watershed before the river enters the ocean. The fragile ecosystems here must deal with everything that has happened upstream as it funnels down into the bay. Life here is incredibly diverse, with the mix of salt and freshwater. Another cycle is introduced by the tide, creating constant conditions of change.

Key Objectives

At the coast, we take a look at the incredible biodiversity and listen to what the number of organisms tell us. In this lesson students will.

- Describe the characteristics of a coastal /bay habitat
- Explain the role of a bioindicator
- Describe why benthic macroinvertebrates are good bioindicators
- Identify bioindicators in Delaware Bay
- Interpret the meaning of bioindicator population levels
- Interpret pollution data and identify patterns
- Describe the effects of pollution on the coastal biodiversity
- Explain ways we can rebuild the coast to benefit all the inhabitants

Guiding Questions

- Why is the bay ecosystem so fragile?
- How do we monitor the health of the bay?
- What are signs to look for that things aren't in balance?
- What pollutants is the bay exposed to?
- How does it deal with them?
- What kind of damage can happen with coastal erosion?
- How can we mitigate the damage?
- How can we restore the ecosystem in mutually beneficial ways?

Curriculum Connections

Next Generation Science Standards (NGSS): National

HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

- Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.

HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

- Students explore evidence about factors affecting biodiversity and populations in ecosystems of different scales.

HS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics

- Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.

HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics

- Students discover the cycling of matter and flow of energy among organisms in an ecosystem.

Unit 6 - Overview (cont.)

Curriculum Connections (cont.)

HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics

— Students evaluate the evidence about complex interactions in ecosystem that maintain organism populations in stable conditions, and how the ecosystem alters with changing conditions.

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics

— Students investigate the possibilities and effectiveness of methods to reduce the impacts of human activities on the environment and biodiversity.

HS-LS4-5 Biological Evolution: Unity and Diversity

— Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.

HS-LS4-6 Biological Evolution: Unity and Diversity

— Students discover solutions to mitigate adverse impacts of human activity on biodiversity.

HS-ESS3-3 Earth and Human Activity

— Students discover relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-4 Earth and Human Activity

— Students evaluate solutions that reduce the impact of human activities on natural systems.

Pennsylvania State Standards/Common Core

3.1.12.A1

— Students explore the ways organisms must derive energy from their environment or their food in order to survive.

4.1.10.B

— Students explore the consequences of interrupting natural cycles.

4.1.12.B

— Students consider solutions to problems caused by interrupting natural cycles.

4.1.10.C

— Students discover how energy is converted from one form to another as it moves within a food web.

4.1.12.C

— Students explore human impacts from industrial, agricultural, and commercial enterprises on energy flow and the health of an ecosystem.

4.1.10.D

— Students investigate the relationship between habitat changes, plant and animal populations, and corresponding fluctuations in biodiversity.

4.1.12.E

— Students consider solutions that address human impacts on ecosystems over time.

Unit 6 - Overview (cont.)

Curriculum Connections (cont.)

4.2.10.A

– Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.

4.2.12.A

– Students examine the ways laws and regulations regarding land use management impact on the water quality and flow within a watershed.

4.2.10.B

– Students examine how human interactions like land use impact wetlands and their surrounding environments.

4.2.12.B

– Students consider the effects of policies and regulations on wetlands and their surrounding environments.

4.2.10.C

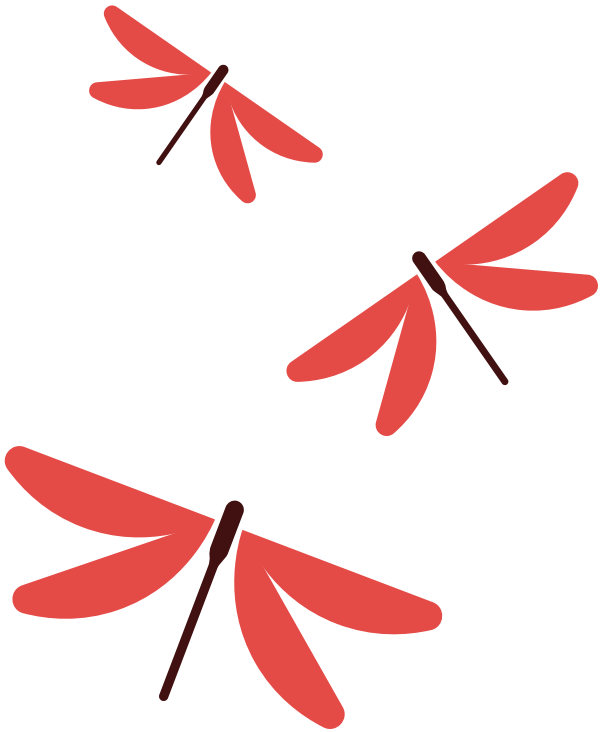
– Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.

4.2.12.C

– Students investigate the effects of policies and regulations on water quality.

4.5.10.C

– Students investigate data and ways that point and non-point source pollution can be detected and eliminated.



Unit 6 - Lesson: All Paths Lead Here

Introduction

The Delaware bay is the last stop before the river reaches the Atlantic Ocean. The ecosystem here must deal with pollutants from upstream, local pollutants, other disruptive human activity, as well as constant erosion from the ocean. That's a lot of stress on one habitat. Luckily there is a class of small organisms able to tell us what's going on.

There is a vibrant and diverse ecosystem where the river meets the ocean. How do upriver activities impact this habitat? What steps can we take to restore the ecosystems?

Teacher Prep

- Queue up video for the lesson
  - New Jersey's Hidden Coast - Episode 5
    Video - 5 minutes
  - Biological Monitoring - Invertebrates
    Video - 3 minutes
- Ensure access to enough computers for each student, or enough to work in small groups
- Provide link for students to Delaware River Basin interactive threats map
  - Threats to the Delaware River Basin
- Download the Benthic Community Biomass & Abundance folder from the Bay Bottom Inventory and print copies of the DEBI_Species Count for each student
  - Bay Bottom Inventory
- Print copies of the Stroud Identification Guide to Freshwater Macroinvertebrates
  - Identification Guide to Freshwater Macroinvertebrates

Procedure

1. Introduce Delaware Bay, the last habitat to investigate, and the only one that is exposed to salt water. What do these conditions mean for the ecosystems in this habitat? How might the tide influence these ecosystems?

2. Just like the other scapes, the Delaware Bay is exposed to a number of pollutants, both natural and from human activity. But the bay is impacted even more because of its location at the end of the river. Everything upstream eventually makes it to the bay, and the organisms living here feel the results. Have students recall the other habitats and name pollutants that occur upstream. Excessive sediments from erosion in the mountains, pesticides from farmland runoff, and litter carried in storm drains from the city all can show up in the bay. So how can we make sure these ecosystems are doing okay?

3. Hand out the Identification Guide to Freshwater Macroinvertebrates to students. Ask them to consider the Macroinvertebrates on the sheet. What are macroinvertebrates? Have any students ever seen any of these? What can they tell us about the health of the ecosystem?

Unit 6 - Lesson: All Paths Lead Here (cont.)

4 Play the Biological Monitoring video.

— Biological Monitoring - Invertebrates

5 Ask students to recap the video. What is biological monitoring? What is an indicator species? Why are macroinvertebrates so well suited for this role? These little organisms can tell us quite a bit about certain pollutants, but they still contribute to the overall biodiversity of the ecosystem. Being so low on the food chain, their presence, or lack thereof affects the entire food web. We will take a closer look at the local biodiversity in the bay.

6 Hand out the DEBI_Species Count maps. Give students a moment to study the map and the areas of high and low species count. Discuss which areas have the lowest species count. Why might that be? What does the lack of biodiversity tell us about the water quality? Which areas have the highest species count? Why?

7 Students can work alone or in small groups with the Threats to the Delaware River Basin interactive map. If working in pairs, one student can work with the digital map and the other can mark the printed map. They will use the Threats map and turn on and off the different layers to pinpoint areas of high pollution in the bay. They will mark on their species count map the highest areas of pollutant runoff and concentrations. Give students time to run through all the layers of the map, think critically, and discuss in their groups the connections between the data.

— Threats to the Delaware River Basin

8 Regroup and discuss students' findings. Where were areas of highest pollution in the bay? Why? What was located near these areas? How did this correlate with the species count in these areas? Students should find that the areas with the highest impervious surfaces and agricultural runoff are adjacent to the lower recorded species counts.

9 Explain that wetlands can filter a good deal of pollutants out of the water, but there's only so much they can handle. This is especially a problem if they are already in danger of being eroded. However, there are ways we work to restore and conserve these areas. Play the Conserve Wildlife Foundation video:

— New Jersey's Hidden Coast - Episode 5

10 What kind of restoration is the community taking on? How does that help the health of the beach? What else is happening as a result of their restoration?

Unit 6 - Lesson: All Paths Lead Here (cont.)

At the River Alive! Exhibition

As students are engaging in the exhibits, consider prompting them to think further by posing questions, such as:

Watershed Map

- Why is mud so meaningful where the river blends into the bay?
- Describe one way that shoreline communities are working to improve water health.
- What are some upstream activities that affect the health of the bay?

Watershed Data Visualization

- What are ways we measure river health in different places?
- How does water chemistry reflect water quality?
- What are some methods we can use to improve river health for everyone?

Status of the Watershed Visualization

- Find data about shorebirds and oysters. How do you think the bay is doing?
- Overall, what is your sense of the watershed's health and our efforts to clean it up?
- If you could do one thing to improve the status of the watershed, what would it be?

Watershed Life Glass Tile Wall & Rubbing Experience

- Can you name some of the estuary plants and animals shown in this mural?
- How do the organisms shown here connect to and rely on each other?
- How would damaging this food web affect humans?

RIVER ALIVE! Scavenger Hunt: Unit 6

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits.
Carefully explore each stop to fill in the answer to the prompts, and discover even more about our watershed.

☐ Watershed Scapes Exploration Wall

Take a closer look at each of the habitat scapes that make up our wonderful watershed. Find the "Work with the Watershed" bullets. **How we can keep our watershed healthy in the urban / suburban habitat?**

☐ Watershed Map

Investigate the different tracks of the media activity. **Describe two ways people are using to save shorelines and estuary habitats in the Delaware Bay.**

☐ Citizen Science Lab

Become a citizen scientist and look at some of the smallest watershed creatures through the microscope. **Draw what a cyclops looks like when magnified!**

☐ Watershed Data Visualization

Investigate the three different factors that contribute to the health of the watershed. **What are the ideal levels of salinity, oxygenation, and water bug life that indicate a healthy watershed? Write one way to help achieve that for each.**

Salinity _____ %

Oxygen _____ %

Water Bugs _____ %

☐ Status of the Watershed Visualization

Investigate the different facts about watershed health. **What's happening to a bird called the Red Knot? What would you suggest to help this bird?**

Unit 6 - Wrapping Up

Debrief

At our last stop on the river, we see how damaging the accumulated effects of the whole watershed are by the time they reach the Bay. There's only so much our marshes can filter. By looking at some of the smallest organisms, we learn a great deal about the trends of the ecosystem and can track the effects of pollutants.

But restoration is possible. Not only is it possible, but it can be beneficial to the needs of the ecosystems inhabitants as well as our own. Restoration and preservation go hand in hand to reinstate and maintain the health of this habitat.

Throughout this journey, we keep coming back to the interconnectivity of the watershed as a whole. We as people are not separate. Our daily activities are felt by the ecosystems around us. But we have the power to change. To step up and take responsibility as stewards of this beautiful natural resource.

Additional Resources

Knowledge Project - Bioindicators
Article - Introducing bioindicators and their use to measure environmental impact

Partnership for the Delaware Estuary - Water Quality
Report - Study of trends in water quality of different tidal habitats of the estuary

Delaware River Biomonitoring Program
Website - Delaware River Basin Commission's monitoring program for diversity and health of aquatic life

Partnership for the Delaware Estuary - Aquatic Habitats
Report - Study of trends in benthic organisms as indicators in different tidal habitats of the estuary

Dragonflies: Important Environmental Indicators
Article - About dragonflies role as environmental indicators

Delaware Bay Habitat Survey
Report - Comprehensive survey of the Delaware Bay aquatic habitats noting indicator populations

Delaware Coastal Programs
Website - The Division of Climate, Coastal, & Energy's Coastal Programs Section

Are Plastics a Problem in the Delaware Bay?
Article - Research into plastic pollution in Delaware Bay and the pervasiveness of microplastic

Philadelphia Water Department - Life Aquatic
Website - List of the native bay animals, including pollution-sensitive indicator species

ADDITIONAL RESOUCES

Can’t Get Enough Watershed

A – UNIT 1 APPENDIX

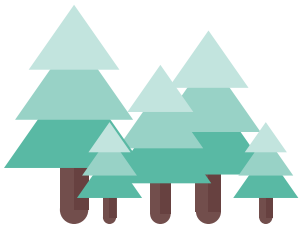
Unit 1 - Teacher Background

Understanding the Value of Water

Thinking critically about the natural processes of water, the life it supports, and our own relationship with water will help to prepare students to immerse themselves in the River Alive! exhibition. Throughout this guide, we use the Delaware River watershed as the primary focus of our lessons and discussions so students can associate exhibition concepts in the context of a body of water they may already recognize, live near and drink from. This guide intends to illuminate the vital role water plays in our everyday lives, connecting educators and students to this essential resource in meaningful ways.

Water is a finite resource that all living things rely on, including humans. Beyond drinking, we need it to cook, grow crops, manufacture, even power cities. 60% of our own bodies are water! This dependency demands that we work with the natural water cycle that keeps our limited bit of potable water clean for continued use. The earth has natural cycles and processes that move water through the environment, but human activity and its resulting impact requires new assistance to keep these cycles sufficient. For our part, that means the urban water use cycle, which in addition to the stages of the water cycle, incorporates the process of cleaning the water we have used to return it to the natural system.

To start, the natural water cycle involves the transition of water through phase changes as it circulates through oceans, bodies of water, the atmosphere, and land. Phase changes occur through evaporation, transpiration, and precipitation. The cycle is driven by the sun's energy, causing water to evaporate into the atmosphere. Plants contribute to the cycle by releasing water into the atmosphere as a gas, through transpiration. Precipitation causes water to come down as rain and snow, circulating back into the land. This closed loop system now includes the intake of water, purification, human use, and treatment before returning it to our rivers and streams to continue to move along the cycle.



Water also moves through the land in very specific pathways. These pathways are defined by topography, with the highest elevations designating different geographic regions that funnel water from rainfall and snowmelt down towards a final outlet: oceans, rivers, or basins. These regions are called watersheds, and everything and everyone on land lives within a watershed. Watersheds are made of a network of drainage paths and can include several sub-watersheds. The health of a watershed is highly dependent on what it contains. Because water moves through the entire watershed, it will accumulate whatever is in the watershed as it moves from the highest points to the lowest points of the system. This means it can pick up pollutants that travel with it through different habitats during the water cycle. Animal waste, fertilizers, and pesticides are just some of the elements water will dissolve and carry through the watershed, hurting not just the watershed, but the body of water it drains into and every habitat along the way.

The Delaware River watershed is the regional watershed we live in. It is 13,500 square miles and includes some of the most densely populated states in the country, from the Catskills to the Atlantic Ocean. It spans New York, Delaware, Pennsylvania, and New Jersey. The Delaware River watershed is much more than the great river that flows through it. It's a web of waterways that weave through many environments—mountains, forests, farmlands, lowlands, tidal basins, small towns, and great cities. It's the interplay between water and land, each affecting the other, back and forth endlessly. It's every pond, creek, stream, river, bog, beach and bay. Every sparkling pool and industrial sewer. Every osprey and otter, shad and snake, crayfish and caddisfly, plankton and pine tree. And us! Every single one of the millions of humans in that same 13,500 square miles—drinking its water, eating its fish, kayaking its rivers—is part of the living world of the watershed.

Our impact on the watershed is an inevitable result of our dependence and physical proximity. We are part of the ecological systems around us,

Unit 1 - Teacher Background (cont.)

and our actions play a role in the bigger picture. Not one, but two rivers run through the city of Philadelphia. The heart of the City of Philadelphia is positioned very close to where the Schuylkill River and the Delaware River meet. This is not an accident. Many older cities are built along waterways as they provide both commerce and self-sustainability. The river gives an easy, fast means of transportation, facilitating trade. When Philadelphia was founded, the river highway was the fastest means of travel and transport, while also providing clean water for drinking and sustaining a diverse food supply for the city's population.

The kind of land development that is necessary when building a city disrupts the natural infiltration from rain and melted snow that is a crucial part of the water cycle. The impervious surfaces we create to support our infrastructure (such as asphalt, concrete, sidewalks, roofs, etc.) change the way water is drained through the watershed. Water cannot penetrate these surfaces, which led to the creation of a stormwater management systems to channel the runoff. In Philadelphia, we have a network of over 3,000 miles of underground pipes that make up this system. These sewer pipes can be two types, combined or separate sewers. Combined sewers carry stormwater and wastewater in the same pipe. Separate sewers return stormwater to the river and send wastewater in another pipe to a water treatment plant. While this does aid in the draining of the watershed, heavy rain can overwhelm the sewer pipes and carry pollution into the river.

As we dive into this unit, keep in mind the overarching value of water. This unit will have students consider preconceived notions while creating a base of knowledge to draw from when asking questions.

Unit 1 - Key Vocabulary

Aquifer
A body of permeable rock that can contain or transmit groundwater

Condensation
The process by which liquid changes from a gas to a liquid

Dehydrate
To lose or remove water

Desalination
The process that removes salts and minerals from a target substance, this could be soil or water

Deposition
The process by which water vapor changes directly into a solid without going through the condensation process

Environment
Ecology — the air, water, minerals, organisms and all other external factors surrounding and affecting a given organism at any time

Evaporation
The process by which liquid changes into vapor

Groundwater
Water held underground in the soil or in pores and crevices in rock

Hydrate
To cause to absorb water

Hydrological Cycle
Or the water cycle, the continuous movement of water through Earth, from the ocean, atmosphere, and land

Hydrologic Unit Codes (HUC)
The sequence of numbers or letters used to identify a hydrological feature, such as a river, lake, or watershed

Hydrology
A science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

Hydrographs
A graph showing the past, present and predicted levels of streams and rivers

Hydrosphere
All of the combined water above, below, and on Earth's surface, including lakes, oceans, and even clouds

Infiltration
The part of the water cycle in which water passes through (a substance) by filtering or permeating or penetrating its pores

Organism
A living thing

Percolation
The part of the natural water cycle in which water moves slowly downward through the porous ground

Population
The total number of persons inhabiting a country, city or any district or area

Potable
Safe to drink

Precipitation
The part of the natural water cycle in which rain, snow, sleet, or hail falls from the atmosphere to the ground

Recharge
The replenishment of an aquifer by the absorption of water

Saturation
The state when no more of something can be absorbed or added

Stormwater Runoff
The part of the water cycle in which water flows off the land into the nearest body of water

Unit 1 - Key Vocabulary (cont.)

Sublimation
The process by which water changes from a solid to a gas without becoming liquid

Surface Water
Water that collects on the surface of the ground

Transpiration
The part of the water cycle in which water absorbed by living things, like plants and trees, evaporates into the atmosphere

Transportation
The movement of moisture due to wind. This allows water evaporated over the ocean to precipitate over land

Tributary
A river or stream which flows into a larger river or lake

Water
The colorless, transparent, tasteless liquid that makes up our rivers, lakes, oceans, clouds, and is the basis for life on Earth

Water Cycle
Or the hydrological cycle, the continuous movement of water through Earth, from the ocean, atmosphere, and land

Watershed
The region or area of land that drains into the nearest river or stream or other body of water

Unit 1 - Lesson 1: Variations, Extensions, and More

Build It and See
The beauty of using post-its is they are easy to move around, rearrange, or trash as students are working through their water cycle diagrams. However, it can be useful to take things to the next step with a physical representation. Students can create 3D shoebox dioramas of their water cycle models using craft paper, modeling clay, and other creative elements. Here, there's opportunity to lead into the concept of a watershed, pointing out the mountains and valleys that are present in the diorama.

