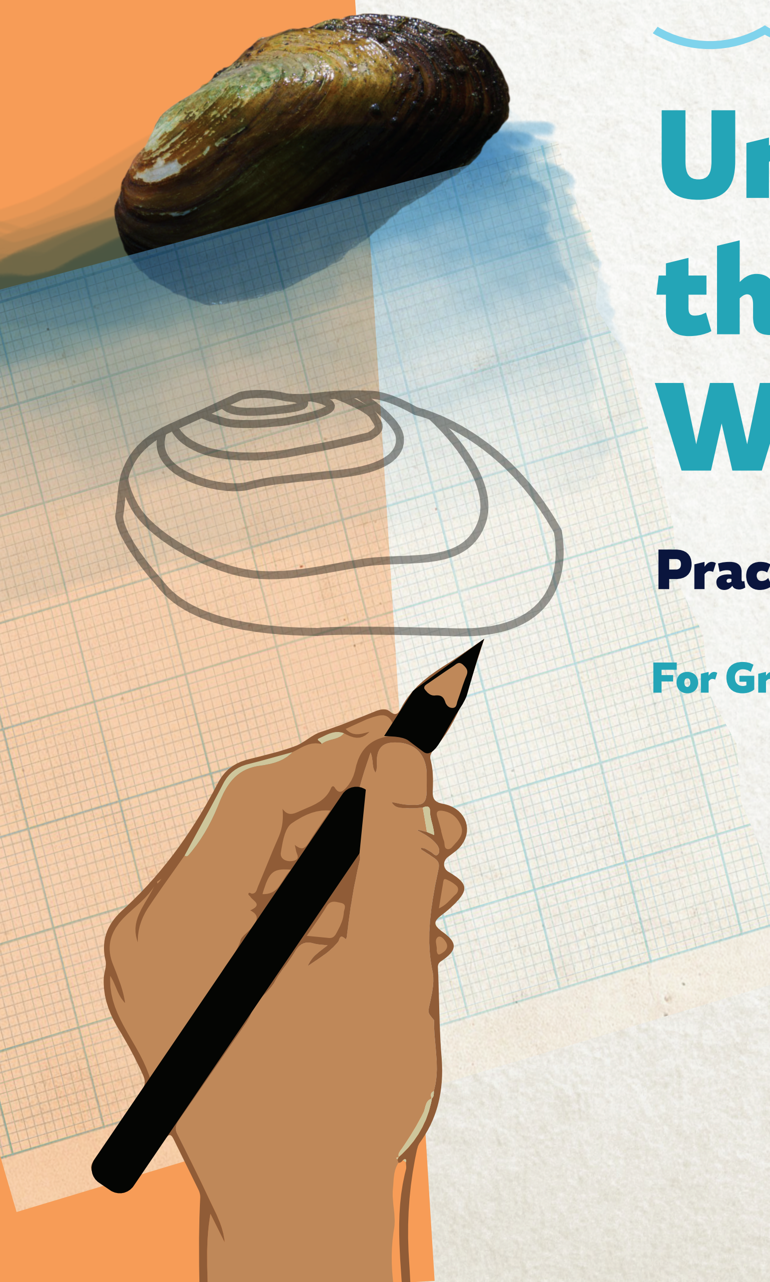
GUIDE FOR
INFORMAL EDUCATORS:

Understanding the Urban Watershed

Practical Lessons and Activities

For Grades K–8 | UPDATED SPRING 2021



FAIRMOUNT
WATER
WORKS

ACKNOWLEDGEMENTS

The creation of the first edition of this Activity Guide (2012) grew out of the Education and Outreach programs of the Fairmount Water Works/Philadelphia Water Department. The Fairmount Water Works Interpretive Center and the Philadelphia Water Department in partnership with the Partnership for the Delaware Estuary, Eco Express and Philadelphia Parks and Recreation reviewed and revised the content for the original guide. It was introduced as a pilot project during the academic year 2012–13 in partnership with the George Nebinger School Faculty and Principal.

Once published, this Guide was used as a framework for the development of a classroom curriculum for teachers. In the fall of 2014, the Fairmount Water Works launched a three-year Middle School Teacher Fellowship Program to develop an integrated urban watershed curriculum for grades 6–8, and titled with the same name: *Understanding the Urban Watershed*. Supported by the Philadelphia Water Department and the William Penn Foundation, nine Philadelphia schools and more than 50 teachers participated over the three year period to develop and test the curriculum. The following two years were devoted to additional piloting, refining, aligning with standards and “sustainable-izing” the Learning Experiences to ready them for classroom integration. The full implementation of the curriculum began in the fall of 2019, with thousands of classroom students across Philadelphia engaging with their watershed through formal education.

This updated and expanded Guide, completed in 2020, contains new ideas and activities that reflect our ever changing environment, particularly around the effects of a changing climate, new scientific research, evolving policy and a more focused commitment to educate for a sustainable future. With a new title, this *Understanding the Urban Watershed* Guide for Informal Educators is meant for anyone interested in bringing Philadelphia watershed education to the young people in their lives—for teachers, parents, siblings, and friends. The Activities herein are meant to be fun and engaging, understandable and adaptable. They reflect a holistic, interdisciplinary, hands-on approach to learning. For some, it will be helpful to note that all the activities are aligned with the Common Core State Standards as well as Next Generation Science Standards and Education for Sustainability Standards for grades K through 8. Additional resources, online materials, and suggested readings can be found in the Appendices at the end of this Guide.

This is intended to be a practical guide for both formal and informal K–8 educators interested in systems thinking and educating for a sustainable future by making connections for young people between one of the most fundamental elements in all living things— water—and the complexities and responsibilities associated with accessing it, using it, cleaning it up and returning it to our waterways. You will discover how a safe and reliable public city water system ensures public health, provides a safe and reliable water supply, sustains life and helps us thrive over time.

Environmental education encompasses any learning activities that help ecosystems and societies thrive. It includes learning opportunities embedded in hands-on stewardship, citizen science, environmental activism, and unstructured time spent in nature. And it is part of a larger effort by policy makers, researchers, the private sector and civil society to respond to pressing environmental challenges. The goal of environmental education is nurturing individual behaviors and collective actions that lead to healthy and resilient environments and communities.