Water, Water, Everywhere
We can simulate the evaporation and condensation processes easily with a jar of water, plastic wrap, and a sunny day. This can be set up at the beginning of class and observed during the closing discussions. Outside of class, have students keep an eye out for other water cycle processes in their daily life (condensation on a car windshield in the winter, or in the bathroom after a hot shower, etc). Discuss the micro scale of these processes and how they act in the larger, global processes every day.

Cycle Through Nature
Water has a cycle, but it's not only one! The water cycle is just one of many related cycles that sustains life here on earth. The carbon cycle is another natural process closely tied to the watershed and to living things in the watershed, like us. Students can watch this video and create a new diagram depicting the carbon cycle. Comparing the two cycles side by side, it's easy to see similarities and cross over. For example, plants give off both water vapor and carbon dioxide. The ocean holds most of our planet's water, but carbon dioxide is also dissolved into the ocean. Discuss these kinds of relationships and draw connections between the cycles when possible.

– The Hydrologic and Carbon Cycles: Always Recycle!
Video - 10 minutes

Discussion Questions

– What is the value of water?
– Where does water come from?
– What do we use water for?
– How is this different from people in other countries?
– Why are our experiences different?
– What are the 12 components of the water use cycle?
– What phases can water be found in during the cycle?
– Which stages are these phases found in?
– What drives the water cycle?
– How have people impacted the water cycle?

Unit 1 - Lesson 2: Variations, Extensions, and More

Know No Boundaries
The arbitrary nature of political boundaries becomes evident when considering watersheds. The Delaware River Watershed encompasses 4 different states! Conflict over water seems like a likely problem in the future, mainly associated with water scarcity. However, water conflict can be found in our own backyard. Have students read this National Geographic article discussing conflict over waters in the United States and write a response. For an additional challenge, they can research more about the issues surrounding the dam practices in the Susquehanna River, right here in Pennsylvania.

— Water Wars Threaten America's Most Endangered Rivers
Article

Line By Line
We briefly looked at topography when learning about the habitats, but there's a lot more there to explore. Topography maps store a wealth of information about an area that is hard to piece together through normal maps or photographs. After watching this video, students should be able to accurately read their Watershed Map, noting key geographical features. Have students mark the sub-watersheds using the Regions of the Watershed map link. How are these related to the topography of the entire basin?

— How to Read a Topo Map
Video - 4 minutes

— Regions of the Watershed
Website

Keep an Ear to the Ground
We've introduced the basics about watersheds, but there's so much more we can learn. We've barely scratched the surface. Have students listen to the podcast How Watersheds Work from How Stuff Works outside of class. It dives into more details about watersheds, ecology, and human impact. Have students write a response to this podcast, telling something new they learned.

— How Watersheds Work
Podcast - 31 minutes

Discussion Questions

— What is a watershed?
— What makes a healthy watershed?
— Why are watersheds important?
— How does human activity affect the watershed?
— What happens to precipitation in the watershed?
— How are the boundaries of watersheds determined?
— What is the relationship between topography and the watershed?
— Why does the health of a watershed affect the health of the ocean?
— What are the habitats located along the Delaware River?
— How are the habitats related to each other?

Unit 1 - Lesson 3: Variations, Extensions, and More

Live Action Watershed
Instead of a presentation, students can prepare a skit or charades about their animal in the watershed, portraying key features of the relationship to the habitat. For example, the life cycle of a mayfly in the coastal habitat, or the daily life of a deer in the wilderness. Students can get creative to act out their play with props.

A Day Without Water
We've learned how important water is to our daily lives and to everything else living in watersheds. Watersheds work to clean water and balance a dynamic, ever changing system as it moves through them, but what if there wasn't any water? With global use ever increasing, the strain has never been more real. Have students consider how their days would change if they didn't have access to water. What would be different? Discuss what a day without water would mean for each of watershed habitats and the animals they researched.

– Imagine a Day Without Water 2018
Video - 2 minutes

Discussion Questions

– What is the interaction between the natural water cycle and the watershed?
– What can you do to improve the health of the watershed?
– How is the watershed impacted by human activity? In positive ways? In negative ways?
– What drives behaviors that have a negative impact?
– How are habitats suited to the needs of their inhabitants?
– What are the limiting factors for life in these habitats?
– Why do animals move between habitats?

Unit 1 - Lesson Links

Water is Life

Lesson

Why Care About Water?
Video - 3 minutes
https://www.youtube.com/watch?v=Fvkzjt3b-dU

River Water Harvesting in Ethiopia
Video - 1 minute
https://www.youtube.com/watch?v=s5FHyDJEzhc

Our Water Cycle
Video - 2 minutes
https://vimeo.com/276101935

CoCoRaHS Water Cycle
Video - 7 minutes
https://www.youtube.com/watch?v=ZzY5-NZSzVw

Variations and Extensions

The Hydrologic and Carbon Cycles: Always Recycle!
Video - 10 minutes
https://www.youtube.com/watch?v=2D7hZpIYlCA&list=PL8dPuuaLjXtNdTKZkV_GiIYXpV9w4WxbX&index=8

What is Our Watershed

Lesson

What is a Watershed?
Video - 1 minute
https://www.youtube.com/watch?v=QOrVotzBNto

CoCoRaHS Watersheds!
Video - 5 minutes
https://www.youtube.com/watch?v=2pwW2rlGIa8

Variations and Extensions

Water Wars Threaten America's Most Endangered Rivers
Article
https://news.nationalgeographic.com/2016/04/160412-americas-most-endangered-rivers-list-conservation/

How to Read a Topo Map
Video - 4 minutes
https://www.youtube.com/watch?time_continue=213&v=CoVcRxza8nI

Regions of the Watershed
Website
http://www.delriverwatershed.org/the-watershed/

How Watersheds Work
Podcast - 31 minutes
https://www.stuffyoushouldknow.com/podcasts/watersheds.htm

What is Our Watershed

Lesson

Nature Works - To Make Clean Water
Video - 4 minutes
https://www.youtube.com/watch?v=7fqEuKXanBg&feature=youtu.be

Unit 1 - Lesson Links (cont.)

A Watershed Moment
Video - 12 minutes
https://vimeo.com/160105867

Our Water Quality
Video - 1 minute
https://vimeo.com/276102549

Variations and Extensions

Imagine a Day Without Water 2018
Video - 2 minutes
https://www.youtube.com/watch?time_continue=3&v=zxjeXdsD-Jw

Additional Resources

Delaware River Basin Interactive Watershed Map
Website
https://www.delawarewatershed.org/

EPA - How's My Waterway?
Website
https://watersgeo.epa.gov/mywaterway/mywaterway.html

How Stuff Works - How Watersheds Work?
Article
https://science.howstuffworks.com/environmental/conservation/issues/watershed.html

NOAA - Watersheds, Flooding, & Pollution
Website
https://www.noaa.gov/resource-collections/watersheds-flooding-pollution

Philadelphia Water Department Watershed Locater
Website
http://www.phillywatersheds.org/your_watershed/find_your_watershed

USGS - Water Cycle Summary
Website
https://water.usgs.gov/edu/watercyclesummary.html

USGS - Science In Your Watershed
Website
https://water.usgs.gov/wsc/map_index.html

Water Conflict Chronology
Website
http://www.worldwater.org/conflict/list/

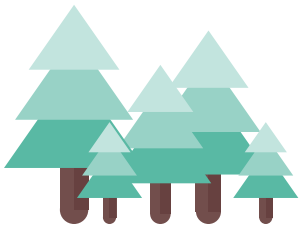
B - UNIT 2 APPENDIX

Unit 2 - Teacher Background

Straight From The Source

The Catskill Mountains are a geological feature 350 million years in the making. Today they stand 4,180 feet above sea level at their highest point with 35 mountain peaks above 3,500 feet and contain the starting place for the Delaware River. Or rather, the starting places. Our river's headwaters actually come from two different branches within the Catskills. The West Branch stems from Mount Jefferson while the East Branch starts in Grand Gorge. The origin of our river is critical because everything along the rest of the river is affected by what's happening upstream. As water travels down the mountains, through our cities, and eventually back to the ocean, it carries sediments, animals, and even pollutants. But nothing comes before the headwaters. There's only what lies downstream. Here at the start of it all, we will take a closer look at the processes that make our headwaters possible and keep the river moving.

So where does all of the river water come from? This could be a case of the chicken and the egg. It comes from stores of water deep in the earth, but those stores were built up through precipitation, sometimes for millions of years. In the United States, around 40% of the flow in all rivers comes from groundwater. Thinking a little closer to home, where does all the water we use on a daily basis come from? When we turn on the tap in our homes, water comes out, we use what we need and continue on with our day. It's easy for our awareness to begin and end with turning on and off the faucet, but there is much more at play here. Groundwater constitutes more than half of the drinking water for the United States. But groundwater by definition is water found in the spaces and crevices in soil and rock deep in the earth. To make water as accessible as the turn of a knob, we have had to build an infrastructure to support transporting water up from these deep spaces.



The layer of rock and soil deep in the earth that stores water is called an aquifer. Aquifers provide vast storage for clean water. Aquifers are refilled by recharge areas with permeable surfaces that allow precipitation to infiltrate the ground and travel down all the way through to the water table. This top surface of the aquifer marks the amount of water the aquifer is holding. As the water tables move up and down with the changing saturation level, the volume of water also changes. A healthy aquifer needs recharge area or it will not be able to refill and the water table will fall. This can happen seasonally, with drought, or with increased water use by people. Philadelphia actually lies on a 3 aquifer system, the Potomac-Raritan-Magothy aquifer system but only uses river water, or surface water, for drinking water. The city pulls directly from the Delaware and Schuylkill rivers.

For other areas on the watershed without an urban infrastructure, we have to drill down into the earth until we reach the water table to draw out water. As we draw more and more water through these wells, the water table falls, sometimes at rates the precipitation recharge cannot replace. This is even more problematic when we have impervious surfaces that lower infiltration and cause runoff instead. It becomes a balancing act between our needs for water and not outpacing the natural processes that have been in place for millennia. On the other hand, too much precipitation can also be an issue. When the water table is oversaturated, runoff increases because there isn't anywhere for it to go. Water infiltrates at a slower rate and the excess water becomes surface runoff. This can cause flooding and erosion. A healthy aquifer is again a balancing act of natural processes and human activity.

The water cycle tells us that water moves through the soil and on the surface of the ground, but there is much more involved with any kind of movement. There are many factors that determine what happens to water when it hits the ground, and how quickly it moves. Soil texture, soil makeup, presence of water, slopes, and impervious subsurfaces all

Unit 2 - Teacher Background (cont.)

affect what happens to water. When precipitation falls on the ground, three things can happen: infiltration, runoff, or evaporation. Infiltration is the absorption of water by soil in the topmost layer of soil. Some water stays here and is taken in by plants. Some water continues its downward journey through percolation, all the way through to the water table. This is the water that refills our aquifers and keeps the whole cycle moving. Percolation and seepage (horizontal water movement) also can bring water to the river. In fact, more water joins the river through percolation and seepage from aquifers than through direct precipitation. If a water table is higher than the adjacent land, such as on a mountain, water can flow out creating a spring. The headwaters of the Delaware River come from springs way up in the Catskills. From modest beginnings comes our proud waterway.

The mountain unit looks closely at the natural processes that let water move through the watershed as part of the water cycle. Students experiment with these processes and must think critically about the water needs of human activity vs. the health of the watershed.

Unit 2 - Key Vocabulary

Aquifer
A body of permeable rock that can contain or transmit groundwater, a zone of saturation

Erosion
The process where solid material is removed from a surface with the force of wind or water

Groundwater
Water held underground in the soil or in pores and crevices in rock, solid and sediments

Headwaters
A smaller, tributary stream of a river that is close to or forming part of that river's source

Infiltration
The part of the water cycle in which water passes through (a substance) by filtering or permeating or penetrating its pores

Percolation
The part of the natural water cycle in which water moves slowly downward through the porous ground

Precipitation
The part of the natural water cycle in which rain, snow, sleet, or hail falls from the atmosphere to the ground

Recharge
The replenishment of an aquifer by the absorption of water

Recharge Area
The area where water flows into the ground to resupply a body of water or an aquifer

Saturation
The state when no more of something can be absorbed or added

Saturated Zone
The area in an aquifer below the water table, where all openings, pores, and fractures are saturated with water

Sediment
Any particulate matter that can be transported by fluid flow and which settles into a solid layer at the bottom of a body of water

Soil
A mixture of minerals, gases, liquids, living organisms, and decaying organic matter

Spring
Anywhere groundwater flows out to the surface

Surface Runoff
The part of the water cycle in which water flows off the land into the nearest body of water

Surface Water
Water that collects on the surface of the ground, such as lakes, ponds, even the ocean

Topsoil
The upper, outermost layer of soil, usually the top 2 to 7 inches, with the highest concentration of organic matter and microorganisms

Tributary
A stream or river that flows into a larger stream or main river or lake instead of directly into a sea or ocean.

Water Table
The upper surface of the zone of saturation, beneath this surface all soil and rocks are saturated with water

Well
An excavation or structure created in the ground by digging, driving, boring, or drilling to draw water out of aquifers

Unsaturated Zone
The area above the water table where water can still move down

Unit 2 - Variations, Extensions, and More

It's Time for the Percolator
Students now know that different soil types have different percolation rates. But why? Have students watch this video and diagram the different soil particle shapes. How do these affect the speed of percolation? Have students draw the relative sizes of the soil particles used in this lesson to explain their results.

– Water Movement in Soil
Video - 3 minutes

Bending Over Backwards for Water
We know erosion wears away the earth, but how does that affect the path of the river. Have students watch the following video about the shape of the channel. They can note on the Watershed map major bends in the river that might be caused by major bends in the river, but have students use Google maps or Google earth to look more closely at enlarged portions of the river. Locate a section that has the types of bends described in the movies.

– Why Do Rivers Curve
Video - 3 minutes

Mountain Profile
To help visualize the elevation changes in the Catskill Mountains, students can use cross sections from a topographic map to draw a profile of the surface of the mountain. After selecting a small portion of this map, students can draw a line anywhere across the entirety of the paper. This is their cross section. If using the same portion for the map for the whole class, have students compare their results and their cross sections. Have students note how spacing of topography lines changes the slope of the mountain.

– Catskill Mountaineer: Topography Map
Map

Discussion Questions

– What is the difference between surface and groundwater?
– What is a water table?
– How does groundwater move through the ground?
– How do aquifers relate to mountain headwaters?
– How are aquifers refilled?
– Why do different soils have different percolation rates?
– What affects percolation rates?
– How does the soil around an aquifer affect recharge?
– What human activities affect aquifers?
– How do topographical features relate to water movement in the watershed?
– What factors affect runoff? (soil changes, seasonal changes in precipitation, deforestation)?
– How are runoff and infiltration related?
– What else can cause erosion in the mountain habitat?
– How might different percolation rates in soil be beneficial? (think of the bottoms of rivers / lakes, rice crop enclosures that need to hold water).

Unit 2 - Lesson Links

Let It Soak In

What is Groundwater?
Video - 5 minutes
https://www.youtube.com/watch?v=oNWAerr_xEE

Power of Water Erosion
Video - 5 minutes
https://www.youtube.com/watch?v=MFpCJsc_k64

Variations and Extensions

Water Movement in Soil
Video - 3 minutes
https://www.youtube.com/watch?v=vmo0FRAVgkM

Why Do Rivers Curve
Video - 3 minutes
https://www.youtube.com/watch?v=8a3r-cG8Wic

Catskill Mountain Topography Map
Map
http://www.catskillmountaineer.com/maps-05.html

Additional Resources

Catskill Streams - East Branch Delaware River
Website
http://catskillstreams.org/major-streams/east-branch-delaware-river/

Catskill High Peaks
Website
http://catskill-3500-club.org/peaks.php

Where the Delaware River Begins
Article
https://www.recordonline.com/news/20161106/845-life-this-is-where-delaware-river-begins

US Aquifer Map
Website
https://water.usgs.gov/ogw/aquifer/USAaquiferMAP11_17.pdf

A Quick Guide to Groundwater in Pennsylvania
Website
https://extension.psu.edu/a-quick-guide-to-groundwater-in-pennsylvania

Water Table Map of Philadelphia 1980
Website
https://pubs.usgs.gov/ha/676/plate-1.pdf

National Geographic - Aquifer
Website
https://www.nationalgeographic.org/encyclopedia/aquifer/

Geohydrology and Ground-Water Resources of Philadelphia, PA
Report
https://pubs.usgs.gov/wsp/2346/report.pdf

Aquifers
Website
https://www.watereducation.org/aquapedia/aquifers

Groundwater and River Flow
Article
https://agwt.org/content/groundwater-and-river-flow

C - UNIT 3 APPENDIX

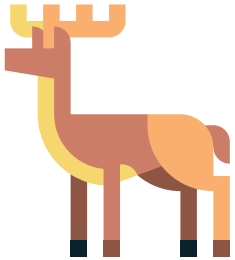
Unit 3 - Teacher Background

Species Diversity is Key

The wilderness is a unique watershed scape in that it can mean different things to different people depending on personal experiences. We all have perceptions of what constitutes wilderness, which can depend on cultural, recreational, or geographical factors. Legally, wilderness is "a large area of unmodified or slightly modified land, and/or sea retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition." This definition is intended to protect and conserve our remaining wilderness areas and their many values. One of the many values of the wilderness is its support for the species diversity that keeps the watershed thriving. Before exploring that, we should understand the anatomy of our friendly neighborhood river.

There are more than 250,000 rivers in the United States, but only 78 major river basins. This is possible because rivers are actually vast networks, with many smaller rivers feeding into larger ones. These tributaries help funnel water through the watershed until it ends up at a pond, lake or ocean. This downstream area is the river's mouth, the stretch of river that widens as it approaches these larger bodies of water. Sediments, nutrients, and other materials fall here in the delta as the water slows and spreads out. The largest river in our watershed is the Delaware River, but there might be a smaller tributary closer to your home.

What makes up a river? There's more to our rivers than what we might imagine in our heads. Perhaps most easily recalled is the riverbank, the land next to the river. In a healthy watershed this land is populated by streamside trees and other vegetation that makes up the riparian zone. This green zone is important to the biodiversity of the river, providing a nutrient-rich area for ecosystems and filtering runoff and underground water as it seeps back into the river. The roots of an established riparian zone also decrease erosion from floods, a problem encountered in Unit 2. The actual shape of the earth holding the river is the river channel. There are many different river channels shapes, each with unique benefits to the local ecosystems. Channels can be wide, change, cross over one another, or stay contained within steep riverbank walls. Less apparent are the floodplains, the low flat areas next to rivers that flood and relieve rivers when the water overruns the riverbank. Flooding helps manage the flow of the river during storms, protecting downstream habitats from fast and damaging floodwaters.



In Unit 2, we learned about the Delaware River's headwaters, the actual start of the river. Our headwaters come from underground springs, but not all headwaters are the same. Rivers can start from marshy areas fed by snow, many smaller streams, or a single lake or pond. However they begin, the headwaters are vital to the rest of the rivers because what happens upstream affects habitats and communities downriver. These water networks connect us, demanding cooperation to maintain the health and security of everything and everyone living in the watershed.