— Marianne E. Krasny, Advancing Environmental Education Practice (Ithaca, NY: Cornell University Comstock Publishing Associates, 2020)

Environmental Education (EE) increases public awareness and knowledge about environmental issues and provides the participants in its programs the skills necessary to make informed environmental decisions and to take responsible actions. EE is based on objective and scientifically sound information and does not advocate a particular viewpoint or a particular course of action. EE teaches individuals how to weigh various sides of an issue through critical thinking, problem solving and decision making skills on environmental topics. EE covers the range of steps and activities from awareness to action with an ultimate goal of environmental stewardship. EE involves lifelong learning; its audiences are of all age groups, from very young children through senior citizens. EE can include both outdoor and in-classroom education, in both formal and informal settings.

— EPA Definition of Environmental Education

Education for Sustainability (EfS) functions as a powerful rationale for teaching and learning in the 21st Century (Sterling, 2001; Wheeler and Byrne, 2004; Cloud, 2010). EfS is a whole system of inquiry that combines current best practices of teaching and learning with the content, core competencies, and habits of mind required for students to actively participate in creating a sustainable future.

— Bergstrom, 2009; Cloud, 2010; ESA, 2012

EfS can be defined as a transformative learning process that equips students, teachers, schools, and informal educators with the knowledge and ways of thinking that society needs to achieve economic prosperity and responsible citizenship while restoring the health of the living systems upon which our lives depend.

— Cloud, 2004 and 2010

THE MISSION OF THE FAIRMOUNT WATER WORKS

To foster stewardship of our shared water resources by encouraging informed decisions about the use of land and water. We educate citizens about Philadelphia's urban watershed, its past, present and future, and collaborate with partners to instill an appreciation for the connections between daily life and the natural environment. Administered by the Philadelphia Water Department, the Fairmount Water Works Interpretive Center and its partners transform the way people think and live by making them aware of how individual actions on the land impact the quality of water for all living things.

The Center leads the education and interpretation of PWD's innovative green management solutions to treat stormwater as a precious resource and to restore our rivers and streams to clean, safe, fishable, swimmable, and beautiful amenities. The public plays a vital role in understanding and supporting the City's environmental goals and programs, and the FWW serves this very special purpose and educates citizens regarding the interconnections between their community and environment, particularly the public's essential role in protecting and stewarding our water and natural land resources.

Core Values

- We care about *Clean Water* for all living things. We recognize that clean water starts with each individual's actions and we nurture a sense of personal responsibility for the conservation of our watersheds and the health of the planet.

- We take a *Personal Approach* to guide visitors in thoughtful exploration of our historic site and to engage their intellect. Every visitor is warmly greeted and treated with courtesy.

- We believe that *Collaboration* is the way to bring creative people, sound science, and great ideas together to cultivate excellence in all we do. We accomplish this by developing *Strategic Partnerships* with those individuals and groups who share our values and aspirations.

- We provide *Experiential Learning* that engages all visitors in understanding the concepts that pervade our messages, programs, and exhibits. Our approach is both "hands on" and "minds on," for all audiences, recognizing that people come to us through different "gateways."

- We value the *History* that has shaped our lives, informs our messages, and inspires our future. Our National Historic Landmark setting, exhibits, and programs celebrate Philadelphia's past and the engineering marvel that was and is the Fairmount Water Works.

- We care about *Our People*, value their individual contributions and seek to attract and retain the very best staff, volunteers, and advisors.

THE PHILADELPHIA STORY

Most of us turn on the tap or flush the toilet without much thought about how the water got there or where it goes, about its drinkability, supply or cost. Many of us do not know anything about the people and the processes that make a citywide water system "hum" along on a daily basis in order to ensure public health or the balanced ecology of our streams.

Historically, the development of the water supply system in Philadelphia, essential to the life and economy of the city, was born out of necessity and inventiveness. Characterized as one of the most successful public water systems in America, Philadelphia's public system grew by meeting the challenges related to public health and industrialization.

Individuals have the ability to protect the quality of our waterways for all living things and to advocate for a healthy environment. The activities that follow will help young people gain a greater understanding of their connection to the land defined as the urban watershed and the system defined as the urban water use cycle. For Philadelphians, watershed education is about understanding the delicate balance between land and water, how we are supplied with abundant safe drinking water, proper sanitation and the management of stormwater runoff and how we sustain healthy ecosystems.

Ben Franklin's adage that "When the well's dry, we know the worth of water" reminds us of the value of water and speaks to our goals. Ultimately, the activities in this guide will encourage young people of all ages to discuss, assess, calculate and evaluate the value of water (so the well never runs dry).

WHY LEARN ABOUT WATER?

The need for water is something that unites all living things. Abundant fresh water may cause a region to flourish whereas the lack of access to clean water can destroy a community. It is every human's most basic need and yet it is rarely discussed or even considered in most developed regions. In an age where potable (drinkable) water simply flows from the tap, it is quite possible for a person to be unaware of where that water originated, or trust it to be safe enough to drink.

Learning about our local water story contributes to our sense of place, which sparks our interest in taking care of it so that it can take care of us. Watershed education helps us feel more connected to the life and health of our waterways, helping us learn where drinking water comes from, how it gets to the consumer, where it goes next, how it can be threatened, and how to take better care of it. The more we understand the interdependence of all living things, the more we will transform our thinking and behaviors so that our actions make a difference in the protection of water, a precious (and finite) resource for all living things.

In Philadelphia, The Philadelphia Water Department (PWD) is working to protect water resources from harmful pollution through its Green City, Clean Waters plan, a 25–year plan to transform the health of the City's creeks and rivers primarily through a land-based approach.
By implementing green stormwater infrastructure projects such as rain gardens and stormwater planters, the City can reduce water pollution impacts while improving our essential natural resources and making our neighborhoods more beautiful. PWD's vision is to "unite the City of Philadelphia with its water environment, creating a green legacy for future generations while incorporating a balance between ecology, economics, and equity." Similarly, the School District of Philadelphia's GreenFutures Sustainability Plan aims to connect students with their watershed using the principles of education for sustainability as well as the physical installation of green stormwater infrastructure projects at schools.

Simply put, effective watershed education is essential to transforming the way people think and live by making them more aware of how individual actions impact the collective quality of water for all living things.

INNOVATION AND SOLUTIONS: A CAPTIVATING STORY

This guide presents a variety of ways to help you engage young people in the fascinating and yet complex narrative, with its twists and turns, describing the story of Philadelphia's Water system. As with any good story, it has a theme, a plot—with conflict and struggle — as well as resolution, interesting characters, and a setting. The style and tone of how you tell the story is up to you, but the content is compelling and real. The only difference between this narrative and the one found in a book may be that it has no ending. It is up to all of us to write the next chapters and to pass it on.

ABOUT THIS ACTIVITY GUIDE

If you are someone who just wants to dip your toes into the world of watershed education, an informal environmental educator looking for new ways to engage your audiences, or a parent or caregiver in your new supporting role in your child's day to day education, this guide is for you! It is intended to spark your interest alongside your student. Use your own experiences and creativity as well as the young person or people in your life. Learning may begin with one individual or a small "unit", but can have a rippling effect, like a pebble in a pond, to spread to the small or vast world outside.

The activities are presented in sections, and grow concentrically to an ever-widening world of water; student exploration starts on a personal level at home, then expands to the neighborhood or community, and to the city and beyond. Although there is no prescribed plan here, it is written in a sequential approach and the material builds upon itself. The activities do have suggested age-ranges and discipline areas but anything can be adapted. Flexibility abounds.

ABOUT THE *UNDERSTANDING THE URBAN WATERSHED* CURRICULUM

If you are excited about what you find in this guide, but you are interested in integrating watershed education as Curriculum in the classroom, check out our Understanding the Urban Watershed Curriculum. It is designed for middle school educators in grades 6 to 8 to integrate real world environmental experiences into the formal classroom, providing locally-based learning that is relevant and impactful for student learning. Like this Guide, the Curriculum is designed as a series of thematic units that are divided into learning experiences that build on each other, starting with the personal perspective. Ultimately, the Curriculum provides students with an in-depth exploration of the development of urban water delivery systems and will help students become active participants in 21st-century solutions to water issues in the world around them, leading them through the steps of thought, knowledge and action; the final thematic unit guides them through the development and implementation of their own youth action project.

Students, faculty, administrators, families and community members will help shape this project to be both sustainable and valuable. Each thematic unit includes broad learning objectives, a "What You Should Know" section to begin to inform the educator, and a series of learning experiences for the students. Each learning experience is aligned with Pennsylvania Academic, Common Core, Next Generation Science, and Education for Sustainability Standards.

Thematic Unit 1: Water in Our World

ESSENTIAL QUESTION: What is the value of water?

First, it is helpful to reflect upon the value of water in our own lives and develop a thorough understanding of how the natural water cycle (the hydrologic cycle) functions and interacts with the natural world. It is important to embrace this basic level of appreciation and understanding before exploring subsequent thematic units, which address human settlement and interaction with the natural world, the growth of cities, and how people adapted and innovated to meet the challenge of providing clean water as the population grew.

LESSONS:

1. Water for Life (or My BFF)
2. The Natural Water Cycle
3. Landforms and Watersheds
4. Plants, Trees and Wetlands: Nature's Filters and Buffers
5. Ecology of Waterways
6. Ecological Interdependence

Thematic Unit 2: Drinking Water and You

ESSENTIAL QUESTION: What does it take for us to drink a glass of fresh, clean, delicious water?

Students will learn about the urban water use cycle and how this is both different and similar to the natural water cycle. They will explore their individual connection to it as well as their human impact on it. They will develop a basic understanding of safe and reliable urban water systems, infrastructure and management of drinking water (supply). More than 200 years ago, Philadelphia approached access to a clean drinking water supply as a civic responsibility for the public good.

LESSONS:

1. My Daily Water Use Log
2. Water for the Federal City: Civic Responsibility for the Public Good
3. Technology and Innovation: Engineering a Public Water System
4. Clean Water and Public Health: Consider the Source
5. Public Drinking Water Treatment Process Explained
6. Testing the Waters: Making it Safe
7. Bottled or Tap?

Thematic Unit 3: Down the Drain, or Out of Sight, Out of Mind

ESSENTIAL QUESTION: What became of Philadelphia's natural streams and valleys?

Just as Philadelphia developed a collective drinking water supply system to ensure the public health of its citizens, it also developed ways to collect and dispose of its waste or "used" water. Students will discover that it was no small task to engineer an effective system of drains and pipes to carry human and industrial waste away from where people lived.

LESSONS:

1. The Growth of the City: Population and Wastewater Systems
2. Industrial Revolution and Environmental Devolution
3. Streams to Sewers: Creating an Underground Infrastructure
4. Sinks, Pipes and Mains: Make the Connection
5. Public Wastewater Treatment Process Explained

Thematic Unit 4: Land and Water: A Delicate Balance (or Can't We All Just Get Along?)

ESSENTIAL QUESTION: Can we create sustainable urban design solutions that work with the natural water cycle?

Homes, markets, factories, parks and roadways – these are many of the ways land has been transformed to create our cities and affect water quality. Students will learn how the relationship of land to water is an ecological balancing act, both for humans and for the natural environment. At many points throughout the last two centuries, the balance has been tipped, equilibrium lost. They will discover not only the consequence of pollution (making people sick), but also how public health prevailed and we are moving towards equilibrium being restored.

LESSONS:

1. The Rain Drain: Stop Trash in its Tracks
2. What's the Point: Exploring Point Source and Non-point Source Pollution
3. What's Combined Sewer Overflow?
4. Ecological Imbalance: The Effects of Pollution
5. The Environmental Movement: Empowering People, Creating Change
6. The Clean Water Act: A Policy Solution

Thematic Unit 5: Green (and Blue) Plan for the Future: Playing a Part

ESSENTIAL QUESTION: Can we create a healthy, beautiful, and sustainable Philadelphia?

The greatest threat to our water resources in the 21st century is pollution carried by stormwater runoff. As students have learned by now, past solutions and innovations for the collective good have moved the story forward. Next they will explore how individuals and communities play a key role in shaping the future environmental health and well-being of their city. "Sustainability," "greening" and "stewardship" are not just vocabulary words, but will become an integral part of our future story. new ways of living that are written into our story's plot narrative.

LESSONS:

1. How to Slow the Flow: Properties of Soil and Plants
2. Green Stormwater Infrastructure: Following Nature's Lead
3. Calculating Rainwater
4. Restoring Urban Waterways
5. Reimagining your Schoolyard, Backyard, or Streetscape
6. Freshwater Mussels: Nature's Water Quality Engineers

Thematic Unit 6: Environmental Stewardship

ESSENTIAL QUESTION: What are we going to do to protect and sustain water quality in our watershed?

In order to sustain life on the planet and protect the health of our environment, we all must play an active role. Whether we aim to improve our waterways by restoring a natural balance between stormwater runoff and infiltration or reduce the effects of climate change by planting tress and increasing green space, every action adds up. Through their own hands-on project, students will learn the roles and responsibilities of being part of the solution as they become environmental stewards and climate activists.