Let's jump back to the life support value of the river. This is especially important in the wilderness as we can study natural processes in this untouched land to better understand our environment. The mountain habitat showed us that balance between the water cycle and human needs is critical for a stable self-sustaining watershed. This is true for the other wildlife living in a watershed. We share this planet, and plants and animals will always be affected by the water cycle, and therefore by humans. Protected wilderness provides a refuge for animals to thrive in established ecosystems that support biodiversity.

The food chain is balanced to achieve a self-sustaining, biodiverse ecosystem. Producers, consumers (carnivores, herbivores, and omnivores) and decomposers rely on each other for food. Nutrients and energy cycle through an ecosystem as much as water does, although they travel through the trophic levels, absorbed from the level below. In this way, the layers rest on one another, the producers at the base getting their energy from the sun. However the relationships are rarely a simple chain.

Unit 3 - Teacher Background (cont.)

The web explored in the lesson activity is a closer representation of the very complex connections between various levels. This interconnectivity shows the need for biodiversity to support the diverse ecosystems and sustain multiple food sources for organisms.

Biodiversity might seem like a big, abstract concept more applicable to a rainforest or exotic location, but it can be found anywhere, even in your home. From the spiders in your attic to the weeds in your front yard, biodiversity is all around us. It is the variety of life on earth, but its multidimensional. It encompasses variety in genes, species, ecosystems, and ecological process of every living thing. All of these living organisms, including ourselves, fit into ecosystems, and these ecosystems interact with one another. The case for biodiversity can take several forms. However, scientifically biodiversity increases the stability and chances of an ecosystem's survival. From pollination of our food to medical discoveries, we also rely on biodiversity to sustain our own activities. However you value the need for biodiversity, there are very real threats to it that could create much larger problems down the line.

Things like habitat loss, pollution and resource depletion are part of a much more complex problems. However, as humans, we have the power to act responsibly as stewards of our planets, and of our wilderness. Whether you see it as an exciting place to explore nature's secrets, a recreational backdrop for outdoor activities, or just a good spot to enjoy the scenery and wildlife of the natural world, the wilderness is an important part of the watershed.

Unit 3 - Key Vocabulary

Carnivore
A "meat eater" or an organism that feeds mainly on other animal tissue for energy and nutrients

Carrying Capacity
The size of a population an ecosystem can support indefinitely with the available resources and services in that ecosystem

Channel
An area that contains flowing water confined by banks

Community
All of the different species populations that are living in the same area and interacting with one another

Consumer
Heterotophs, organisms that cannot create their own food and must eat other organisms

Decomposer
Organisms that break down organic matter in an ecosystem for energy and nutrient

Delta
The end of the river where it fans out to meet an ocean, lake, or wetland, water slows and deposits sediments as it drains into the larger body of water

Detritus
Organic material that is composed of dead plant matter, animal matter, and animal waste

Detritivore
Organisms that eat decomposing matter such as animal waste and dead remains of animals and plants

Ecology
The branch of biology that studies interactions among organisms and their environments

Ecosystem
A biological community of all the populations in an area that are interacting and their physical environment

Energy Cycle
The movement and transfer of energy through an ecosystem

Environment
Ecology — the air, water, minerals, organisms and all other external factors surrounding and affecting a given organism at any time

Floodplains
The low flat areas next to rivers that are periodically flooded when the riverbank overflows

Food Chain
The linear succession of a hierarchical series of organisms in a food web, each dependent on the previous as a source of food, starting from producers

Food Web
The connections between a network of organisms and food chains representing the feeding relationships in an ecosystem

Forest
A large area dominated by dense tree growth and underbrush

Headwater
A tributary stream of a river close to or forming part of its source

Herbivore
Organisms who only eat consumers, plant matter, for nutrients and energy

Habitat
The natural environment a particular plant, animal, or other organism occupies, characterized by physical and biological features

Unit 3 - Key Vocabulary (cont.)

Nutrient Cycle
The movement and exchange of organic and inorganic matter in a cycle, nature's recycling system

Omnivore
Organisms that eat both plants and animals for nutrients and energy

Organism
A living thing, animal, plant, or single-celled life form

Population
A group or organism of the same species that are living in the same area and interacting with one another

Primary Consumers
Herbivores, organisms that feed on producers

Primary Producers
Organisms that make their own food from sunlight and / or chemical energy

Producer
Autotrophs, organisms that capture sunlight for energy to to create their own food

Riverbank
The land next to a river, usually populated with trees and other vegetation that slow erosion of the bank and filter pollutants

Secondary Consumers
Organisms that eat primary consumers, can be carnivores or omnivores

Trophic Structure
The hierarchy or organization of organisms based feeding relationships, showing paths of energy flow and chemical cycles

Tributary
A stream or river that flows into a larger stream or main river or lake instead of directly into a sea or ocean.

Water Cycle
Or the hydrological cycle, the continuous movement of water through Earth, from the ocean, atmosphere, and land

Wilderness
A large area of unmodified or slightly modified land, and/or sea retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition (legal)

Unit 3 - Variations, Extensions, and More

My River Runneth Over
To expand upon the river anatomy spend some more time looking at the river bank, and what happens when it overflows. Floodplains are an important part of the river system, but human activity interrupts their use. Have students identify how and why floodplains are restricted. What are the dangers of this? How might we design better floodplain management?

– What is Floodplains by Design?
Video - 6 minutes

Little Bug, Big Problems
One of the factors that can throw off the balance of an ecosystem is an invasive species. It doesn't even matter how big the intruder is! We've seen how connected the food web really is, so even a small change will be felt throughout the system. This video shows the devastation caused by a tiny beetle. Have students watch this video and discuss what this means for the rest of the habitat. Students can research other invasive species that are in the Delaware River ecosystem.

– National Geographic: Life of Pine
Video - 6 minutes

Dead But Delicious
Humans are usually located at the upper end of an ecosystem's food chain. But life on the bottom levels is just as important. We rely on the decomposers who are always cleaning up after the rest of the ecosystem. What is it like to survive on dead matter and plant waste? Have students select an organism from the wilderness habitat that is a decomposer, such as a black slug or worm. They will compose a narrative describing a day in the life of this organism. They should include the 5 components of a short story: character, setting, plot, conflict, and theme, as well as their strategy for survival.

– Ted Ed: Dead stuff - The secret ingredient in our food chain
Video - 4 minutes

Discussion Questions

– What components make up a river?
– Where are these located on the Delaware River?
– What is a trophic structure?
– What is the primary source of energy?
– How does energy move through an ecosystem?
– What is the roles of a producer? Consumer? Decomposer?
– How they are related?
– What happens if the balance of the food chain is thrown off?
– What factors impact an ecosystem's ecology?

Unit 3 - Lesson Links

Into the Wild

FuseSchool: Ecology
Video - 3 minutes
https://www.youtube.com/watch?v=bvqN9H3QtTQ

Forest Fact Break
Video - 2 minutes
https://www.youtube.com/watch?v=dIT5W936FWA

Variations and Extensions

What is Floodplains by Design?
Video - 6 minutes
https://www.youtube.com/watch?v=-PBT4OEJfGs

National Geographic: Life of Pine
Video - 6 minutes
https://www.youtube.com/watch?v=vR30qlK0-Cw

Ted Ed: Dead stuff - The secret ingredient in our food chain
Video - 4 minutes
https://www.youtube.com/watch?v=KI7u_pcfAQE

Additional Resources

Crash Course: Ecosystem Ecology
Video - 10 minutes
https://www.youtube.com/watch?v=v6ubvEJ3KGM&list=PL8dPuuaLjXtNdTKZkV_GiIYXpV9w4WxbX&index=7

FuseSchool: What is Biodiversity?
Video - 4 minutes
https://www.youtube.com/watch?v=_bk2nnDI68g

TED-Ed: The Threat of Invasive Populations
Video - 5 minutes
https://ed.ted.com/lessons/the-threat-of-invasive-species-jennifer-klos#watch

UNESCO Learning to Protect Biodiversity
Video - 3 minutes
https://www.youtube.com/watch?v=kHhspf5IfdE

American Rivers: What Makes A River?
Website
https://www.americanrivers.org/rivers/discover-your-river/river-anatomy/

Forests to Faucets
Website
https://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml

Ecology Without Wilderness
Article
https://www.theatlantic.com/technology/archive/2011/09/ecology-without-wilderness-tending-the-global-garden-we-call-nature/245170/

10 Surprising Wild Animals Spotted in Philadelphia
Article
https://www.phillymag.com/news/2015/04/05/10-surprising-philadelphia-wild-animals/#gallery-2-2

Peregrine Falcons in Philly City Hall Nest
Article
https://www.phillyvoice.com/philadelphia-peregrin-falcon-chicks-hatched-city-hall-nest/

Unit 3 - Lesson Links (cont.)

Philadelphia - Biological Resources
Website
http://www.phillywatersheds.org/doc/Delaware_RCP_Section_6.pdf

PA Fish Species
Website
https://www.fishandboat.com/Fish/PennsylvaniaFishes/GalleryPennsylvaniaFishes/Pages/PASpeciesWatershed.aspx

D - UNIT 4 APPENDIX

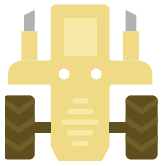
Unit 4 - Teacher Background

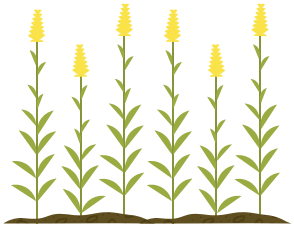
Growing Our Future

With this unit, we arrive at the first scape that is entirely defined by human activity. The Delaware River Watershed sees a wide range of agricultural activity within its boundaries. Cattle, poultry, mushrooms, apples, pears, grapes, and dairy products such as milk and cheese are just some of the foods grown on farms here. In fact, 27% of land in the watershed is used for agriculture, either for crops or as pasture for livestock. This amount is second only to forested land in the watershed!

The shift from hunting and gathering to farming is a pivotal point in human history. It changed not only the way we feed ourselves, but our diets and our social structures. Today, we wouldn't be able to survive without the increasingly complex agricultural systems in our country. From industrial farms to family farms, agriculture keeps our country running, both with food and in some cases (such as ethanol and methane) with energy. Think about the food in your cabinets or refrigerator at home. Almost all of the products on the shelf can be traced back to the land it was grown from, not just the raw vegetables and pure grains like flour. A simple loaf of bread contains flour, salt, sugar, yeast, butter and possible more. All of these ingredients need to be grown and harvested on a farm somewhere before they can be put into your bread. Constructing a food web in the first part of this unit's lesson is designed to instill that understanding in students. We rely so heavily on the earth to feed us with even the simplest of meals. We must take care of the land while we farm it so it is healthy enough to continue feeding us.

In order to protect the earth, we need to understand the impact of agricultural activity and the resources it demands. About 50% of the land in America is used for agriculture, creating many opportunities for impact on our watersheds. However, even as our population continues to grow and the demand for food increases, the proportion of land used for agriculture has been decreasing since the 1940s.In addition to large land needs, agriculture is a water intensive process, with meat being especially water intensive. 80% of our consumptive water use in the United States is for agriculture. This is not only used for crops and livestock that feed us, but growing feed for the livestock as well. Poor or outdated infrastructure on farms can lead to excessive water leakage, increasing consumptive water use. Efficient irrigation and water management prices can help reduce water use for crops, and at the very least make sure water is not being wasted in the agricultural processes. We learned earlier the impact on the water table of well drilling and pumping for water use. Making agricultural water use as efficient as possible only helps maintain the balance in the watershed we know is so important.





An important part of maintaining that balance is restoring and maintaining a natural feature of the river bank: the riparian buffer. From improving water quality, managing erosion, and increasing biodiversity, riparian buffers are a vital component to the health of the river and the watershed. A riparian area is the strip of land along a river, pond, stream, or wetland before it transitions to the uplands. This land becomes a riparian buffer when it is vegetated with trees and plants that act as a natural protective layer between the river and the surrounding land. Wider buffers offer more effective protection and stability for the body of water. They distance human activity from direct contact with the river and increase the capacity of the protective layer.

Improved water quality is a major component of the impact of the riparian buffers. We learned earlier how water moves through soil as it returns to groundwaters or surface waters. With a riparian buffer, water must travel through the vegetated area, and on the way sediments are trapped, and nutrients and pollutants are reduced or removed. A river's pollutant can be a plant's food. Materials suspended in infiltrating water get trapped in the soil and then are taken in and used by plants. Nutrients that are dissolved can chemically bond with certain kinds of soil particles. These are then also used as food for plants. Agricultural activity in farmlands produces significant pollutants, due to manure,

Unit 4 - Teacher Background Continued

fertilizers and pesticides. These can make their way to our surface water and groundwater as stormwater runoff and infiltration during irrigation. While not everything can be filtered by the plants along a riparian buffer, its presence goes a long way in cleaning surface runoff and underground water to keep pollutants out of aquifers and rivers and stopping them from continuing to travel downstream.

Riparian buffers are also excellent at protecting the river from erosion and sediment pollution. The presence of a buffer physically distances activity from the river, reducing the direct impact to the riverbank. Buffers reduce erosion by slowing the speed of runoff and reducing the volume of runoff as well. This increases the water's potential for infiltration and gives plants the chance to clean the water of pollutants. The vegetation also creates obstacles and slows the speed of the river during storms, reducing erosion and flood water damage to the land beyond the buffer. Finally, the root system of the vegetation in a riparian buffer stabilizes the structure of the bank and reduces erosion as well.

We see how important maintaining established, healthy riparian buffers are as a benefit to the river and to farmers as well. Again, the key to a healthy watershed is balance. While agriculture and its related activities can have a negative impact, there is a potential to reach a balance between the local river ecosystem and farmland. Responsible agricultural practices supported by responsible consumer habits can set a new standard for stewardship in this highly human focused habitat.

Unit 4 - Key Vocabulary

Agriculture
Cultivation of land to produce crops and raise livestock for food, fiber, medicine, and other products

Aquaculture
The farming of plants and animals that live in water

Crops
A plant or animal product that is grown and harvested for profit or for substance

Desertification
The degradation of once fertile land to desert as a result of drought, deforestation, or irresponsible agriculture practices

Erosion
The process where solid material is removed from a surface with the force of wind or water

Fertilizer
A chemical or natural material that is applied to soil, plant tissues, or land to increase land fertility by supplying nutrients essential for growth

Irrigation
The controlled application of water for agricultural purposes through man-made systems to supply water needs not satisfied by rainfall

Leaching
The process by which soluble materials in the soil are carried deeper into the soil or are carried away by water, can be salts, nutrients, pesticides, or other chemicals

Livestock
Domesticated animals raised for labor and commodities like their meat, eggs, milk, leather, etc.

Livestock Water Use
The water used for livestock, watering, feed lots, dairy operations, fish farming, or other farm needs

Nonpoint Source Pollution
Pollution that accumulates from a contamination across a widespread area, not one specific location, that is carried by surface runoff to lakes and streams

Pesticides
Any substance used to kill, repel, or control specific forms of plant or animal life that are considered pests

Point-source Pollution
Pollution that originates from a single point, such as a sewage outflow pipe

Pollutant
A substance that is introduced into an environment and has undesired effects or adversely affects the usefulness of the resource

Riparian Water Rights
Rights of a land owner whose property abuts water, differ from state to state

Riparian Buffer
The natural vegetation form the edge of a stream bank out through the riparian zone, filtering pollutants, slowing runoff, controlling erosion, and providing a habitat and nutrients for the river or stream

Unit 4 - Key Vocabulary (cont.)

Sediment
The particles carried and deposited by waters of rivers, lakes, and oceans

Sedimentation
The process where particles in suspension in water, sediment, settle or are deposited

Soil Salinization
The process where water-soluble salts accumulate in soil, increase the salt content of soil

Spray Irrigation
Irrigation method where water is shot from high-pressure sprayers onto crops, some water is lost to evaporation with this method

Topsoil Loss
The loss of the top, fertile layer of soil due to erosion

Unit 4 - Variations, Extensions, and More

It Grows Where?
For an additional challenge, have students research online where the food in their maps is being grown as well as where it was originally grown. For instance, California grows almost ¾ of all of the fresh head and leaf lettuce in the United States. However, lettuce is not native to the Americas. Students can also find where the ingredients from their meal originated. Who has the most diverse meal? Students can also discuss the environmental costs of shipping food grown across the country all the way to the supermarket in our neighborhood.

– Origins and Primary Regions of Agricultural Crops

Potent Pollutants
Students can take the case study a step deeper by learning more about the pollutants coming from Farmer John's land. Agricultural pollution is a global problem. So much, that the United Nations released a comprehensive study on the water-quality crisis and agriculture's role. Page 12 of the UN's global review will help students categorize the pollutant from the case study and pages 11-16 explain more about the causes of these pollutants. Students should pick a category to learn more about the methods used to avoid them.

– Water Pollution From Agriculture - A Global Review

Still Buffering
Farmer John's example shows the positive effects of rebuilding riparian buffers. Farmers in Lancaster, PA also know this. They're even able to use the plants in the buffer as crops. After watching the video, have students discuss the kinds of plants being used to restore the riparian buffer and why. Then use the UV article to design a riparian buffer that farmer John could use.

– Riparian Buffer Building
– Grow Agriculturally Productive Buffers

Discussion Questions

– What is agriculture?
– What resources are needed to support agriculture?
– What are the ways water is used in agriculture?
– What is the human water cycle?
– What is soil salinization? How does this affect agriculture?
– What practices are farmers and scientists using to safeguard the watershed?
– How is tech being used in agriculture?
– What kinds of pollutants can occur as a result of agriculture?
– What is a riparian buffer?
– How can it help the river?
– How can it help the watershed?

Unit 4 - Lesson Links

Something in the Water

Human Water Cycle: Agriculture
Video - 5 minutes
https://www.youtube.com/watch?v=5b-zbSWG8e8

Riparian Management: Increasing Biodiversity on Farms
Video 2 minutes
https://www.youtube.com/watch?v=YiaxoTkhnBA

Variations and Extensions

Origins and Primary Regions of Agricultural Crops
Map
https://cgspace.cgiar.org/bitstream/handle/10568/75665/PRINT_origin-species-world-map-v9_hires_poster%20EN.pdf?sequence=1&isAllowed=y

Water Pollution From Agriculture - A Global Review
Report
http://www.fao.org/3/a-i7754e.pdf

Riparian Buffer Building
Video - 2 minutes
https://www.lancasterfarming.com/farm_life/conservation/riparian-buffer-building/video_9c828806-ebff-11e7-9c3c-5b355fafcbaf.html

Grow Agriculturally Productive Buffers
Handout
https://www.uvm.edu/seagrant/sites/default/files/uploads/publication/ag_productive_buffers_-_farmer_handout___fall_2013_small.pdf

Additional Resources

CIAT Website
Website
https://blog.ciat.cgiar.org/origin-of-crops/

Radical Cartography
Website
http://www.radicalcartography.net/index.html?crops

Americans Love Spices. So Why Don't We Grow Them?
Article
https://www.npr.org/sections/thesalt/2017/12/26/572100613/americans-love-spices-so-why-don-t-we-grow-them

Protecting Water Quality from Agricultural Runoff
Handout
https://nepis.epa.gov/Exe/ZyPDF.cgi/P10039OH.PDF?Dockey=P10039OH.PDF

Riparian Buffers for Wildlife
Article
https://extension.psu.edu/riparian-buffers-for-wildlife

Riparian Buffers: Types and Establishment Methods
Article
https://www.uaex.edu/publications/pdf/FSA-5027.pdf

E – UNIT 5 APPENDIX

Unit 5 - Teacher Background

Our Waters Keeper

Urban and suburban habitats are the pinnacle of human activity. Nowhere else is the presence of people so distinctive and defining of an environment. These densely populated areas see a decrease in pervious land and vegetation, replaced by pavement, houses, and skyscrapers. Living in this setting, we as people become accustomed to a distant relationship with our watershed. In lesson 1, we noted how easy it is to forget where our water comes from when we turn on the tap. Now, we must realize how easy it is to also overlook what happens to our water after it goes down the drain. The sink drain, the shower drain, even the storm drains along our streets funnel water away and keep it out of sight and out of mind. However, the journey water takes once it's out of our sight is incredibly important and inherently tied to what comes out of the faucet.

Liquids that are poured down the sink for flushed are either taken to a sewage system or a septic system. Septic systems manage waste water on site using bacteria to breakdown the waste in the water. However, septic systems need to be pumped periodically, to remove the sludge left behind or they will not continue to function. Sewage systems are a much larger network of huge underground pipes that bring waste water to be cleaned at a central treatment plant before releasing it back into a local body of water. In Philadelphia, the sewage treatment plant releases water back into the Delaware river. There was a time when there were no treatment plants in place in cities and waste was dumped directly into the river. Even today, outdate pipes of an older city like Philadelphia can leak and dump waste directly into our rivers and streams. Philadelphia has made an extensive effort to reduce these sources of point pollution to improve the health of the river. Still, there are other characteristics of an urban area that create a different kind of pollution.

We know that when it rains, some of the precipitation is absorbed through pervious surfaces, allowing it to enter the ground and recharge our aquifers. However, in the urban/suburban habitat, there is an distinct shift in proportion of pervious to impervious surfaces. Impervious surfaces, such as sidewalks, roads, roofs, do not allow water to pass through them. Water coming off of these surfaces needs somewhere to go, which is why cities have established stormwater infrastructure. Storm drains pull water off of the streets and funnel it to a water treatment plant. The more impervious surfaces there are, the higher volume and speed the stormwater flows at, putting extra strain on stormwater management systems. However, because stormwater must travel across impervious surfaces to reach the drains, they are susceptible to other pollutants along the way. As water moves to storm drains, it picks up everything along the way. From spilled car oil to literal garbage, it all can end up in our drains. These kinds of non-point pollution don't come from any one specific source, rather it's an accumulation over time and surface area that create problems as water runs back into rivers or into the storm drains.

Philadelphia has a combined sewer system for about half of the city, meaning stormwater and waste are channeled in the same pipes to the treatment plants. This is common in older cities with aging infrastructures. During heavy rains, a combined sewer is more likely to overflow, with excess untreated waste and stormwater flowing into our rivers and streams. Newer areas in Philadelphia operate on a separate sewer system, meaning different pipes carry stormwater and waste. In our separate system, stormwater drains directly into the city's rivers. This can also increase pollutants because of untreated surface water collecting pollutants from impervious surfaces and directly dumping them in the river. Both systems face challenges, although much of the damaging effects could be alleviated by reducing the pollutants stormwater is exposed to in our cities.

In addition to drawing drinking water directly from aquifers, some areas supplement their water supply with surface water. In fact, Philadelphia draws all of its water from the surrounding rivers, the Delaware and the Schuylkill. The water that comes out of the tap needs to be safe to

Unit 5 - Teacher Background Continued

drink, so there are several stages in the cleaning process to ensure we have safe, potable water. This unit's lesson walks through these stages to give students an idea of how much effort goes into making drinkable water. First, water is pumped into reservoirs where it sits and gravity pulls larger particles out of suspension. It is then disinfected with sodium hypochlorite. Next is coagulation & flocculation. In this stage, chemicals are used to clump finer particles particles together with the help of some gentle mixing. These clumps are called "floc." Once again, gravity is used to settle the floc out of suspension during sedimentation. The water is disinfected with sodium hypochlorite one more time before being sent through a series of filter which are able to remove even microscopic particles. The final step is adding fluoride, zinc orthophosphate, and ammonia before sending out for use by the city. Philadelphia treats and distributes 250,000,000 gallons of water everyday. This is done among Philadelphia's three waste water treatment plants.

It's also incredibly important for the health of the river and for ourselves, that the water we put back after use isn't adding more pollutants to the water we drink from. Wastewater and stormwater that is directed to treatment plants are thoroughly cleaned before being returned to the river. Waste treatment is also a multistep process but is not explored in this activity. However, it uses some similar processes to the drinking water treatment. After being pumped through the sewers to a treatment plant, the wastewater is passed through screens, removing the largest pieces of trash and debris. Next water is slowed down so smaller debris is removed by gravity, falling to the bottom. This grit is sent to a landfill. Gravity is also used in the next stage, to settle suspended solids and let oil and grease rise to the top. In the aeration and biological reduction stage, air and waste eating microbes are added to the water to remove the remaining contaminants.Gravity is used again to settle the microbes out of the water. The last step is disinfection, where sodium hypochlorite is added to kill any remaining organisms in the water. Finally, this cleaned water is ready to be put back into the rivers, free of pollution and contaminants.

The urban / suburban scape gives us the chance to examine not only our impact on the environment, but also the methods we've developed that have become a part of naturally occurring process. The waste treatment process is part of the urban water cycle, an addition to the natural water cycle that compensates for our water use. We are able to see an intersection of human activity and nature that works together to ensure a balanced watershed. While there still is much to do to alleviate the pollution caused by the urban impervious, we can see it is possible for our needs not to harm the natural processes we rely on.

Unit 5 - Key Vocabulary

Aeration
Process by which air and waste-eating microbes are added to water to remove contaminants

Coagulation
Process where chemicals are added to the wastewater so particles in suspension clump together

Combined Sewer
A series of pipes making up a drainage system that collect and transport stormwater and wastewater

Disinfection
Process where sodium hypochlorite is added to wastewater to kill disease-causing organisms

Erosion
The process where solid material is removed from a surface with the force of wind or water

Filtration
Process where water flows through filters of varying porosity to remove microscopic particles

Impervious surface
A surface that water cannot pass through

Infiltration
The part of the water cycle in which water passes through (a substance) by filtering or permeating or penetrating its pores

Nonpoint source pollution
Pollution that accumulates from a contamination across a widespread area, not one specific location, that is carried by surface runoff to lakes and streams

Pervious Surface
A surface that water is able to pass though

Point Source Pollution
Pollution that originates from a single point, such as a sewage outflow pipe

Pollutant
A substance that is introduced into an environment and has undesired effects or adversely affects the usefulness of the resource

Precipitation
The part of the natural water cycle in which rain, snow, sleet, or hail falls from the atmosphere to the ground

Rain Garden
A planted depression or hole that allows rainwater runoff from impervious surfaces to be reabsorbed into the soil

Stormwater Runoff
The part of the water cycle in which water flows off the land into the nearest body of water

Sanitary Sewer
A series of pipes that collects and transports only wastewater

Unit 5 - Key Vocabulary (cont.)

Sedimentation
The process where particles in suspension in water, sediment, settle or are deposited

Stormwater
Precipitation that falls on the ground and flows to the sewer system as runoff

Stormwater Runoff
The flow of rainwater that occurs when the precipitation rate overtakes the infiltration and percolation rates

Storm Sewer
A series of pipes making up a drainage system that only collect and transport stormwater

Surface Water
Water that collects on the surface of the ground

Waste Water
The water that leaves our home

Waste Water Treatment Plant
A facility designed to treat municipal wasterwater, cleaning and treating the water before releasing it back into surface water collection systems, like the river

Unit 5 - Variations, Extensions, and More

The Pavement Next Door
To bring this lesson closer to home, use the local context of the school to calculate impermeable surfaces and rain runoff. Use google maps or google earth to capture an image of the school and enough surrounding area to make a comparison. Be sure to include the image's scale for students to use when measuring. Ask students to discuss times they've seen signs of flooding or collection of water on impermeable surface at school. Why did that happen?

Wastewater What?
We learned how river water is made drinkable, but what happens when we've used that water? How do we clean all the storm runoff that has collected pollutants from impervious surfaces? Wastewater processing is the second half of the water treatment cycle ending with discharging the clean water back into the river to be used another day. After watching this pollution control video, have students diagram each step of the wastewater process. Compare this to the diagram created in the lesson. How is this different from the steps in the experiment? How is it similar?

– Urban Water Cycle: Pollution Control
Video - 4 minutes

Drainage by Design
We've learned that urban areas can create serious drainage problems for stormwater, risking the spread of pollutants into our water. But there is hope! People have been hard at work imagining new ways the urban can exist in the watershed. Have students watch these videos and research sustainable practices. Students will design and diagram new drainage systems and features for the school, or local public facility that embody these principles in exciting ways. When presenting to the class, students should explain their design inspiration and intent with their plan.

– Susdrain: Sustainable Drainage
Video - 4 minutes
– Landscape Institute: Water Sensitive Urban Design
Video - 4 minutes

Discussion Questions

– What is unique about the urban habitat?
– What is an impervious surface?
– What is a pervious surface?
– How does the relative ratio of these surfaces affect runoff?
– How have we adapted to manage runoff in urban areas?
– What are the hazards associated with urban runoff?
– How do we remove pollutants from runoff?
– How do we remove pollutants from drinking water?

Unit 5 - Lesson Links

Pollution You Can't Point At

Urban Water Cycle: Water Treatment
Video - 3 minute
https://vimeo.com/276103615

Variations and Extensions

Urban Water Cycle: Pollution Control
Video - 4 minutes
https://vimeo.com/276103310

Sustainable Drainage
Video - 4 minutes
https://www.youtube.com/watch?v=LMq6FYiF1mo&feature=youtu.be

Water Sensitive Urban Design
Video - 4 minutes
https://www.youtube.com/watch?v=b_DTnOzYTR4

City of Philadelphia: Philadelphia's Water Story
Handout
https://www.phila.gov/water/PublishingImages/MainStoryPoster_reduce.jpg

Philadelphia 2017 Drinking Water Quality Report
Report
https://www.phila.gov/water/wu/Water%20Quality%20Reports/2017-Water-Quality-Report.pdf

Nassau SWCD: Stormwater Pollution & Green Infrastructure Solutions
Video - 30 minutes
https://www.youtube.com/watch?v=ATNy-vaIPXI

EPA Protecting Water Quality from Runoff
Handout
https://nepis.epa.gov/Exe/ZyPDF.cgi/20004PP1.PDF?Dockey=20004PP1.PDF

Delaware DNREC: Stella Ellis Stream Restoration
Video - 3 minutes
https://www.youtube.com/watch?v=O-4YX6gmGIA

Additional Resources

City of Philadelphia: Treatment Process
Handout
https://www.phila.gov/water/PublishingImages/WaterDiagramPoster.jpg

City of Philadelphia: Water Utility
Website
https://www.phila.gov/water/wu/Pages/default.aspx

F – UNIT 6 APPENDIX

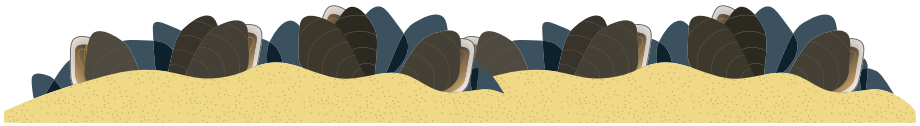
Unit 6 - Teacher Background

Waters Keeper

The Delaware River watershed's coastal scape is the last stop before water meets the ocean. Here, water travels through a robust estuary that provides a unique home for fish, birds, and other wildlife. Estuaries are partially enclosed transitional zones where freshwater and saltwater mix as a river or creek meets a tide flowing in and out, such as river mouths, coastal bays, tidal marshes, lagoons, and deltas. The Delaware Estuary is actually quite large, covering land in Maryland, Pennsylvania, New Jersey. It comes quite far inland, all the way up to Trenton, New Jersey and up to Pottsville, Pennsylvania. The city of Philadelphia actually lies within the Delaware Estuary.

The Delaware Estuary is unique because it is almost entirely surrounded by tidal wetlands. Wetlands are areas of land that are saturated with water either all the time or seasonally. The wetlands are an important natural resource that help us maintain the health of the watershed as a whole. The meeting of fresh and salt water to create a brackish mixture provides a unique habitat for species. These conditions create an incredibly biodiverse ecosystems. Wetlands are home to both aquatic and land dwelling creatures. Feeding, spawning, and nursery activities all occur in the wetlands for a variety of species that continue their journey to other habitats.

Much like the riparian buffers served as a protective layer for the river further upstream, coastal wetlands act as a buffer between the ocean and other habitats. They are like big sponges, absorbing nature's excess. They absorb excess water during storms and reduce flooding. This reduces erosion due to flooding. The wetlands also prevent shoreline erosion. Their lush vegetation stabilizes the soil with roots creating obstacles that slow water's movement. The ability to hold large quantities of water also makes them effective at recharging wells and aquifers when needed. Wetlands are highly vegetated, providing a lot of capability to filter and clean water. They absorb excess carbon, sediments, and other pollutants, releasing less toxic forms or incorporating them into the plant until it dies.



While coastal wetlands are able to absorb so much, they cannot absorb everything. Maintaining a healthy wetland is critical to continue benefiting from their natural buffering ability. One way we are able to gauge the health of our ecosystems is through monitoring biological indicators. Bioindicators include plants, animals, microorganisms used to track changes in an environment over time by monitoring one of three things: the physical or chemical changes in the environment, ecological processes or biodiversity. Bioindicators can be aquatic or land dwelling, depending on the environment being studied. Bioindicators must have particular qualities that make them ideal to represent the ecosystem. They generally have a moderate tolerance to variability in their environment. If they were too intolerant, their population would change too quickly to allow measurement of a population response over time. Species with too high tolerance wouldn't register any reaction to conditions that were affecting other species. Bioindicators generally have a mid range tolerance, but are considered in total to give a more comprehensive picture of how an environment is changing. Bioindicators also must be abundant and common, having a stable, local population density that allows them to be easily found. They must be well studied, so their tolerances and reactions to environmental stressors and changes are known and can be used to infer the health of the river.

In this lesson we look specifically at macroinvertebrates, organisms without a backbone that can be seen with the naked eye. They exist in large quantities with diverse habitat preferences in any given location, with about 40 identifiable species in a healthy river. This range of species and ideal conditions allows scientists to record ecological responses to a variety of different stressors and disturbances, such as sediments, metals, or nutrients. Their suitability to the role of bioindicator has made macroinvertebrates the go-to in stream monitoring. Every state in the U.S. relies on aquatic macroinvertebrates as stream bioindicators.

Unit 6 - Teacher Background Continued

In addition to macroinvertebrates, different kinds of organisms can be used as bioindicators. Algae blooms can be used to indicate changes in aquatic environments, such as increases in nitrates and phosphates. Pollution in soil can be measured by the quantity of worms, as well as the functioning of their nervous systems. Lichens are another type of bioindicators. They live on the surface of things likes trees, rocks, or soil. These organisms get all of their nutrients from contact with the air because they have no roots, making them ideal to measure toxins in the air. The amount and types of lichens in an area can tell us a lot about the level of pollution because different species have different susceptibilities to pollution.

Unfortunately maintaining a healthy wetlands is not enough. Our wetlands are at risk from both human and environmental influences. The United States has been losing wetlands at an increasing pace. From 2004-2009, the Atlantic Coast lost 111,960 acres of wetlands. This is largely due to rural or urban development. Development near wetlands can also be detrimental, disrupting how water flows in and out of them. Rising sea levels and increasingly violent storms also degrade the wetlands, submerging them and surpassing their capabilities to stop erosion. This alone leads to a loss of about 1 acre per day and diminishing health of other wetlands. Unhealthy wetlands can't fulfill the same biological services, but when we lose the wetlands entirely we lose the ecological services they provide, such as clean air, clean water, and incubation of species. Not only do we need to keep our wetlands healthy, we also need to act to restore our wetlands.

Unit 6 - Key Vocabulary

Bay
A body of water that is partly surrounded by land in an inlet

Benthic Macroinvertibrates
Small animals living among stones, logs, sediments, and aquatic plants on the bottom of streams, rivers, and lakes

Bioindicators/Biomonitor
An organism whose status in an ecosystem is analyzed as an indication of the ecosystem's health

Brackish
Water that is slightly salty because it is the mixture of river water and seawater in estuaries

Buffers
Estuaries and their wetlands that stabilize shorelines by reducing erosion and storm surges

Coastal Erosion
The loss of coastal lands due to the removal of sediments or bedrock from the shoreline

Delta
Area at the mouth of a river with large fan-shaped deposits of sediments

Estuary
A partially enclosed body of water and surrounding habitats where oceanic saltwater mixes with freshwater from a river or stream

Flagship Species
A species chosen to raise support for biodiversity conservation in a given place or social context

Foundation Species
A species that has a strong role in structuring a community, whose existence provides shelter and suitable habitat for other organisms in an ecosystem

Freshwater
Naturally occurring water that is not seawater or brackish water

High Tide
The state of the tide at its highest level

Indicator Species
Species chosen to represent the status of an ecosystem because of their ability to be observed, ability to be sampled, sensitivity to environmental conditions, and consistent reaction to environmental changes. See Bioindicators / Biomonitor

Keystone Species
A species on which other species in an ecosystem largely depend, their removal would have a disproportionately large effect on the ecosystem

Salinity
The measure of salts dissolved in water, usually measured in parts per thousand (ppt)

Tide
The cyclic rising and falling of the ocean's surface due to tidal forces of the Moon and Sun acting on the earth

Umbrella Species
Species selected for making conservation-related decisions, because protection of these species extends to protect many other species in the same ecosystem or habitat

Unit 6 - Variations, Extensions, and More

Will It Tolerate?
There's a lot more that goes into biological monitoring as a means to assess the health of an ecosystem or waterway. Have students read through this biological monitoring article with their Identification Guide to learn more about these tiny telltales. Then, have students classify the macroinvertebrates on the guide as sensitive to pollution, somewhat sensitive to pollution, and tolerant to pollution using the internet and the Onondaga Lake Watershed pdf.

– Biological Monitoring
Article

– Macroinvertebrates in Onondaga Lake Watershed
Handout

The Shore is Alive!
This lesson showed us one way people are restoring the bay, but there are so many different ways to support life in the bay. We know biodiversity is key to a health watershed and clean water, so why not create opportunities for river life to reclaim the bay through living shorelines. Students should watch the videos and read through the Partnership for the Delaware Estuary information about installations of living shorelines. How do they work? What are the additional benefits of living shorelines? What's the closest living shoreline installation?

– Living Shorelines
Videos - 4-8 minutes

Discussion Questions

– How does the tide characterize the bay habitat?
– Why is the bay exceptionally vulnerable to pollution?
– How do we monitor the health of the bay?
– What are macroinvertebrates?
– What can they tell us about an ecosystem?
– Why are they so well suited as biological indicators?
– What pollutants in the Delaware Bay are hurting biodiversity?
– Why do certain areas have less biodiversity than others?
– What can we do to improve the conditions of the bay?
– How does this help with biodiversity?
– How can this also help people?