Standards Alignment

Turn to page 72 to see how the Lesson plans align with Common Core State Standards for Literacy and Math, Next Generation Science Standards and Education for Sustainability Standards.

Interested in accessing the Understanding the Urban Watershed curriculum online? Visit resourcewater.org for more information.

Thematic Unit 1:

Water in Our World

First, it is helpful to reflect upon the value of water in our own lives and develop a thorough understanding of how the natural water cycle (the hydrologic cycle) functions and interacts with the natural world. It is important to embrace this basic level of appreciation and understanding before exploring subsequent thematic units which address human settlement and interaction with the natural world, the growth of cities, and how people adapted and innovated to meet the challenge of providing clean water as the population grew.

What you should know:

We use water all the time in our daily lives. We drink it, clean with it, cook with it, water plants, and even swim in it. The water that Philadelphians rely on for most of these activities, originating from the Schuylkill and Delaware Rivers, is a *common* resource, utilized and required by all. Also described as "The Commons," this kind of (public) resource is something upon which we all depend and for which we are all responsible. A Healthy Commons is something students will come to recognize and value. Both the government and citizens alike have a role to play in responsibly managing this resource—to supply it, clean it up, and protect it at its source.

Water is essential to life, but the freshwater resources on Earth upon which our own life depends are limited. Only about 3% of the water on Earth is freshwater and about 2/3 of that is frozen into icebergs or trapped in the earth. Much of the remaining 1% of available freshwater is polluted, either intentionally and unintentionally, by human activities.

The Earth has a very efficient method of cycling water through the atmosphere and the land. As precipitation falls from the sky, it takes one of many different routes: some infiltrates, replenishing groundwater and recharging our streams, some is taken up by plants keeping them healthy, and some runs into waterways refreshing surface water. The heat from the sun warms the water and turns it into a gas, causing it to rise back into the atmosphere, a process called evaporation. Transpiration, or "sweating", releases water from plants as a gas into the atmosphere. These steps make up what we call the natural water cycle.

Precisely because of the way the natural water cycle functions, there is an inseparable connection between water and the land that surrounds it. All of the land that sheds its water or feeds underground to a particular water body when it rains is called a watershed. Unfortunately, if both land and water are not cared for and become polluted, all living things that depend on it can suffer. There is an inherent connection between these living and non-living things, which is defined as an ecosystem, or a community of living organisms that interact with each other and the non-living components of their environment.

One way to determine the health of our waterways is for scientists to observe nature itself by using biological indicators. Biological indicators are plant and animal species that tell us, by their very nature, about the health of an ecosystem. In the Schuylkill River, scientists will look at species like the American Shad, a delicate fish species, to infer how healthy or polluted the water is. Other species that can be used as indicators include the Great Blue Heron and macro-invertebrates like the Mayfly.

In order for students to become stewards of their watershed, they must begin by nurturing a basic appreciation for our natural resources. This starts by understanding how water is ingrained within all aspects of our daily lives, as they will see in the following lessons.

"Because environmental education, like much education, often fails to acknowledge the crucial role of emotions in the learning process, activities that both inform the mind and engage the heart proved to be a powerful and effective combination. Helping children fall in love with earth is what we do. Because people protect what they love, this is a powerful prescription for stewardship and ultimately, we hope kinship."

- MK Stone and Z Barlow (eds) Ecological Literacy: Educating Our Children for a Sustainable World. San Francisco, CA: Sierra Club Books (2005). P 116.

Sequence of Lessons

1. Water for Life (or My BFF)
2. The Natural Water Cycle
3. Landforms and Watersheds
4. Plants, Trees and Wetlands: Nature's Filters and Buffers
5. Ecology of Waterways
6. Ecological Interdependence

Lesson 1: Water for Life (or My BFF)

All living things need water to live and all living things contain a certain percentage of water. From your favorite sports figure or pop singer to the clams at the beach, everything living in this world needs water to survive. Although water is essential to life, there is another part to this story. There are aspects of water that may not seem integral to life itself, but without access to clean water, our world would be transformed into a dry, thirsty environment around us. Consider our lives without water, without fishing, swimming or boating in our waterways or the way we feel after a summer thunderstorm.

VOCABULARY

Water *(noun and verb)*: Collect in a notebook or post around your room as many definitions as you can find to describe this word. Write as many sentences as possible using the word. See who can write the most. Research and post the word "water" in many languages.

ACTIVITIES

a. Compare how much water exists in a variety of everyday living things. Choose anything from the mundane (something related to what they eat everyday for lunch) to something outside their home or school that they can see or pass by. (K–5)

b. Write a love letter to water. Illustrate it. (K–5)

c. Write a story using rivers as symbolism. Discuss such words as flow, rhythm, light, grace, fluidity or even rushing, raging and flooding. Use aspects of the landscape as a metaphor. (6–8)

d. Survey the landscape paintings of 19th century "plein air" artists. Analyze composition and color before copying a master's work or creating their own outside. (3–8)

e. Research, collect and compare data related to how much water is used in manufacturing and in agriculture (e.g. a shower, a t-shirt, growing soybeans on a family farm) also called a "Water Footprint." Chart and graph. (6–8)

f. Listen to audio clips of water (ocean, river, thunderstorms, rain). Describe the sound using adjectives. Ask them to attempt to pinpoint the sound and to connect the sound to a personal experience. Have them make their own audio recoding and have others guess. (6–8)

CONSIDER AND DISCUSS

- What is a water footprint?
- Why is water used as an indicator of life on other planets?
- How is water used in spiritual or secular rituals?

ASK THE QUESTION

How do I relate to water in my life? Why should I care?

Lesson 2: The Natural Water Cycle

Technically called the "hydrologic" cycle, the natural water cycle is the ultimate sustainable process. As human beings we absolutely depend on getting and using clean, safe, fresh water to sustain us. We can't make new water on the planet, so the water we do depend on exists in a closed system, an endless loop from earth to sky and back again. Getting students to understand this fundamental concept will serve as the foundation for any study of the topic of water and will help them explore the value of water in their world.

VOCABULARY

Hydrology *(noun, from Latin hydrologia)*: A science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

THE NATURAL WATER CYCLE

Condensation *(noun)*: The part of the water cycle in which a vapor or gas is converted to a liquid.

Evaporation *(noun)*: The process by which liquid changes into vapor.

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

Percolation *(noun)*: The part of the natural water cycle in which water moves slowly downward through the porous ground.

Precipitation *(noun)*: The part of the natural water cycle in which rain, snow, sleet, or hail falls from the atmosphere to the ground.