Unit 6 - Lesson Links

All Paths Lead Here

New Jersey's Hidden Coast - Episode 5
Video - 5 minutes
https://youtu.be/HDBu3oxpMT4

Biological Monitoring - Invertebrates
Video - 3 minutes
https://www.youtube.com/watch?v=28j4D5o2RqQ

Threats to the Delaware River Basin
Interactive Map
https://www.delawarewatershed.org/#/map

Bay Bottom Inventory
Report
http://www.delawareestuary.org/data-and-reports/bay-bottom-inventory/

Identification Guide to Freshwater Macroinvertebrates
Handout
https://3jgs2o4a02n22u73bi2gnd3l-wpengine.netdna-ssl.com/wp-content/uploads/MacroKey_Complete.pdf

Variations and Extensions

Biological Monitoring
Article
https://dep.wv.gov/WWE/watershed/bio_fish/Pages/Bio_Fish.aspx

Macroinvertebrates in Onondaga Lake Watershed
Handout
http://static.ongov.net/WEP/wepdf/we1508j.pdf

Living Shorelines
Videos - 4-8 minutes
http://www.delawareestuary.org/science-and-research/living-shorelines/

Additional Resources

Knowledge Project - Bioindicators
Article
https://www.nature.com/scitable/knowledge/library/bioindicators-using-organisms-to-measure-environmental-impacts-16821310

Partnership for the Delaware Estuary - Water Quality
Report
http://www.delawareestuary.org/wp-content/uploads/2018/01/Chp3-water-quality.pdf

Delaware River Biomonitoring Program
Website
https://www.nj.gov/drbc/quality/reports/biomonitoring.html

Partnership for the Delaware Estuary - Aquatic Habitats
Reports
http://www.delawareestuary.org/wp-content/uploads/2018/01/Chp5-aquatic-habitats.pdf

Dragon Flies: Important Environmental Indicators
Article
https://www.biophiliafoundation.org/dragonflies-environmental-indicators/

Delaware Bay Habitat Survey
Report
http://www.delawareestuary.org/wp-content/uploads/2018/01/Chp5-aquatic-habitats.pdf

Delaware Coastal Programs
Website
https://dnrec.alpha.delaware.gov/coastal-programs/

Are Plastics a Problem in the Delaware Bay?
Article
https://www.capegazette.com/article/are-plastics-problem-delaware-bay/140234
Philadelphia Water Department - Life Aquatic
Article
http://www.phillywatersheds.org/category/blog-tags/life-aquatic?page=1

G – ADDITIONAL WEBSITE AND VIDEO LINKS

Additional Resources

Websites

Delaware River Water Basin Commission
https://www.state.nj.us/drbc/about/

Delaware River Watershed Initiative
https://4states1source.org/

Delaware Sea Grant
https://www.deseagrant.org/

National Oceanic and Atmospheric Administration Education
https://oceanservice.noaa.gov/education/

Penn State Water Lesson Plans
https://ecosystems.psu.edu/youth/sftrc/lesson-plans/water/9-12

Stroud Water Research Center
https://stroudcenter.org/

USGS Water Science School
https://water.usgs.gov/edu/waterquality.html

Water Conservation Tips
https://www.nationalgeographic.com/environment/freshwater/water-conservation-tips/

The Water Footprint Calculator
https://www.watercalculator.org/

Wiki Watershed
https://wikiwatershed.org/

Videos

Cheasapeake Bay Program - Bay 101
Video Album
https://vimeo.com/album/1579758

Chesapeake Bay Program - From the Fields
Video Album
https://vimeo.com/album/1771508

TED-Ed Environmental Science Lessons
Video Album
https://ed.ted.com/lessons?content_type=animations&category=environmental-science&direction=desc&sort=publish-date

WWF Watershed conservation
Video - 3 minutes
https://www.youtube.com/watch?v=aq_AydC77Gs

H - EXHIBIT EDUCATIONAL STANDARDS - HIGH SCHOOL

RIVER ALIVE! EXHIBITION EDUCATIONAL STANDARDS CONNECTIONS
HIGH SCHOOL (GRADES 9-12)

	Numerical Standard Designation	Standard Learning Goal	Exhibits: River Continuum Interactive Media Experience	Rate the Risks to the Watershed	Watershed Scapes Exploration Wall	Plankton Bloom Table	Nature's Highway Theater	River Window: Flow on Flow & Audio Stories of the River	Water Cycle Puzzle	Watershed Story Theater	Watershed Map Interactive Media Station	Watershed 3D Modeling Table	Fisharium Classroom & Aquaponics System	Watershed Life Cross-Sectional Wall	Watershed Data Visualization Media Station & Status of the Watershed Wall	Citizen Science Lab & Watershed Wellness Station	Available Program Lessons: Water Is Life	What Is Our Watershe	We Go Together	Let It Soak In	Into the Wild	Something in the Water	Pollution You Can't Point At	All Paths Lead Here
NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTIONS (NATIONAL) **Note: These national standards are also the state standards for New Jersey.**	HS-LS1-5 From Molecules to Organisms: Structures and Processes	Students discover that photosynthesis transforms light energy into stored chemical energy, along with a release of oxygen.	X			X							X	X		X			X			X			
	HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics	Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.	X			X					X				X	X			X			X			X
	HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics	Students explore evidence about factors affecting biodiversity and populations in ecosystems of different scales.	X		X	X							X	X	X	X			X	X		X			X
	HS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics	Students investigate the cycling of matter and flow of energy in aerobic and anaerobic conditions in a habitat.	X			X							X	X	X	X		X	X	X		X			X
	HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics	Students discover the cycling of matter and flow of energy among organisms in an ecosystem.	X			X							X	X	X	X		X	X	X		X			X
	HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics	Students evaluate the evidence about complex interactions in ecosystem that maintain organism populations in stable conditions, and how the ecosystem alters with changing conditions.	X	X	X	X							X	X	X	X		X	X	X		X			X
	HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics	Students investigate the possibilities and effectiveness of methods to reduce the impacts of human activities on the environment and biodiversity.		X	X			X			X				X	X				X			X	X	X
	HS-LS4-5 Biological Evolution: Unity and Diversity	Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.		X	X						X				X	X				X		X	X	X	X
	HS-LS4-6 Biological Evolution: Unity and Diversity	Students discover solutions to mitigate adverse impacts of human activity on biodiversity.		X	X			X			X				X	X				X			X	X	X
	HS-ESS2-5 Earth's Systems	Students explore the properties of water and its effects on Earth materials and surface processes.			X				X		X	X						X	X	X	X				
	HS-ESS3-3 Earth and Human Activity	Students discover relationships among management of natural resources, the sustainability of human populations, and biodiversity.		X	X			X	X		X				X	X				X			X	X	X
	HS-ESS3-4 Earth and Human Activity	Students evaluate solutions that reduce the impact of human activities on natural systems.		X	X			X			X				X	X				X		X	X	X	X
PENNSYLVANIA STATE STANDARDS (PENNSYLVANIA DEPARTMENT OF EDUCATION)																									
Subject Area 3: Science, Technology & Engineering Education	Standard Area 3.1: Biological Sciences																								
	3.1.12.A1	Students explore the ways organisms must derive energy from their environment or their food in order to survive.	X			X	X						X	X		X		X	X	X		X			X
	Standard Area 3.3: Earth & Space Sciences																								
	3.3.10.A5	Students explore the processes of the hydrologic cycle.			X				X		X	X						X	X		X				
Subject Area 4: Environment & Ecology	Standard Area 4.1: Ecology																								
	4.1.10.A	Students evaluate possible causes of population fluctuations, the idea of "carrying capacity" in an ecosystem, and how different factors threaten organism survival.	X	X	X					X			X	X	X	X		X	X	X		X	X	X	
	4.1.12.A	Students analyze the significance of biological diversity in an ecosystem, causes of biodiversity loss, and management laws meant to effect biodiversity.	X				X						X	X	X	X				X		X	X	X	
	4.1.10.B	Students explore the consequences of interrupting natural cycles.	X		X						X		X		X	X		X	X	X	X	X	X	X	X
	4.1.12.B	Students consider solutions to problems caused by interrupting natural cycles.									X				X	X		X	X	X		X	X	X	X
	4.1.10.C	Students discover how energy is converted from one form to another as it moves within a food web.	X			X	X						X		X	X		X	X						X
	4.1.12.C	Students explore human impacts from industrial, agricultural, and commercial enterprises on energy flow and the health of an ecosystem.		X	X						X				X	X			X	X			X	X	X
	4.1.10.D	Students investigate the relationship between habitat changes, plant and animal populations, and corresponding fluctuations in biodiversity.									X				X	X				X		X	X	X	X
	4.1.12.D	Students analyze the effects of new and emerging technologies on biodiversity within an ecosystem.									X				X	X				X			X	X	
	4.1.12.E	Students consider solutions that address human impacts on ecosystems over time.									X				X	X				X			X	X	X
	Standard Area 4.2: Watersheds and Wetlands																								
	4.2.10.A	Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.		X	X			X	X		X	X	X		X	X		X	X	X	X		X	X	X
	4.2.12.A	Students examine the ways laws and regulations regarding land use management impact on the water quality and flow within a watershed.		X							X				X	X			X				X	X	X
	4.2.10.B	Students examine how human interactions like land use impact wetlands and their surrounding environments.		X							X				X	X		X	X	X		X	X	X	X
	4.2.12.B	Students consider the effects of policies and regulations on wetlands and their surrounding environments.		X							X				X	X				X			X	X	X
	4.2.10.C	Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.	X		X	X	X	X		X	X		X	X	X	X		X	X	X		X	X	X	X
	4.2.12.C	Students investigate the effects of policies and regulations on water quality.		X							X				X	X				X			X	X	X
	Standard Area 4.3: Natural Resources																								
	4.3.10.B	Students explore the environmental consequences of human extraction and use of natural resources (e.g., mining).		X							X				X	X				X			X	X	
	Standard Area 4.5: Humans & the Environment																								
	4.5.10.C	Students investigate data and ways that point and non-point source pollution can be detected and eliminated.									X				X	X				X			X	X	X

RIVER ALIVE!
EXHIBITION EDUCATIONAL STANDARDS CONNECTIONS
HIGH SCHOOL (GRADES 9-12)

INTRODUCTION

A **Fisharium Classroom** that features a floating wetland and hydroculture/aquaponics demonstration installation using Delaware River water;

A **Citizen Science Lab** that extends from the exhibition out onto Penn's Landing, connecting visitors to real-time data throughout the 330-mile Delaware River watershed in partnership with the Academy of Natural Sciences of Drexel University and Stroud Water Research Center;

A 10-ft long **Watershed 3D Modeling Table** with 3D puzzle pieces allowing visitors to create their own riverscape and control its permeability;

A 32-ft long dynamic projection **River Continuum Wall** where users trigger digitally animated content to see that mountains, wilderness, farmland, cities, and coastal plains are all connected by the river that runs through them, and meet the biologically diverse characters who call these places and spaces home;

A **River Window** sound and acrylic sculpture installation that transforms the windows looking out onto the river (and into the space from Penn's Landing) into a visual and audio adventure into four key exhibition themes: geology, biology, history, and restoration.

These are just a few of the highlights that students and educators will encounter at the new **RIVER ALIVE!** exhibition — a compelling, educationally engaging new cultural asset for the City of Philadelphia that positions the Independence Seaport Museum at the forefront of citizen science and watershed education in the region. In both form and function, this 4,000+ sq. ft. exhibition merges 21st century communication technologies, water conservation and protection concepts, and scientific methods with the richness of interdisciplinary learning, where history, art and scientific discovery intersect.

River Alive! reveals the Delaware River watershed as an amazing system that covers 13,500 square acres in the heart of the northeastern United States. More than 15 million people — and thousands of plant, animal, and insect species — are part of this complex world.

The makers of River Alive! are guided by the view that curiosity about the world can be cultivated when hearts and minds are ignited through self-guided exploration and play where the storytelling is based in history, real science, and imaginative interpretations. Each exhibit element has been designed to trigger the senses while tapping into a universal desire to build knowledge about our shared watershed world. Iconic interactive components provide foundational knowledge that answers not only, "What's alive in the river?" but, just as importantly, "Why should I care?" and "What can we do about it?"

Each River Alive! visitor is asked to reflect on his/her relationship to water as an integral member of a living freshwater system. Exhibit elements throughout the space create opportunities for participation in hands-on science activities that express our connection to the watershed, build knowledge about the watershed's structure and challenges, and invite action on behalf of all watershed inhabitants —

including us! Additionally, by aligning the themes of ISM's water-focused programs with the primary content within the River Alive! Exhibition, visitors are encouraged to make additional contributions as "river ambassadors," and share impactful firsthand experiences on the water that connect them to the rich life of the river.

Site specific artwork throughout the exhibition explores wetlands (wild freshwater nurseries); the interdependency of sky, water and land habitats through storytelling and visitor-directed soundscapes; and a site-specific film that will take visitors to places and spaces throughout the watershed from a bird's eye perspective.

River Alive! illuminates the continuous life of the Delaware River through a watershed science and innovation lens, providing platforms for project partners (the other 22 members of the Alliance for Watershed Education of the Delaware River, as well as Stroud Water Research Center, Partnership for Delaware Estuary, Philadelphia Water, the Academy of Natural Sciences of Drexel, the Wagner Free Institute of Science of Philadelphia, and others) to directly engage young learners with their important work.

Educational Standards

All of the experiences in River Alive! have been designed not only to impact the mind and emotions of visitors, but also to support educational science standards as designated on a national and state level. This document details the specific standards addressed by River Alive! exhibits. It is intended to assist educators in determining how best to incorporate the River Alive! experience into their curricula, and use this new and exciting resource to build knowledge, experience, and empathy for the natural world in their students.

Additional materials and resources are available for educators from the Independence Seaport Museum's education department.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTIONS (NATIONAL)

*** NOTE: NEW JERSEY HAS ADOPTED THESE STANDARDS AS ITS STATE STANDARDS, AS WELL. NEW JERSEY TEACHERS SHOULD REFER TO THIS SECTION FOR CURRICULUM CONNECTIONS.

HS-LS1-5 From Molecules to Organisms: Structures and Processes

Students discover that photosynthesis transforms light energy into stored chemical energy, along with a release of oxygen.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
What Is Our Watershed
Into the Wild

HS-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

Students explore the factors that affect the capacity of an ecosystem to support life ("carrying capacity") at different scales.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
What Is Our Watershed
Into the Wild
All Paths Lead Here

HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics

Students explore evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Plankton Bloom Table
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
What Is Our Watershed
We Go Together
Into the Wild
All Paths Lead Here

HS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics
Students investigate the cycling of matter and flow of energy in aerobic and anaerobic conditions in a habitat.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
All Paths Lead Here

HS-LS2-4 Ecosystems: Interactions, Energy, and Dynamics
Students discover the cycling of matter and flow of energy among organisms in an ecosystem.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
All Paths Lead Here

HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics
Students evaluate the evidence about complex interactions in ecosystem that maintain organism populations in stable conditions, and how the ecosystem alters with changing conditions.

Related Exhibits:
River Continuum Interactive Media Experience
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Plankton Bloom Table
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
All Paths Lead Here

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics
Students investigate the possibilities and effectiveness of methods to reduce the impacts of human activities on the environment and biodiversity.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

HS-LS4-5 Biological Evolution: Unity and Diversity
Students explore evidence that changes in environmental conditions may result in population changes in species, changes in types of species, and the extinction of other species.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together

Into the Wild
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

HS-LS4-6 Biological Evolution: Unity and Diversity
Students discover solutions to mitigate adverse impacts of human activity on biodiversity.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

HS-ESS2-5 Earth's Systems
Students explore the properties of water and its effects on Earth materials and surface processes.

Related Exhibits:
Watershed Scapes Exploration Wall
Water Cycle Puzzle
Watershed 3D Modeling Table
Watershed Map Interactive Media Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Let It Soak In

HS-ESS3-3 Earth and Human Activity
Students discover relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Water Cycle Puzzle
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall

Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

HS-ESS3-4 Earth and Human Activity
Students evaluate solutions that reduce the impact of human activities on natural systems.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

PENNSYLVANIA STATE STANDARDS (PENNSYLVANIA DEPARTMENT OF EDUCATION)

Subject Area 3: Science, Technology & Engineering Education

Standard Area 3.1: Biological Sciences

3.1.12.A1: Students explore the ways organisms must derive energy from their environment or their food in order to survive.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
All Paths Lead Here

Standard Area 3.3: Earth & Space Sciences

3.3.10.A5: Students explore the processes of the hydrologic cycle.

Related Exhibits:
Water Cycle Puzzle
Watershed 3D Modeling Table
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
Let It Soak In

Subject Area 4: Environment & Ecology

Standard Area 4.1: Ecology

4.1.10.A: Students evaluate possible causes of population fluctuations, the idea of "carrying capacity" in an ecosystem, and how different factors threaten organism survival.

Related Exhibits:

River Continuum Interactive Media Experience
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At

4.1.12.A: Students analyze the significance of biological diversity in an ecosystem, causes of biodiversity loss, and management laws meant to effect biodiversity.

Related Exhibits:
River Continuum Interactive Media Experience
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At

4.1.10.B: Students explore the consequences of interrupting natural cycles.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together

Let It Soak In
Into the Wild
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.1.12.B: Students consider solutions to problems caused by interrupting natural cycles.

Related Exhibits:
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.1.10.C: Students discover how energy is converted from one form to another as it moves within a food web.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
All Paths Lead Here

4.1.12.C: Students explore human impacts from industrial, agricultural, and commercial enterprises on energy flow and the health of an ecosystem.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
What Is Our Watershed
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.1.10.D: Students investigate the relationship between habitat changes, plant and animal populations, and corresponding fluctuations in biodiversity.

Related Exhibits:
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.1.12.D: Students analyze the effects of new and emerging technologies on biodiversity within an ecosystem.

Related Exhibits:
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At

4.1.12.E: Students consider solutions that address human impacts on ecosystems over time.

Related Exhibits:
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

Standard Area 4.2: Watersheds & Wetlands

4.2.10.A: Students explore the relationship between topography and the flow of water, the effect of vegetation on water runoff, and the effects of land use on the quality of water in a watershed.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Water Cycle Puzzle
Watershed Map Interactive Media Station
Watershed 3D Modeling Space
Fisharium Classroom & Aquaponics System
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Let It Soak In
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.2.12.A: Students examine the ways laws and regulations regarding land use management impact on the water quality and flow within a watershed.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.2.10.B: Students examine how human interactions like land use impact wetlands and their surrounding environments.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.2.12.B: Students consider the effects of policies and regulations on wetlands and their surrounding environments.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

4.2.10.C: Students discover the relationship between water quality and biodiversity in a freshwater ecosystem.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Plankton Bloom Table
Nature's Highway Theater
River Window: Flow on Flow & Audio Stories of the River
Watershed Story Theater
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
Water Is Life
What Is Our Watershed
We Go Together
Into the Wild
Something in the Water
Pollution You Can't Point At

All Paths Lead Here

4.2.12.C: Students investigate the effects of policies and regulations on water quality.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

Standard Area 4.3: Natural Resources

4.3.10.B: Students explore the environmental consequences of human extraction and use of natural resources (e.g., mining).

Related Exhibits:
Rate the Risks to the Watershed
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At

Standard Area 4.5: Humans & the Environment

4.5.10.C: Students investigate data and ways that point and non-point source pollution can be detected and eliminated.

Related Exhibits:
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Related Available Program Lessons:
We Go Together
Something in the Water
Pollution You Can't Point At
All Paths Lead Here

I – EXHIBIT EDUCATIONAL STANDARDS – MIDDLE SCHOOL

RIVER ALIVE! EXHIBITION EDUCATIONAL STANDARDS CONNECTIONS
MIDDLE SCHOOL (GRADES 6-8)

	Numerical Standard Designation	Standard Learning Goal	Exhibits: River Continuum Interactive Media Experience	Rate the Risks to the Watershed	Watershed Scapes Exploration Wall	Plankton Bloom Table	Nature's Highway Theater	River Window: Flow on Flow & Audio Stories of the River	Water Cycle Puzzle	Watershed Story Theater	Watershed Map Interactive Media Station	Watershed 3D Modeling Table	Fisharium Classroom & Aquaponics System	Watershed Life Cross-Sectional Wall	Watershed Data Visualization Media Station & Status of the Watershed Wall	Citizen Science Lab & Watershed Wellness Station
NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTIONS (NATIONAL) **Note: These national standards are also the state standards for New Jersey.**	MS-LS1-5 From Molecules to Organisms: Structures and Processes	Students discover that environmental factors, local conditions, and the operation of the natural world (past and present) impact the growth and evolution of organisms.	X		X			X			X				X	X
	MS-LS1-6 From Molecules to Organisms: Structures and Processes	Students discover the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.	X			X	X						X	X		X
	MS-LS2-1 Ecosystems: Interactions, Energy and Dynamics	Students investigate the effects of resource availability on organisms and populations of organisms in an ecosystem.	X			X					X				X	X
	MS-LS2-2 Ecosystems: Interactions, Energy and Dynamics	Students explore the interactions among organisms across multiple ecosystems, discovering their interdependency and the cause-and-effect nature of relationships between organisms	X		X					X	X		X	X	X	X
	MS-LS2-3 Ecosystems: Interactions, Energy and Dynamics	Students learn about the cycling of matter and flow of energy among living and nonliving parts of an ecosystem through the core idea that food webs are the way matter and energy are transferred between producers, consumers, and decomposers.	X				X						X	X	X	X
	MS-LS2-4 Ecosystems: Interactions, Energy and Dynamics	Students investigate the concept that changes to physical or biological components of an ecosystem have a direct effect on the health and population of organisms within that system.	X	X	X						X		X		X	X
	MS-LS2-5 Ecosystems: Interactions, Energy and Dynamics	Students discover the importance of maintaining the integrity of an ecosystem in supporting biodiversity and organism health (including humans), and evaluate different methods/design solutions for restoring and maintaining a biodiverse ecosystem.	X		X						X					
	MS-ESS2-2 Earth's Systems	Students learn how geoscience processes, including the shaping of earth by water, have changed Earth's surface and shaped regions over periods of time.			X				X		X	X				
	MS-ESS2-4 Earth's Systems	Students explore the cycling of water through Earth's systems, and the ways in which that cycle is driven by the sun's energy, and the force of gravity.			X				X		X	X				
	MS-ESS3-3 Earth and Human Activity	Students investigate the ways that humans have impacted the environment, damaged or destroyed natural habitats, affected flora and fauna populations, and tapped natural resources, as well as ways in which we study and monitor these human impacts to devise solutions and minimize effects.	X	X	X			X	X		X	X			X	X
	MS-ESS3-4 Earth and Human Activity	Students consider how increases in human population and per-capita consumption of natural resources impact Earth's systems.		X	X					X	X	X			X	
	MS-ESS3-5 Earth and Human Activity	Students investigate factors that have caused the rise in global temperatures over the past century.		X							X				X	
PENNSYLVANIA STATE STANDARDS (PENNSYLVANIA DEPARTMENT OF EDUCATION)																
Subject Area 3: Science, Technology & Engineering Education	Standard Area 3.1: Biological Sciences															
	3.1.6.A2	Students discover how energy derived from the sun is used by plants, and is transferred within a food chain from producers to consumers to decomposers.	X			X	X						X	X		X
	Standard Area 3.3: Earth & Space Sciences															
	3.3.6.A4	Students discover how water on earth cycles in different forms and in different locations, including underground and in the atmosphere.			X				X		X	X				
Subject Area 4: Environment & Ecology	Standard Area 4.1: Ecology															
	4.1.7.C	Students discover the flow of energy within an ecosystem.	X			X	X						X	X		X
	4.1.7.D	Students explore and come to understand how biological diversity relates to the viability of ecosystems.	X				X						X	X	X	X
	Standard Area 4.2: Watersheds and Wetlands															
	4.2.6.A	Students investigate the five major watersheds of Pennsylvania.	X		X					X	X					
	4.2.6.C	Students examine and identify the natural and human-made factors that affect water quality.		X				X	X		X	X			X	X
	4.2.7.A	Students investigate how water enters, moves through, and leaves a watershed.			X				X			X				
	4.2.7.B	Students explore the primary functions of wetland environments within a watershed.	X		X		X			X	X			X		X
	4.2.7.C	Students discover the tools and techniques we use to analyze freshwater environments.									X		X		X	X
	4.2.8.A	Students learn the factors that affect the quality of groundwater and surface waters.		X					X		X	X			X	X
	4.2.8.B	Students begin to articulate the value of wetlands to living things, including humans.	X	X	X		X	X		X				X	X	X
	4.2.8.C	Students investigate how diversity indices are used to assess water quality.	X								X	X			X	X
	Standard Area 4.4: Agriculture & Society															
	4.4.6.A	Students investigate how different plants and animals have specific growing requirements related to climate and physical environment (e.g., water, soil, etc.).	X		X					X			X			
	4.4.7.A	Students discover how agricultural practices, the environment, and the availability of natural resources are related.		X	X						X		X		X	X
	Standard Area 4.5: Humans & the Environment															
	4.5.6.A	Students examine how historical events have shaped the sustainable use of natural resources.		X	X			X			X				X	
	4.5.7.C	Students explore how human actions, both residential and industrial, affect the health of the environment.		X	X			X			X				X	X
	4.5.8.A	Students explore how "best practices" can be used to mitigate environmental problems.		X	X			X			X				X	X
	4.5.8.C	Students investigate ways that humans can reduce pollution in our environment.		X	X			X			X				X	X

RIVER ALIVE!
EXHIBITION EDUCATIONAL STANDARDS CONNECTIONS
MIDDLE SCHOOL (GRADES 6-8)

INTRODUCTION

A **Fisharium Classroom** that features a floating wetland and hydroculture/aquaponics demonstration installation using Delaware River water;

A **Citizen Science Lab** that extends from the exhibition out onto Penn's Landing, connecting visitors to real-time data throughout the 330-mile Delaware River watershed in partnership with the Academy of Natural Sciences of Drexel University and Stroud Water Research Center;

A 10-ft long **Watershed 3D Modeling Table** with 3D puzzle pieces allowing visitors to create their own riverscape and control its permeability;

A 32-ft long dynamic projection **River Continuum Wall** where users trigger digitally animated content to see that mountains, wilderness, farmland, cities, and coastal plains are all connected by the river that runs through them, and meet the biologically diverse characters who call these places and spaces home;

A **River Window** sound and acrylic sculpture installation that transforms the windows looking out onto the river (and into the space from Penn's Landing) into a visual and audio adventure into four key exhibition themes: geology, biology, history, and restoration.

These are just a few of the highlights that students and educators will encounter at the new **RIVER ALIVE!** exhibition — a compelling, educationally engaging new cultural asset for the City of Philadelphia that positions the Independence Seaport Museum at the forefront of citizen science and watershed education in the region. In both form and function, this 4,000+ sq. ft. exhibition merges 21st century communication technologies, water conservation and protection concepts, and scientific methods with the richness of interdisciplinary learning, where history, art and scientific discovery intersect.

River Alive! reveals the Delaware River watershed as an amazing system that covers 13,500 square acres in the heart of the northeastern United States. More than 15 million people — and thousands of plant, animal, and insect species — are part of this complex world.

The makers of River Alive! are guided by the view that curiosity about the world can be cultivated when hearts and minds are ignited through self-guided exploration and play where the storytelling is based in history, real science, and imaginative interpretations. Each exhibit element has been designed to trigger the senses while tapping into a universal desire to build knowledge about our shared watershed world. Iconic interactive components provide foundational knowledge that answers not only, "What's alive in the river?" but, just as importantly, "Why should I care?" and "What can we do about it?"

Each River Alive! visitor is asked to reflect on his/her relationship to water as an integral member of a living freshwater system. Exhibit elements throughout the space create opportunities for participation in hands-on science activities that express our connection to the watershed, build knowledge about the watershed's structure and challenges, and invite action on behalf of all watershed inhabitants —

including us! Additionally, by aligning the themes of ISM's water-focused programs with the primary content within the River Alive! Exhibition, visitors are encouraged to make additional contributions as "river ambassadors," and share impactful firsthand experiences on the water that connect them to the rich life of the river.

Site specific artwork throughout the exhibition explores wetlands (wild freshwater nurseries); the interdependency of sky, water and land habitats through storytelling and visitor-directed soundscapes; and a site-specific film that will take visitors to places and spaces throughout the watershed from a bird's eye perspective.

River Alive! illuminates the continuous life of the Delaware River through a watershed science and innovation lens, providing platforms for project partners (the other 22 members of the Alliance for Watershed Education of the Delaware River, as well as Stroud Water Research Center, Partnership for Delaware Estuary, Philadelphia Water, the Academy of Natural Sciences of Drexel, the Wagner Free Institute of Science of Philadelphia, and others) to directly engage young learners with their important work.

Educational Standards

All of the experiences in River Alive! have been designed not only to impact the mind and emotions of visitors, but also to support educational science standards as designated on a national and state level. This document details the specific standards addressed by River Alive! exhibits. It is intended to assist educators in determining how best to incorporate the River Alive! experience into their curricula, and use this new and exciting resource to build knowledge, experience, and empathy for the natural world in their students.

Additional materials and resources are available for educators from the Independence Seaport Museum's education department.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTIONS (NATIONAL)

*** NOTE: NEW JERSEY HAS ADOPTED THESE STANDARDS AS ITS STATE STANDARDS, AS WELL. NEW JERSEY TEACHERS SHOULD REFER TO THIS SECTION FOR CURRICULUM CONNECTIONS.

MS-LS1-5 From Molecules to Organisms: Structures and Processes

Students discover that environmental factors, local conditions, and the operation of the natural world (past and present) impact the growth and evolution of organisms.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

MS-LS1-6 From Molecules to Organisms: Structures and Processes

Students discover the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

MS-LS2-1 Ecosystems: Interactions, Energy and Dynamics

Students investigate the effects of resource availability on organisms and populations of organisms in an ecosystem.

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

MS-LS2-2 Ecosystems: Interactions, Energy and Dynamics

Students explore the interactions among organisms across multiple ecosystems, discovering their interdependency and the cause-and-effect nature of relationships between organisms

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Watershed Story Theater
Watershed Map Interactive Media Station

Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

MS-LS2-3 Ecosystems: Interactions, Energy and Dynamics
Students learn about the cycling of matter and flow of energy among living and nonliving parts of an ecosystem through the core idea that food webs are the way matter and energy are transferred between producers, consumers, and decomposers.

Related Exhibits:
River Continuum Interactive Media Experience
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

MS-LS2-4 Ecosystems: Interactions, Energy and Dynamics
Students investigate the concept that changes to physical or biological components of an ecosystem have a direct effect on the health and population of organisms within that system.

Related Exhibits:
River Continuum Interactive Media Experience
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

MS-LS2-5 Ecosystems: Interactions, Energy and Dynamics
Students discover the importance of maintaining the integrity of an ecosystem in supporting biodiversity and organism health (including humans), and evaluate different methods/design solutions for restoring and maintaining a biodiverse ecosystem.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station

MS-ESS2-2 Earth's Systems
Students learn how geoscience processes, including the shaping of earth by water, have changed Earth's surface and shaped regions over periods of time.

Related Exhibits:
Water Cycle Puzzle
Watershed 3D Modeling Table

Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station

MS-ESS2-4 Earth's Systems
Students explore the cycling of water through Earth's systems, and the ways in which that cycle is driven by the sun's energy, and the force of gravity.

Related Exhibits:
Water Cycle Puzzle
Watershed 3D Modeling Table
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station

MS-ESS3-3 Earth and Human Activity
Students investigate the ways that humans have impacted the environment, damaged or destroyed natural habitats, affected flora and fauna populations, and tapped natural resources, as well as ways in which we study and monitor these human impacts to devise solutions and minimize effects.

Related Exhibits:
River Continuum Interactive Media Experience
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Water Cycle Puzzle
Watershed Map Interactive Media Station
Watershed 3D Modeling Table
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

MS-ESS3-4 Earth and Human Activity
Students consider how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Watershed 3D Modeling Table
Watershed Story Theater
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall

MS-ESS3-5 Earth and Human Activity
Students investigate factors that have caused the rise in global temperatures over the past century.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall

PENNSYLVANIA STATE STANDARDS (PENNSYLVANIA DEPARTMENT OF EDUCATION)

Subject Area 3: Science, Technology & Engineering Education

Standard Area 3.1: Biological Sciences

3.1.6.A2: Students discover how energy derived from the sun is used by plants, and is transferred within a food chain from producers to consumers to decomposers

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

Standard Area 3.3: Earth & Space Sciences

3.3.6.A4: Students discover how water on earth cycles in different forms and in different locations, including underground and in the atmosphere.

Related Exhibits:
Water Cycle Puzzle
Watershed 3D Modeling Table
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station

Subject Area 4: Environment & Ecology

Standard Area 4.1: Ecology

4.1.7.C: Students discover the flow of energy within an ecosystem

Related Exhibits:
River Continuum Interactive Media Experience
Plankton Bloom Table
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

4.1.7.D: Students explore and come to understand how biological diversity relates to the viability of ecosystems

Related Exhibits:

River Continuum Interactive Media Experience
Nature's Highway Theater
Fisharium Classroom & Aquaponics System
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Standard Area 4.2: Watersheds and Wetlands

4.2.6.A: Students investigate the five major watersheds of Pennsylvania

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Watershed Story Theater
Watershed Map Interactive Media Station

4.2.6.C: Students examine and identify the natural and human-made factors that affect water quality

Related Exhibits:
Rate the Risks to the Watershed
River Window: Flow on Flow & Audio Stories of the River
Water Cycle Puzzle
Watershed Map Interactive Media Station
Watershed 3D Modeling Table
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

4.2.7.A: Students investigate how water enters, moves through, and leaves a watershed.

Related Exhibits:
Watershed Scapes Exploration Wall
Water Cycle Puzzle
Watershed 3D Modeling Table

4.2.7.B: Students explore the primary functions of wetland environments within a watershed.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Nature's Highway Theater
Watershed Story Theater
Watershed Map Interactive Media Station
Watershed Life Cross-Sectional Wall
Citizen Science Lab & Watershed Wellness Station

4.2.7.C: Students discover the tools and techniques we use to analyze freshwater environments.

Related Exhibits:
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

4.2.8.A: Students learn the factors that affect the quality of groundwater and surface waters.

Related Exhibits:
Rate the Risks to the Watershed
Water Cycle Puzzle
Watershed Map Interactive Media Station
Watershed 3D Modeling Table
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

4.2.8.B: Students begin to articulate the value of wetlands to living things, including humans.

Related Exhibits:
River Continuum Interactive Media Experience
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Nature's Highway Theater
River Window: Flow on Flow & Audio Stories of the River
Watershed Story Theater
Watershed Life Cross-Sectional Wall
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

4.2.8.C: Students investigate how diversity indices are used to assess water quality.

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Standard Area 4.4: Agriculture & Society

4.4.6.A: Students investigate how different plants and animals have specific growing requirements related to climate and physical environment (e.g., water, soil, etc.)

Related Exhibits:
River Continuum Interactive Media Experience
Watershed Scapes Exploration Wall
Watershed Story Theater

Fisharium Classroom & Aquaponics System

4.4.7.A: Students discover how agricultural practices, the environment, and the availability of natural resources are related.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
Watershed Map Interactive Media Station
Fisharium Classroom & Aquaponics System
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

Standard Area 4.5: Humans & the Environment

4.5.6.A: Students examine how historical events have shaped the sustainable use of natural resources.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall

4.5.7.C: Students explore how human actions, both residential and industrial, affect the health of the environment.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

4.5.8.A: Students explore how “best practices” can be used to mitigate environmental problems.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

4.5.8.C: Students investigate ways that humans can reduce pollution in our environment.

Related Exhibits:
Rate the Risks to the Watershed
Watershed Scapes Exploration Wall
River Window: Flow on Flow & Audio Stories of the River
Watershed Map Interactive Media Station
Watershed Data Visualization Media Station & Status of the Watershed Wall
Citizen Science Lab & Watershed Wellness Station

J – STEPS FOR A HEALTHY WATERSHED POSTER

STEPS FOR A HEALTHY WATERSHED

THERE AS SO MANY THINGS YOU CAN DO TODAY TO PROTECT THE WATERSHED AND KEEP OUR WATER CLEAN!

The average person uses 101.5 gallons of water per day! There are so many easy ways you can cut down your own water usage.

YOU ARE WHAT YOU EAT

At least, your water footprint includes what you eat! Just a cup of coffee has 37 hidden gallons of water required to grow and process the coffee beans! Being aware of the impact of our meals helps us make smarter choices and waste less food.

TURN OFF THE TAP

Turning off the tap while brushing your teeth can make a big difference - 8 gallons of water per day difference! Imagine how much water you can save in a year!

SHORTER SHOWERS

An easy way to save water is to take short showers instead of baths. Create a playlist under 8 minutes to keep track of time and rock out while you get clean!

BATTERED BATTERIES

Stop throwing away old batteries! The mercury inside seeps out in landfills, eventually returning to water and poisoning it. Better yet, use rechargeable alkaline or lithium batteries.

DOWN THE DRAIN

Out of sight shouldn't mean out of mind. Water that goes down the drain eventually ends up back in our rivers, streams, and other water sources. Be careful not to flush non-biodegradable items, like baby wipes. Keep used paint, oil, chemical cleaners, and other questionable cleaners out of the sink. Use biodegradable and environmentally friendly cleaners whenever possible to keep our water clean!

In most urban areas, rainwater and melted snow becomes runoff, carrying pollutants from our streets into the sewer and into our rivers and streams.

DOGGIE DOO-DO'S AND DONT'S

Cleaning up after your furry friends helps the watershed. Stormwater runoff can pick up bacteria-covered dog waste, carrying it into our stormdrains and water supplies. Scooping it up with a recycled bag is even better for the environment!

CARE FOR YOUR CAR

Car maintenance matters! A leaky car can drip oil, antifreeze, or other toxic chemicals in your driveway or on the roads. These chemicals end up in our groundwater when they get carried by stormwater. Taking care of your car takes care of our watershed!

GET TO KNOW THE LOCALS

Planting native species in your garden instead of exotic plants helps maintain the balance in your watershed. Native plants are suited for your local environment and usually require less water, fertilizer and pesticides. This also ensures no invasive species are introduced to the area.

SLOW THE FLOW

Impervious surfaces increase the amount of runoff as well as the speed it travels, increasing erosion and pollutants that make it into the sewer. We can change this by installing downspout gardens, permeable pavers, and raingardens. These pervious places slow water down, give it a chance to infiltrate, and stop it from picking up pollutants.

TAKE A HIKE

Driving isn't all its cracked up to be. Pollutants from car exhaust also end up in our water. Walking, biking, and taking public transportation reduce carbon emissions. Carpooling also helps! Drive with a friend the next time you're both headed in the same direction.

THANK YOU VERY MULCH

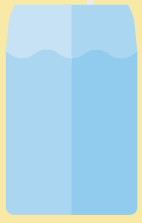
Not all mulch is created equal! Some mulches are actually quite harmful to the environment and your pets. Cocoa bean shells are toxic to dogs and rubber mulch contains pollutants. Old leaves and compost are toxin-free, environmentally sustainable options.

SAY GOODBYE, PESTICIDE

Pesticides introduce poisons to the earth that leech to our groundwater when it rains. You can help prevent this by instead using organic herbicides, which often use acetic acid (the acid in vinegar) or citric acid to kill unwanted plants. Pulling out weeds by hand is always the most effective way to manage your garden without poison.