Stormwater Runoff *(noun)*: The part of the water cycle in which water flows off the land into the nearest body of water.

Transpiration *(noun)*: The part of the water cycle in which water that has been absorbed by living things, like by plants and trees and evaporates into the atmosphere.

ACTIVITIES

a. Create simple icons on cards depicting each stage of the natural water cycle and place them in the proper order on a pre-drawn circle. With younger students, write a script and perform a play demonstrating the natural water cycle (consider calling it "Birth of Small Cloud"). (K–2)

b. Seek out the root of the word "evaporation" to discuss vapor and states of matter. (3–5)

c. Read *Water Dance* by Thomas Locker aloud and discuss the images and first-person style of narration (e.g. "I am rain"). Write additional lines of poetry elaborating on the statements (e.g. "I am rain, and I give life." or "I am rain, I fall from the sky and make rivers."). (2–5)

d. Memorize/review the different stages of the hydrological cycle by creating a song, a poster, or a computer graphic. (4–8)

e. Take a walk outside just after a rainstorm. If it has not rained recently, take some water with you to pour on various surfaces. Ask students to describe what happens to the water and have the same discussion (rain or shine). Observe what is happening to the water outside. Look for examples of precipitation (rain) and condensation (clouds). (6–8)

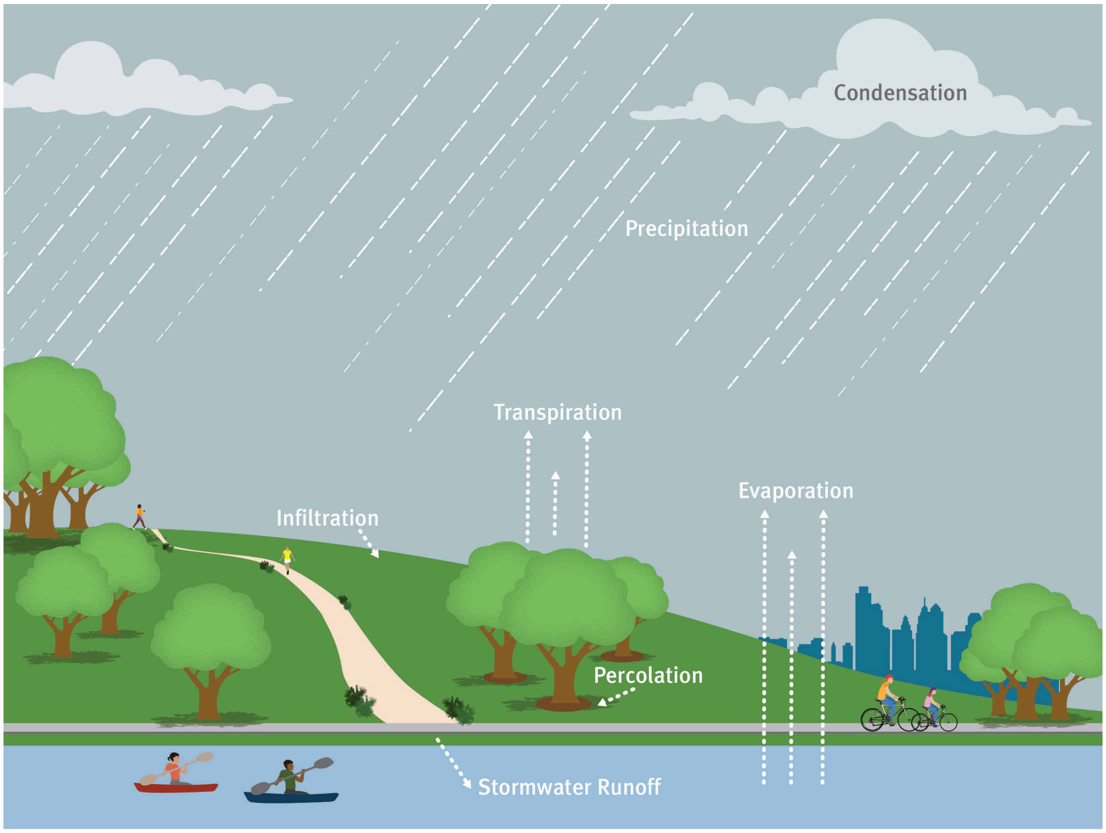
CONSIDER AND DISCUSS

- Is water a finite resource? How do you know?

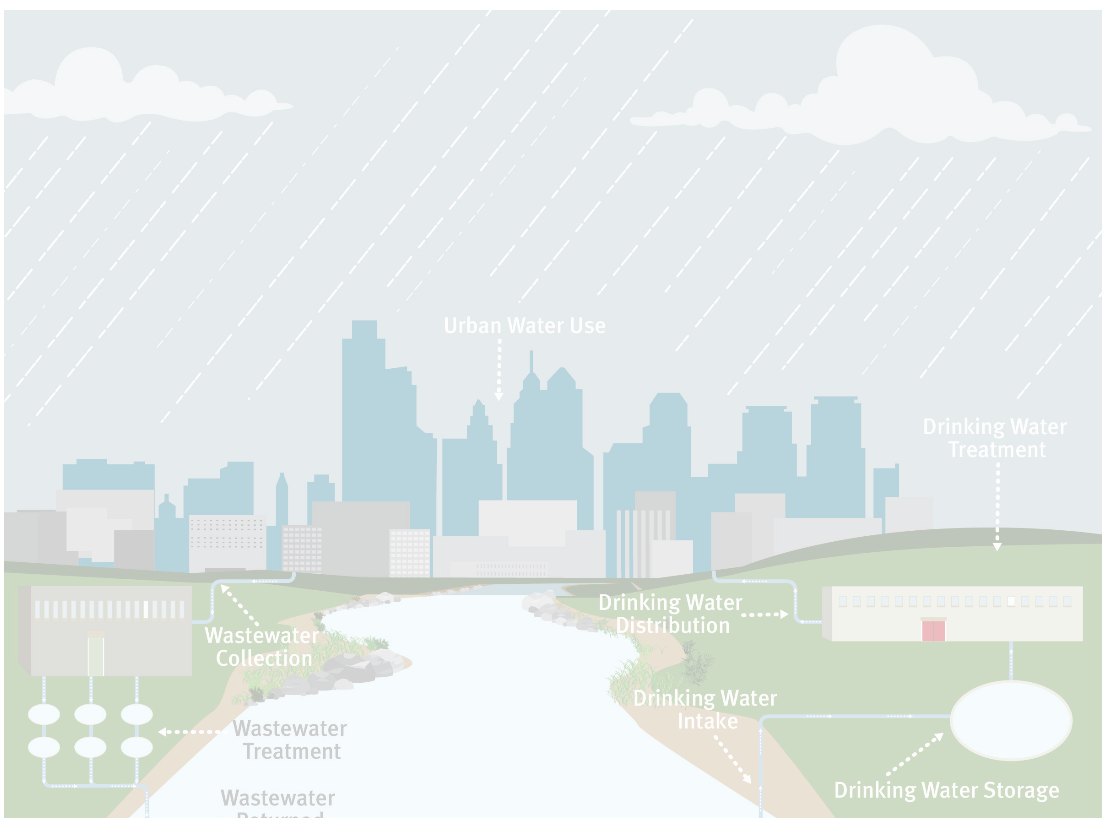
ASK THE QUESTION

Have you "seen" the water cycle at work?