TAKE A RAINCHECK

Installing a rain barrel reduces your water consumption and manages stormwater runoff at the same time. Rain barrels connect directly to a downspout and offset the impervious roof surface. The water you collect can be used to water your garden or houseplants.



SPREAD THE KNOWLEDGE

Set an example for your friends and family and lead by example. It might be easier to make big changes around your house by getting your whole family on board to protect the watershed. Motivate others into action by sharing what you've learned!

There are many more ways we can take responsibility to reduce pollution and minimize the impact of our daily activities. No matter who you are or where you live, anyone can make a difference and keep our watershed healthy.

See what else out there! This is just a glimpse of what you can do to at home to help your watershed. Getting involved with local organizations is a great way to take the next step.

What will you do today?

K – WATER PLAY:
GRADES – HIGH SCHOOL


RIVER ALIVE!
MAKE YOUR OWN WATER PLAY MOBILE
Curricular Guide Art Activitiy
Grades 9-12

Work Plan

GRADE LEVEL: 9-12

Timeline
Approximately 30 combined hours

Project Goals

Building a Water Play mobile, in this fashion with the following instruction, will take a community effort that mimics the community effort that keeps our watershed healthy. The activity will highlight the interaction between people and the river, emphasizing a call to action for conservation and the difference individuals make. The Water Play mobile will work best when the mobile is in balance, just as the watershed is healthiest when it's in balance.

The Water Play mobile is split into six sections; Hello Beautiful Watershed, Mountains + Rain = Our Inventory, Beyond Your Wild Watershed, The River Meets Humans in the Heart of the Watershed, Our Urban World Disrupts the River We Need, and Fresh Water Joins Salt, an Amazing World Filled With Life. The six sections of the Water Play mobile correlate to the six units of the River Alive! curricular guide.

The River Alive! curricular guide is paramount to the construction of the Water Play mobile. The teacher may choose to have the class produce the mobile after the class completes the curricular guide together, or may decide to assign the six sections of the curricular guide to six groups of students, who study the sections independently. Data and images are collected during the study and used in the production of the six Water Play mobile sections. After the sections are joined together to create the Water Play mobile, the groups share in-depth knowledge they attained while studying from the curricular guide. This activity is symbolic of community awareness and effort to keep he watershed healthy. Students should pay special attention to the cycles of the ecosystems, diversity of living things, conservation, community effort, nature's balance, and the significance and intricacies of the watershed.

The Water Play mobile can hang in the classroom or in a community space as art and also as a reminder of nature's beauty and the River Alive! lesson, activism, and the importance of water conservation.

Objectives
The students will:
• Use hands-on active learning to attain and process information
• Be given a section of the River Alive! curricular guide to study and then create a watershed section of the mobile from their study

• Find images that describe the habitats and specific features of their watershed section from online resources, books and magazines
• Size and print their images
• Use collage techniques, cutting, gluing, taping, and tying
• Assemble the pieces of their watershed section
• Connect the watershed section to other watershed sections
• Consider the implications of the balance of one section on other sections to mimic how the watershed is dependent on the health of the watershed upstream
• See the watershed as pieces that fit together to make a whole.
• Speak in detail about the significance and intricacy of the watershed section

MATERIALS AND TOOLS

30' Aluminum wire / 9 gauge (armature wire is available from hobby and art supply stores)
Measuring tape
Wire cutters
Sharpie marker
1 foot of Duck tape
2 rolls of invisible tape
Piece of drawing paper 30" x 86" (cut from a 4' roll)
Monofilament
Crazy glue
Images
Ladder
Computer with photo editing software
Printer and printer paper
Blue thread
Scissors
Glue
Paperclips
Screw hook
Safe area where the mobile can be exhibited

DEMONSTRATION/PROCEDURES

1. Organize the classroom

Set your classroom into six groups of students. Assign a section of the Curricular Guide to each group of students. Clear an area approximately 5' x 5' for the mobile to hang.

2. Collect Images

Students make lists of search words from topics that are pertinent to the Curricular Guide section they are assigned. Images relative to the topics are acquired

from magazines, websites and search engines. Images can also be drawn or photographed by the students. When students use a search engine, set filters to find images without copy write infringement. This is very important. Save images to a desktop folder and curate for appropriate content. Each section needs about thirty images to insure enough research has taken place and to allow for total coverage of the larger mobile sections. Scale images to 4.5 inches in height or smaller. The length can be random. Print the images and cut them out, leaving a white border or cut up to the image edge.

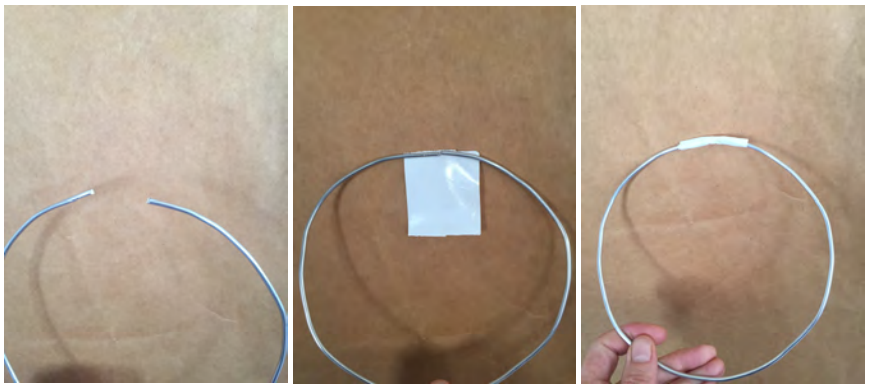
Print 6 sheets of the small water drops and 9 sheets of the large water drops from the attached PDFs. Print the water drops sheets on both sides so each water drop is double sided. They should line up perfectly. Cut out the water drops leaving a white border around each one.

3. Make the aluminum structure rings

Cut six lengths of aluminum wire.

Circle 1 - 85" for Curricular Guide section "Hello Beautiful Watershed,"
Circle 2 - 75" for Curricular Guide section "Mountains + Rain = Our Inventory,"
Circle 3 - 65" for Curricular Guide section "Beyond Your Wild Watershed,"
Circle 4 - 55" for Curricular Guide section "The River Meets Humans in the Heart of the Watershed,"
Circle 5 - 45" for Curricular Guide section "Our Urban World Disrupts the River We Need," and
Circle 6 - 35" for Curricular Guide section "Fresh Water Joins Salt, an Amazing World Filled With Life."

Straighten the wire as it's removed from the spool and lay it against the tape measure. Cut at appropriate lengths with wire cutters. Form the wire into circles with the ends of the wire just meeting. Sculpt the circles to lie as flat and round as possible. If imperfections persist, they will be balanced later in production.



Cut a two-inch piece of duck tape. Line up the ends of the wire, where they meet, in the center of the width of the duck tape. Press the wire onto the duck tape and

wrap the duck tape around the wire joint as tightly as possible. Try not to make creases in the tape so the joint is as sturdy as possible.


Cut a length of monofilament that is at least double the diameter of the circle plus an extra foot for tying the monofilament onto the wire circles. Fold the monofilament in half and tie one end of the doubled monofilament onto the circle at any point. Make sure the knot is very tight. Make at least six knots at that site, one on top of another. Stretch the doubled monofilament across the diameter and tie the other end onto the circle making at least six knots at that site, one on top of another. Check to make sure the doubled strand of monofilament is stretched tightly across your circle as close to the diameter as possible. Put a small drop of crazy glue on the knots and wire where they meet. Turn your circle 90-degrees and tie on another end of a doubled strand of monofilament so that once it's stretched across the diameter, the strands intersect as close to the center of the circle as possible at 90-degree angles. Before the second monofilament strand is attached on the other side of the circle, loop it around the first monofilament strand twice, in the center. Tie the strand to the opposite side of the circle with six knots and fix with a small drop of crazy glue.

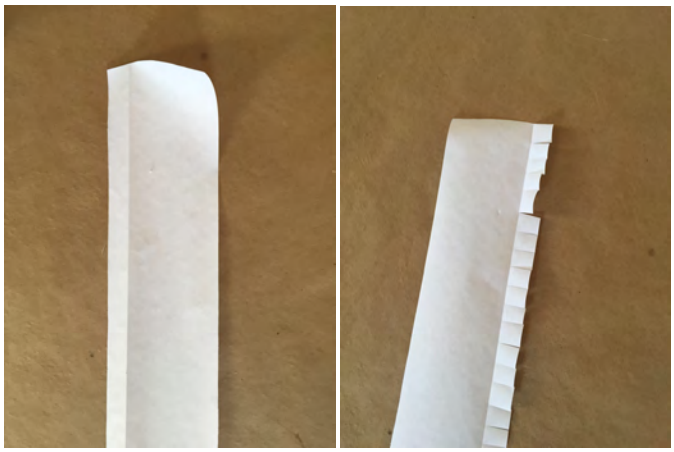
4. Attach paper cylinder structures to the wire circles:

The paper structures perform three jobs. Firstly, they create a foundation for the images to be attached. Secondly, they hid the wire circles. Thirdly, they create a flat even cylinder.

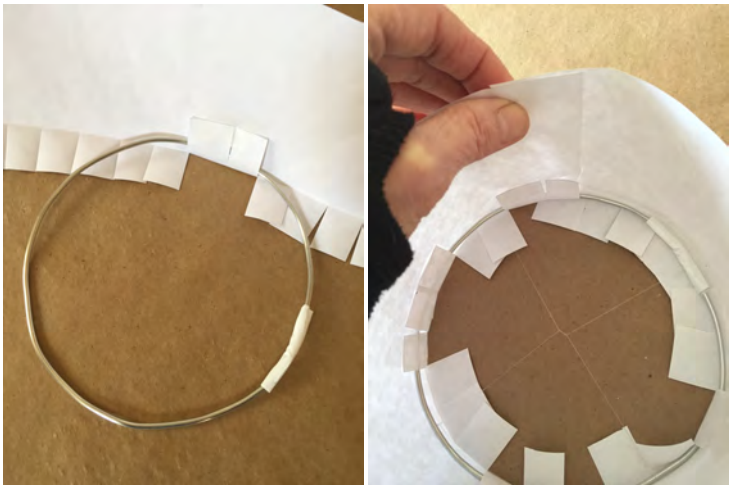
Measure and cut strips of drawing paper to be attached to the wire circles:
Cylinder 1 - 86"x 5" for Curricular Guide section "Hello Beautiful Watershed,"
Cylinder 2 - 76"x 5" for Curricular Guide section "Mountains + Rain = Our Inventory,"
Cylinder 3 - 66"x 5" for Curricular Guide section "Beyond Your Wild Watershed,"
Cylinder 4 - 56"x 5" for Curricular Guide section "The River Meets Humans in the Heart of the Watershed,"
Cylinder 5 - 46"x 5" for Curricular Guide section "Our Urban World Disrupts the River We Need,"

Cylinder 6 - 36"x 5" for Curricular Guide section "Fresh Water Joins Salt, an Amazing World Filled With Life."

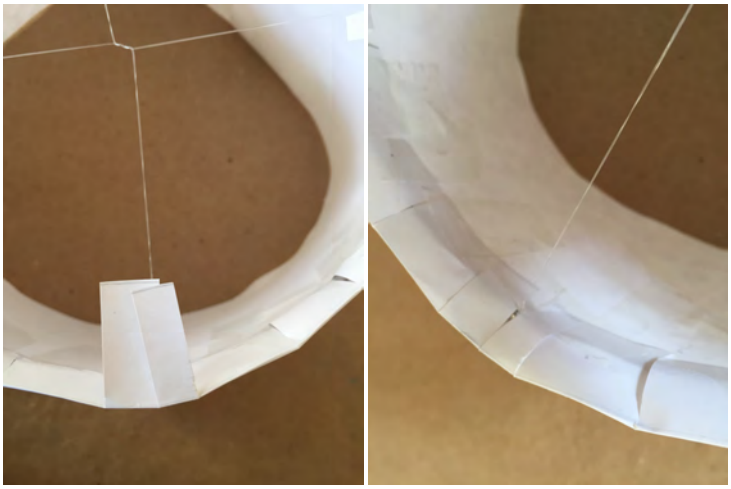
After the strips are cut, measure and draw a line, one-inch from the edge, down the long length of the strip. Fold the one-inch length over. Hold scissors perpendicular to the folded one-inch length and make cuts from the edge to the fold at approximately one inch or so. Continue the cuts down the entire length of the paper. These cuts form tabs that fold around from the outside to the inside of the wire circle and attach the paper cylinder.



Lay the wire circle on a flat work surface and position the paper standing up around the outside perimeter of the correlating circle with the tabs pointing down. Move the tabs under the wire circle pointing into the center. Make sure the paper is tight against the outside perimeter of the wire circle. One at a time, fold each tab around the wire circle and secure with tape to the back of the paper cylinder surface. If the wire circle isn't lying completely flat, allow the wire circle to curve up naturally and attach the tab wherever it may land. Make sure the fold and the tabs are resting flatly on the work surface.

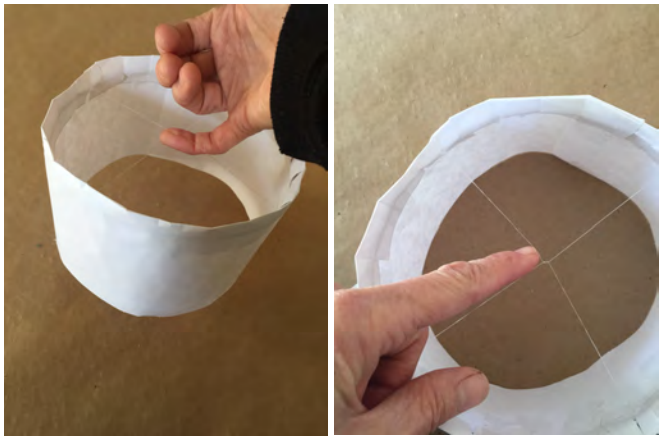


Wherever a tab falls on top of a monofilament knot, make a slit in the tab so it straddles the knot and tape it down under the knot.



After all the tabs are secured, line up the strip overlap and secure with invisible tape on the inside and outside of the paper cylinder. At this point you should have a four-inch paper cylinder with the wire circle against the inside perimeter and a series of tabs wrapped around the wire circle and taped to the inside of the paper cylinder. Glue some water drops to the inside surface of the cylinder in random order for decoration. The top of the cylinder is the end with the center monofilament twist. Make sure the water drops are positioned so the skinny end points to the top of the cylinder.

Once all six-paper cylinders are made, place a finger under the center twisted monofilament and lift the paper cylinder up a couple inched off your flat work surface. The paper cylinder is in balance when it rests evenly. If the cylinder is out of balance, the cylinder will dip down on one side. To create balance, put the cylinder down and with your finger, gently push the center twisted monofilament slightly towards the side of the cylinder that dipped down.



Once again, place a finger under the center twisted monofilament and lift the paper cylinder up a couple inched off your flat work surface. Check if the balance is better and if not repeat moving the center twisted monofilament around until the cylinder finds balance. Once the cylinder is in balance, place a small drop of crazy glue on the center twisted monofilament.

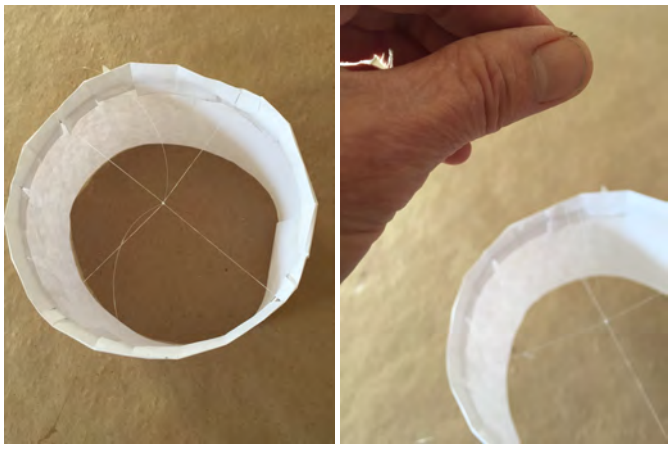
5. Attach images to the paper cylinders

Collage images onto the correlating paper cylinders with tape or glue. Make sure images overlap and are organized in an interesting pattern. Don't leave any white drawing paper exposed.

6. Attaching the paper cylinders to each other

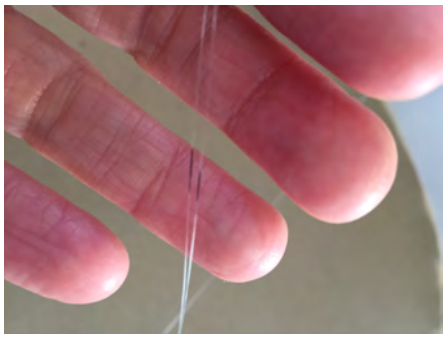
Screw a hook into the ceiling centered over the area where you plan to hang the mobile. The mobile will need about 7' from the floor to hang properly. If the ceiling is 9' the mobile will be suspended 2' from the ceiling. Determine how much space is needed between the ceiling and the top of the mobile leaving 7' of space below. Double the measure of space above the mobile and the ceiling, and add 6" to that measurement. This is the measurement for the suspension strand. For example, if there is 3' of space, measure and cut 6'6" and if there's 4' of space, measure and cut 8'6" of monofilament.

Fold the suspension strand equally in half and tie a knot in the folded end to create a loop through which the screw hook in the ceiling will fit. Tie six knots in the other open end of the suspension strand, under and around the center twisted monofilament of the Cylinder 1. Trim the suspension strand. Hang Cylinder 1 by the loop in the suspension strand on the screw hook in the ceiling. This is the top section of the mobile.



If the ceilings are 7′ there won't be much room for suspension. Create a two-inch loop out of 6 inches of monofilament by looping the suspension strand around the center twisted monofilament of Cylinder 1 and knot 6 times. Hang the loop on to the screw hook in the ceiling.

To attach Cylinder 2 to Cylinder 1, cut approximately 2′ of monofilament to make a suspension strand. Wrap the 2′ length of suspension strand in half under and around the Cylinder 2 center twist and tie with 6 knots close and tight to the center twist. Bring Cylinder 2 up directly under the Cylinder 1 where it hangs. Once Cylinder 2 is attached, the cylinders will be suspended with 5 inches gap between them. To create the 5″ gap, hold the Cylinder 2 suspension strand up to the Cylinder 1 center twist and align so that it creates a 5″ gap between the cylinders. Make a sharpie mark on the Cylinder 2 suspension strand where it contacts the Cylinder 1 center twist while the 5″ gap exists. If the cylinders are out of balance, there will be an opportunity to correct the balance later.



The Cylinder 2 suspension strand will be tied to the Cylinder 1 center twist at the sharpie mark. Put Cylinder 2 down on a surface and tie 6 knots at the sharpie mark on the suspension strand. Bring the knot up under the Cylinder 1 center twist and tie 6 knots above the center twist so there's 6 knots below and above the Cylinder 1 center twist.

Trim the suspension strand. Both cylinders should be successfully suspended from the ceiling screw hook. Continue attaching and suspending the remaining cylinders 3-6 with the same attachment method. Balance issues will be corrected in the next step.

7. Hanging the water drops

Students can choose to write their name on water drops to indicate their commitment to keeping the watershed healthy. After the students write their names, the water drops are hung on the mobile. Alternate cutting short, medium and long lengths of blue thread so water drops hang at random lengths. Tape a blue thread length to a water drop and tape the other end of the thread to any spot on the mobile. Use a ladder as necessary to reach high. Water drops can hang all the way from the top to the bottom on one thread, there can be multiple water drops on a length. Water drops can hang from the center twists of the bottom cylinder. Continue until all the water drops have been used.