NATURAL WATER CYCLE



URBAN WATER CYCLE



Lesson 3: Landforms and Watersheds

All of the land that sheds its water to a particular body of water when it rains is called a watershed. We can think of watersheds as big sinks – because of their slope, the water flows down its sides to the lowest point (like a drain). Before we can discuss the urban watershed with students, help them understand these fundamental characteristics of a watershed—topography (landforms) and gravity (water flows from a high spot to a low spot)! Scale it up, or scale it down, it is all the same.

VOCABULARY

Topography *(noun, from Greek topographein—to describe a place; topos, place and graphein, write)*: The physical or natural features of an object or entity and their structural relationships; the art or practice of graphic delineation in detail usually on maps and charts of natural and man-made features of a place or region especially in a way to show their relative positions and elevations.

Watershed *(noun)*: The region or area of land that drains into the nearest river or stream or other body of water.

ACTIVITIES

a. Using clay, create mountains and a river (hint: create enough slope in both the land and water to allow for "runoff"). Use sprays of water or beads dropped as rain on the mountaintop. (K–2)

b. Make a working watershed model from crumpled paper, foil, paper mache or insulation foam, in a box or plastic bin, of land and water to demonstrate the concept. (3–5)

c. Locate and share varying scales of topographical maps of Pennsylvania, showing the abundance of rivers. Trace the rivers. Compare to a topographic map of the United States. Overlay a watershed map to illustrate the defining nature of a watershed. (6–8)

d. Use a stream table kit to model how water interacts with and flows over different surfaces. (6–8)

CONSIDER AND DISCUSS

- Discuss local and regional natural geological landmarks and the formation of rivers.

ASK THE QUESTION

How do you know you live in a watershed?

Lesson 4: Plants, Trees and Wetlands: Nature's Filters and Buffers

Plants and trees have a sophisticated and vital role to play in the water cycle related to infiltration and transpiration. Along the banks of our waterways, plants act as buffers by catching sediment, keeping things in place or preventing erosion and by using up nitrogen and phosphorous before they reach our waterways. Wetlands, equally as important to our waterways, can clean pollutants carried by stormwater runoff, replenish groundwater, reduce flooding risks and provide a home for wildlife, as do plants and trees.

VOCABULARY

Riparian *(adjective, Latin, riparius first known use c.1841)*: Relating to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater.

Buffer *(noun)*: Something that serves as a protective barrier.

Wetland *(noun)*: An ecosystem that is saturated with water, such as a swamp, marsh or bog.

ACTIVITIES

a. Create a riparian buffer (birds-eye view line drawing of stream bank and river). Imagine their own natural world by populating the stream bank with their own plants and animals from above. Create pre-cut pieces (bugs, flowers, mammals, trees, etc.) and glue them to the sheet of paper. (K-8)

b. Use cut flowers and food coloring to demonstrate capillary action. (K–8)

c. Pour a measured quantity of water into sloped foil pans filled with a sponge (wetland), a reusable dishcloth (lawn) and nothing (paved surface), respectively to demonstrate the different properties of land use and wetlands. (K–8)

d. Collect images of wetlands throughout the United States and make a photo magazine with captions. (K–5)

e. Make a model depicting three different kinds of surfaces on a slope with a catch-basin—a planted area, a grassy area (low lawn-type setting) and a paved surface. Use something to represent water such as beads, beans or rice. Predict and compare the runoff of each of the surfaces. (3–8)

f. Research the different kinds of wetlands in the Philadelphia area and how they may benefit adjacent communities or neighborhoods. Broaden the scope of research to include other regions and scales of wetlands (e.g. New Orleans, Everglades). Turn student research into a news magazine and call it something clever and alliterate like "Wetlands World" or write a newspaper article or editorial. (6–8)

g. Research various wetland restoration projects, including their plant species and habitat. Learn what metrics are being used to evaluate the benefits. (6–8)

CONSIDER AND DISCUSS:

- What other benefits are there to creating and maintaining riparian buffers along our waterways?
- What environmental policies exist around wetlands in the United States?

ASK THE QUESTION

What happens in a heavy rainstorm if a stream does not have any "buffer"?

Lesson 5: Ecology of Waterways

There is an integral connection between the water quality of waterways and the diversity of living things in it. Diversity and abundance are the “watchwords” of our scientists who test and monitor fish and wildlife to measure the health of our waterways. A simple walk along the river can give us an idea of how our rivers are doing. How many birds do you see? Can you see turtles of all sizes? Wait for that surprise splash on the surface that tells us—there are fish in there! With the added benefits of a microscope and chemical testing, we can examine the diverse world of living things through a new lens. Even the smallest drop of water has a story to tell.

VOCABULARY

Ecology *(noun)*: A branch of science concerned with the interrelationship of organisms and their environments.

Diversity *(noun)*: The variety of life in the world or in a particular habitat or ecosystem.

Native *(adjective)*: Describes an animal or plant of indigenous origin or growth.

Invasive Species *(noun)*: Non-native organism that does harm to our environment.

ACTIVITIES

a. Characterize the diversity and abundance of fish species in the river using real data to help understand the work of aquatic biologists. Set up a simulation of the fish census, characterizing the species into pollution tolerant, moderately tolerant and intolerant. Make simple graphs of the data. (K–8)

b. Create an exhibit of images showing the variety of shapes and sizes of this world of macroinvertebrates and microorganisms. Make an exhibit label that describes the relationship of the organism or plant to water quality. Use pencil, pen and ink and/or watercolors or crayons to create the ecology art gallery. Scale this activity up or down depending on the age of your students. (K–8)

c. Assign a journaling activity during a visit to the nearest waterway. Consider having them document what they observe in 5, 10, and 20–minute intervals. (4–8)

d. Research native species and their properties. Create a how-to booklet to accompany a walk in the park for identifying natives or invasives. Make leaf rubbings in the field and display. (6–8)

e. Write a research paper on environmentalists like Dr. Ruth Patrick and Rachel Carson. (6–8)

CONSIDER AND DISCUSS

- What is a biological or wildlife indicator? Why do we use wildlife to measure ecological health? How do we use microorganisms and macroinvertebrates as water quality indicators? What other tests do we give to our water to make sure it is healthy (like we take our own temperature, blood pressure etc.)?
- What happens to native species when invasive species are introduced to an area?

ASK THE QUESTION

Why is diversity a positive ecological indicator? How does diversity make complex life possible?

Lesson 6: Ecological Interdependence

The diversity and abundance of species within our waterways has enormous implications for food webs and the interdependence of organisms within the community. A change which affects any level of the food web can affect the entire stream community, meaning small shifts in one area can have big impacts on an entire group. In addition, changes to the ecology of the riparian buffer and/or to the wetland community can also have a profound impact on the stream community as these communities are ecologically interdependent on each other.

VOCABULARY

Community *(noun)*: A group of organisms that live together and interact.

Niche *(noun)*: The job or role of an organism in its environment; how it fits in with other organisms in the food web.

ACTIVITIES

a. Choose an activity such as cleaning up a shared space in which everyone's participation is essential in meeting the goal: a clean space. Give each individual a job to do (if one person seems to "take over" talk about invasive species here) to demonstrate interdependence within a community as it relates to the goal. Name everyone different plants, animals and humans, and have the space become an ecosystem. (K–3)

b. Give each person a job within a human community (i.e. teacher, dentist, farmer) and have them stand in a circle.

   i. Pass a ball of yarn around the circle, creating a web, and ask them to take turns explaining how or why they may depend on another person and their role within the community. (4–8)

   ii. Explore what would happen if one person leaves the web. Ask what they would do without that person in their community. (4–8)

c. Assign students different organisms to research on their own. Share and see if they can now determine how the organisms interact with each other, what they eat, what they depend on to live. (6–8)

CONSIDER AND DISCUSS

- How does a human community web mimic a natural aquatic web?
- How do aquatic organisms in a stream community interact with the adjacent lands of a wetland, riparian buffer, or forest?

ASK THE QUESTION

Who are the members of a watershed community? Are we?

Thematic Unit 2:

Drinking Water and You

Objectives:

Students will learn about the **urban water use cycle** and how this is both different and similar to the **natural water cycle**. They will explore their individual connection to it as well as their human impact on it. They will develop a basic understanding of safe and reliable urban drinking water supply system, infrastructure and management of drinking water (supply). More than 200 years ago, Philadelphia approached access to a clean drinking water supply as a civic responsibility for the public good.

What you should know:

Philadelphia began using the river (surface water) for drinking water supply over 200 years ago. The tap water that Philadelphians rely on originates from the Schuylkill and Delaware Rivers. The Philadelphia Water Department (PWD) is responsible for making the water clean and safe to drink and for collecting it after we have used it. This used or waste water is cleaned once more and returned to the river. We call this the urban water use cycle; it connects all Philadelphians to the rivers and gives us one big reason to care about protecting this resource. It is viewed as a public responsibility – to supply it, clean it up, and protect it at its source.

By 1801, Philadelphia's first public drinking water system was created. This infrastructure was designed and engineered to pump river water (surface water) for the drinking water supply from the Schuylkill River at 24th and Chestnut Street to a steam-powered water works structure at Centre Square, where Philadelphia City Hall stands today. From here, it was distributed to the city through wooden pipes made from hollowed out logs to flow to public hydrants and to businesses and dwellings. Very soon, the demand for water exceeded the capacity of this first pumping station; cast iron replaced wood pipes and construction began on a newer, larger capacity pumping works at Fairmount. The new site was chosen for its close proximity to the river and, more importantly, to "Faire Mount", one of the highest points in the city, ideal for constructing reservoirs to create enough flow for a new gravity-fed system. From 1815 through 1854, this Water Works at Fairmount was the sole pumping station, supplying Philadelphia with water, including the districts of Spring Garden, Northern Liberties, and Southwark. In the years that followed, new pumping stations were built to meet the growing demands of the expanding city population. In 1854, the City boundaries grew, incorporating all the outlying and adjacent districts and their accompanying pumping stations, diminishing the City's sole dependence on water from Fairmount.

In 1868, the open land upstream of the Water Works, originally purchased by the city to keep open space to protect its water supply, became Fairmount. It was also expanded to more than 2000 acres with the purchase of land on both banks of the Schuylkill River.

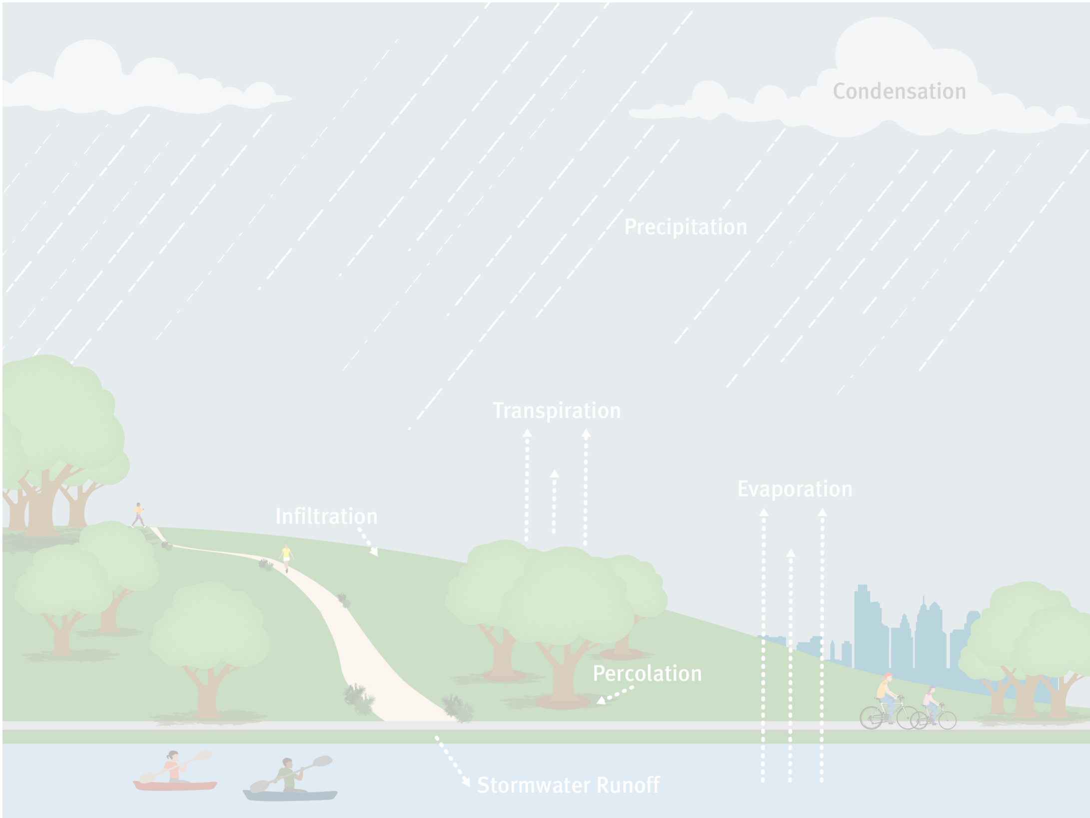
In spite of these protections the state of the Schuylkill, and of drinking water drawn from it at the four separate pumping stations—Shawmont, Belmont, Spring Garden, and Fairmount—continued to deteriorate. One of the problems was even if Philadelphia had been able to completely eliminate pollution of the river within the city limits, it had no direct control over the sewage and industrial pollution from communities upstream. An exploding population, a need to protect public health, and emerging technologies all forced important changes to the system for supplying drinking water. No longer would Philadelphia's water supply be able to be used directly from the source, without being filtered first.