Wherever a cylinder side is lifted out of balance, find a thread or water drop that is attached at that spot and add a paper clip to it. The weight of the paper clips will pull the lifted side down. Keep adding paper clips until the cylinders are in balance.

CLOSURE/REFLECTION

After the Water Play mobile is finished, the six groups of students are given an opportunity to write about the section of the curricular guide they studied. The writing should touch on the experience of finding the images that were attached to the mobile, cycles of the ecosystems, diversity of living things, conservation, community effort, nature's balance, and the significance and intricacies of the watershed. The groups present their ideas to the class in an open discussion. Rubrics can be used at the teacher discretion.

L – WATER PLAY:
GRADES – MIDDLE SCHOOL

RIVER ALIVE!

MAKE YOUR OWN WATER PLAY MOBILE

Curricular Guide Art Activitiy
Grades 6-8

Work Plan

GRADE LEVEL: 6-8

Timeline
Approximately 30 combined hours

Project Goals

Building a Water Play mobile, in this fashion with the following instruction, will take a community effort that mimics the community effort that keeps our watershed healthy. The activity will highlight the interaction between people and the river, emphasizing a call to action for conservation and the difference individuals make. The Water Play mobile will work best when the mobile is in balance, just as the watershed is healthiest when it's in balance.

The Water Play mobile is split into six sections; Hello Beautiful Watershed, Mountains + Rain = Our Inventory, Beyond Your Wild Watershed, The River Meets Humans in the Heart of the Watershed, Our Urban World Disrupts the River We Need, and Fresh Water Joins Salt, an Amazing World Filled With Life. The six sections of the Water Play mobile correlate to the six units of the River Alive! curricular guide.

The River Alive! curricular guide is paramount to the construction of the Water Play mobile. The teacher may choose to have the class produce the mobile after the class completes the curricular guide together, or may decide to assign the six sections of the curricular guide to six groups of students, who study the sections independently. Data and images are collected during the study and used in the production of the six Water Play mobile sections. After the sections are joined together to create the Water Play mobile, the groups share in-depth knowledge they attained while studying from the curricular guide. This activity is symbolic of community awareness and effort to keep he watershed healthy. Students should pay special attention to the cycles of the ecosystems, diversity of living things, conservation, community effort, nature's balance, and the significance and intricacies of the watershed.

The Water Play mobile can hang in the classroom or in a community space as art and also as a reminder of nature's beauty and the River Alive! lesson, activism, and the importance of water conservation.

Objectives
The students will:
• Use hands-on active learning to attain and process information
• Be given a section of the River Alive! curricular guide to study and then create a watershed section of the mobile from their study

• Find images that describe the habitats and specific features of their watershed section from online resources, books and magazines
• Size and print their images
• Use collage techniques, cutting, gluing, taping, and tying
• Assemble the pieces of their watershed section
• Connect the watershed section to other watershed sections
• Consider the implications of the balance of one section on other sections to mimic how the watershed is dependent on the health of the watershed upstream
• See the watershed as pieces that fit together to make a whole.
• Speak in detail about the significance and intricacy of the watershed section

MATERIALS AND TOOLS

11' Aluminum wire / 9 gauge (armature wire is available from hobby and art supply stores)
Measuring tape
Wire cutters
5" of Duck tape
2 rolls of invisible tape
48" roll of drawing paper
Monofilament
Crazy glue
Images
Ladder
Computer with photo editing software
Printer and printer paper
Blue thread
Scissors
Glue
Paperclips
Screw hook
Safe area where the mobile can be exhibited

DEMONSTRATION/PROCEDURES

1. Organize the classroom

Set your classroom into six groups of students. Assign a section of the Curricular Guide to each group of students. Clear an area approximately 5' x 5' for the mobile to hang.

2. Collect Images

Students make lists of search words from topics that are pertinent to the Curricular Guide section they are assigned. Images relative to the topics are acquired from magazines, websites and search engines. Images can also be drawn or

photographed by the students. When students use a search engine, set filters to find images without copy write infringement. This is very important. Save images to a desktop folder and curate for appropriate content. Each section needs about thirty images to insure enough research has taken place and to allow for total coverage of the mobile. Scale images to fit on a 8.5" x 11" paper or smaller. A variety of image sizes is more interesting. Print the images and cut them out, leaving a white border or trim up to the image edge.

3. Make the aluminum structure rings

Cut two lengths of aluminum wire. One for the top of the mobile cone and one for the bottom

85" for the top of the cone mobile

35" for bottom of the cone mobile

Straighten the wire as it's removed from the spool and lay it against the tape measure. Cut at appropriate lengths with wire cutters. Form the wire into circles with the ends of the wire just meeting. Sculpt the circles to lie as flat and round as possible. If imperfections persist, they will be balanced later in production.

Cut a two-inch piece of duck tape. Line up the ends of the wire, where they meet, in the center of the width of the duck tape. Press the wire onto the duck tape and wrap the duck tape around the wire joint as tightly as possible. Try not to make creases in the tape so the joint is as sturdy as possible.

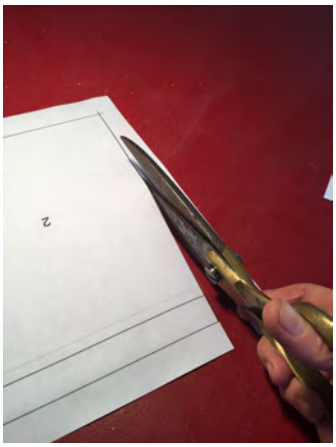
Cut a length of monofilament that is at least double the diameter of the circle plus an extra foot for tying the monofilament onto the wire circles. Fold the monofilament in half and tie one end of the doubled monofilament onto the circle at any point. Make sure the knot is very tight. Make at least six knots at that site, one on top of another. Stretch the doubled monofilament across the diameter and tie the other end onto the circle making at least six knots at that site, one on top of another. Check to make sure the doubled strand of monofilament is stretched tightly across your circle as close to the diameter as possible.

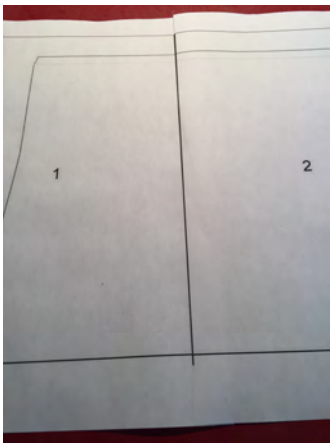
Put a small drop of crazy glue on the knots and wire where they meet. Turn your circle 90-degrees and tie on another end of a doubled strand of monofilament so that once it's stretched across the diameter, the strands intersect as close to the center of the circle as possible at 90-degree angles. Before the second monofilament strand is attached on the other side of the circle, loop it around the first monofilament strand twice, in the center. Tie the strand to the opposite side of the circle with six knots and fix with a small drop of crazy glue. Complete this procedure for both circles.

4. Attach cone pattern to the wire circles:

The cone pattern performs three jobs. Firstly, it creates a foundation for the images to be attached. Secondly, it hides the wire circles. Thirdly, it creates a flat even cone.

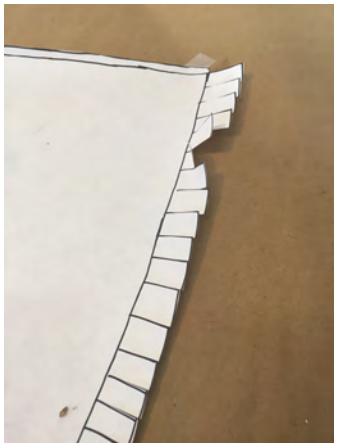
Print the 31 PDF cone pattern sheets that accompany this lesson plan. Cut along the outside border and tape them together in the order as they are numbered moving clockwise. Also print out 6 sheets of the small water drops and 9 sheets of the large water drops that accompany this lesson plan. Print the water drop sheets on both sides. The drops should line up perfectly. Cut them out leaving a white border around each water drop.







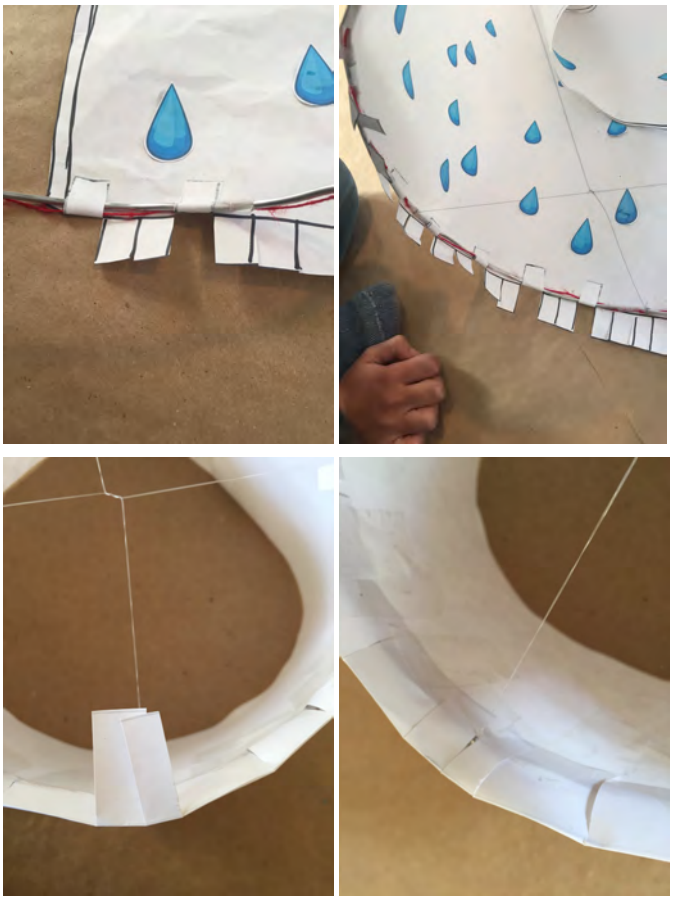
Place two lengths of drawing paper from the 48" roll side by side, to cover the pattern, and tape them together. Trace the pattern onto the drawing paper with a sharpie and cut the pattern out.



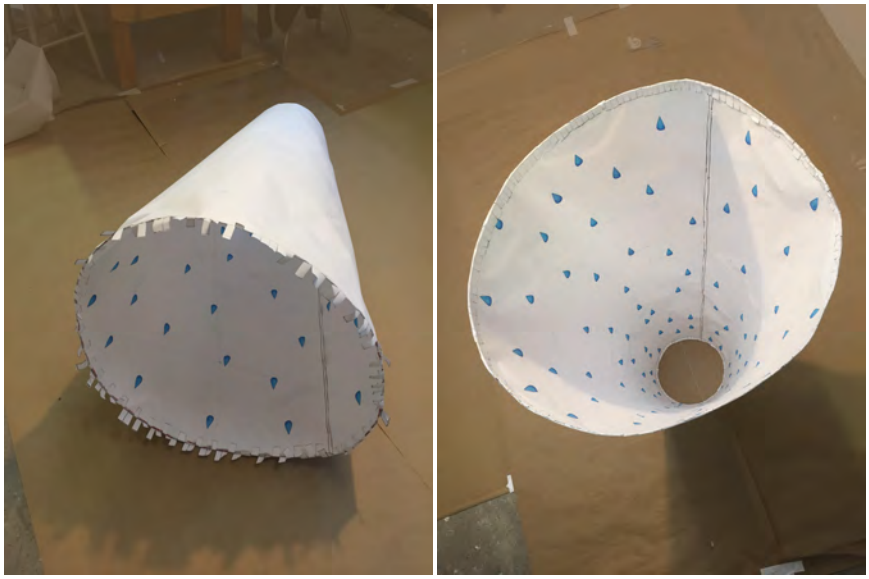

Make slits to separate the tabs in the ends of the cone pattern. These cuts form tabs that fold around from the outside to the inside of the wire circle and attach the cone pattern..

Glue water drops on the cone pattern in random placement. The larger end of the cone is the top. Make sure to place the water drops with the skinny end pointing towards the top.

Work on the larger end of the cone first. Lay the wire circle on the line at the top of the pattern where the tabs stick out. Make sure the wire circle is tight against the pattern line. One at a time, fold every third tab around the wire circle and secure with tape to the inside of the cone pattern. Keep the tabs a little loose to allow room for the imperfections of the circle. Once the tabs are in place, go back and tape the remaining tabs.



Wherever a tab falls on top of a monofilament knot, make a slit in the tab so it straddles the knot and tape it down under the knot.



After all the tabs are secured, line up the cone pattern overlap tab that runs down the length of the cone and secure with invisible tape on the inside and outside of the cone.

Tape the smaller circle into the bottom of the cone by wrapping the tabs around the circle with the same method as the top. Stand the cone up on its bottom. Standing on a ladder, place a finger under the center twisted monofilament from the top wire circle and lift the cone up a couple inched off your flat work surface.

The cone is in balance when it rests evenly. If the cone is out of balance, the cone will dip down on one side. To create balance, put the cylinder down and with your finger, gently push the center twisted monofilament slightly towards the side of the cone that dipped down. Following images show how to check for balance and move the knot but are demonstrated on a smaller cone.

Once again, place a finger under the center twisted monofilament and lift the cone up a couple inched off your flat work surface. Check if the balance is better and if not repeat moving the center twisted monofilament around until the cone finds balance. Once the cone is in balance, place a small drop of crazy glue on the center twisted monofilament.

5. Suspending the cone

Screw a hook into the ceiling centered over the area where you plan to hang the mobile. The mobile will need about 7′ from the floor to hang properly.

If the ceiling is 9′ the mobile will be suspended 2′ from the ceiling. Determine how much space is needed between the ceiling and the top of the mobile leaving 7′ of space below. Double the measure of space above the mobile and the ceiling, and add 6″ to that measurement. This is the measurement for the suspension strand. For example, if there is 3′ of space, measure and cut 6′6″ and if there's 4′ of space, measure and cut 8′6″ of monofilament. Fold the suspension strand equally in half and tie a knot in the folded end to create a loop through which the screw hook in the ceiling will fit. Tie six knots in the other open end of the suspension strand under and

around the center twisted monofilament in the top of the cone. Trim the suspension strand.

If the ceilings are 7' there won't be much room for suspension. Create a two-inch loop out of 6 inches of monofilament by looping the suspension strand around the center twisted monofilament in the top of the cone. Hang the loop on to the screw hook in the ceiling.

6. Attach images to the paper cylinders

Collage images onto the cone with tape or glue. Start with images that correlate with "Hello Beautiful Watershed" curricular guide section at the top of the cone. Eye how much allotment each section should occupy on the cone so that all the sections are represented moving to the bottom of the cone with the "Fresh Water Joins Salt, an Amazing World Filled With Life" section of the curricular guide. Make sure images overlap and are organized in an interesting pattern. Don't leave any white drawing paper exposed.

7. Hanging the water drops

Students can choose to write their name on water drops to indicate their commitment to keeping the watershed healthy. After the students write their names, the water drops are hung on the mobile. Alternate cutting short, medium and long lengths of blue thread so water drops hang at random lengths. Tape a blue thread length to a water drop and tape the other end of the thread to any spot on the mobile. Use a ladder as necessary to reach high. Water drops can hang all the way from the top to the bottom on one thread, there can be multiple water drops on a length of thread. Water drops can hang from the center twists of the bottom cylinder. Continue until all the water drops have been used.

Wherever the cone side is lifted out of balance, find a thread or water drop that is attached at that spot and add a paper clip to it. The weight of the paper clips will pull the lifted side down. Keep adding paper clips until the cone is in balance.

CLOSURE/REFLECTION

After the Water Play mobile is finished, the six groups of students are given an opportunity to write about the section of the curricular guide they studied.

The writing should touch on the experience of finding the images that were attached to the mobile, cycles of the ecosystems, diversity of living things, conservation, community effort, nature's balance, and the significance and intricacies of the watershed. The groups present their ideas to the class in an open discussion. Rubrics can be used at the teacher discretion.

RIVER ALIVE! Scavenger Hunt

As you explore the River Alive! exhibition, use this scavenger hunt to guide you through the exhibits. Carefully explore each stop to fill in the answer to the prompts and discover even more about our watershed.

☐ River Continuum Wall

What's going on in the river? When we don't take care of our watershed, our wildlife suffers. Work together with your classmates to activate all of the input stations. **How did your station change the continuum wall?**

☐ Rate the Risk

We all have different concerns about the watershed. Let your voice be heard by casting your vote on the wall! **Which concern did you vote for? Why?**

☐ Nature's Highway Theater

Grab a costume and take center stage! Explore the different river scenes and fly, swim, or walk like your character. **Find the pollution scene. What is one set of animals that can be most destructive to river life?**

☐ Water Cycle Puzzle

Solve the puzzle to see how water moves through our watershed. **Which 5 stages are directly caused by human activity (the Urban Water Cycle)?**

☐ Watershed Scapes Exploration Wall

Take a closer look at each of the habitat scapes that make up our wonderful watershed. Find the "Work with the Watershed" bullets. **How we can keep our watershed healthy in the urban / suburban habitat?**

☐ Plankton Bloom Table

The diversity our watershed relies on starts with creatures so tiny we can't even see them! But balance is everything. **What happens when there's too many phytoplankton?**

☐ River Window Installation

Take a moment to reflect at the River Window Installation. Try sitting on each of the benches and see what secret sounds you discover. **Which speaker is a maritime studies instructor? What do you think of when you look at the river?**

Get up close to the window and draw your favorite part(s) or pattern(s):

☐ Currents: Partners and Projects

Take the quiz and find out which river hero you are! Make sure to dive in and connect with the watershed. **Write the suggested partner or activity you find most exciting.**

☐ Watershed Map

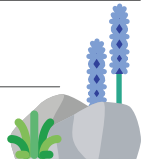
Be sure to grab a post-it and leave your own watershed story on the wall. **Explore the 4 different Watershed Trails and write a sentence about each.**

Life:

Health:

History:

Land:



RIVER ALIVE! Scavenger Hunt

☐ Watershed Artifacts

Take a closer look at pieces of the watershed. The smallest inhabitants are still incredibly complex. **Which butterfly could be mistaken for royalty?**

Which fishing fly is different from the others?

☐ Watershed Story

Take time to experience this entire short film, immersing you in the sights and sounds of the watershed. **Who is telling this story?**

What happens when the land flattens out, and soil and dirt turn into sand and rocks?

☐ Watershed 3D Modeling Table

Human activity has a huge impact on the speed and direction of the river. Experiment with some of the objects here to create a flow that twists and speeds up. **Sketch and label the pieces that make up your model. What is the water doing at different points?**

☐ The Fisharium

Look around the Fisharium and try to identify some of the plants and animals in the aquaria on the wall. **How do the "floating wetlands" support the hydroponic plants next to it?**

☐ Citizen Science Lab

Become a citizen scientist and look at some of the smallest watershed creatures through the microscope. **Draw what a cyclops looks like when magnified!**

☐ Watershed Data Visualization

Investigate the three different factors that contribute to the health of the watershed. **What are the ideal levels of salinity, oxygenation, and water bug life that indicate a healthy Watershed? Write one way to help achieve that for each.**

Salinity _____ %

Oxygen _____ %

Water Bugs _____ %

☐ Watershed Life Glass Tile Wall

Be sure to collect a rubbing of the Watershed Life Wall. Imagine being submerged in the river and seeing all of these creatures up close. **Write a 5 sentence story about a plant or animal on the wall.**

☐ Status of the Watershed Visualization

The Delaware River watershed is lucky to have people and organizations devoted to keeping it clean and healthy but there is always work to be done. **Why is land development a process that still has room to improve?**