In 1909, the Fairmount Water Works was decommissioned and water filtration plants were constructed at other locations. Philadelphia started with five sand filtration systems, which greatly reduced water-borne disease occurrences. The addition of chlorine to water in 1914 further reduced negative health impacts as well as the implementation of a comprehensive sewage treatment plan during the 1950s. With the city's 3rd century of public water supply underway, the Philadelphia Water Department continues to use the best science and engineering available to ensure the city's drinking water meets all national, state, and local standards for drinking water quality, while protecting our environment and making Philadelphia a healthier city. Federal regulation enacted in the 1970s and still in place today, the Clean Water Act in 1972 and the Safe Drinking Water Act in 1974, are critical to assuring the safety and public health of one of our most critical natural resources—water.

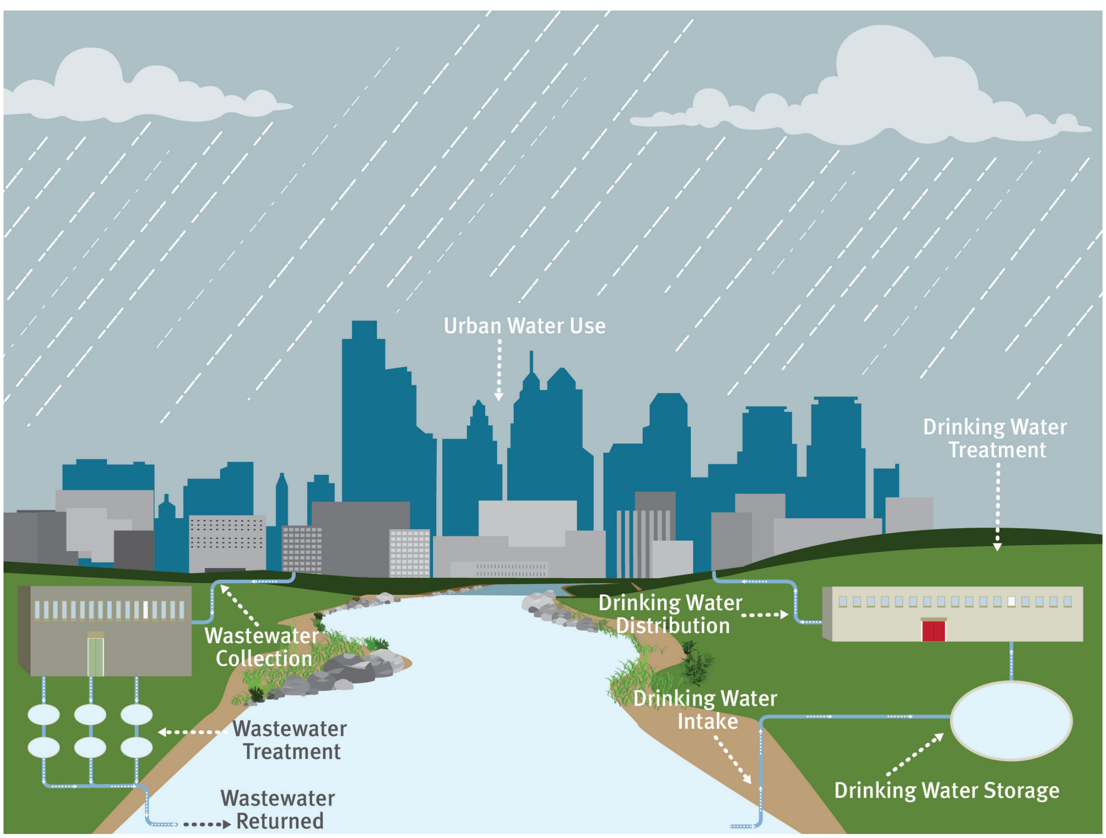
Sequence of Lessons

1. My Daily Water Use Log
2. Water for the Federal City: Civic Responsibility for the Public Good
3. Technology and Innovation: Engineering a Public Water System
4. Clean Water and Public Health: Consider the Source
5. Public Drinking Water Treatment Process Explained
6. Testing the Waters: Making it Safe
7. Bottled or Tap?

NATURAL WATER CYCLE



URBAN WATER CYCLE



Lesson 1: My Daily Water Use Log

Most American cities enjoy clean water resources for drinking, cooking, and bathing. Lets remember that the seemingly endless supply is, in fact, a finite resource. The simple act of tracking and logging personal gallons used will enlighten, inform and perhaps modify how and what we take for granted.

VOCABULARY

Hygiene *(noun)*: A science of the establishment and maintenance of health. Conditions or practices (as of cleanliness) conducive to health.

ACTIVITIES

a. Start with a group discussion about how people use water every day and make a list and/or simple icons to depict the basic uses of water. Put these uses into larger categories (e.g. bathing, cooking, cleaning) based on the active use of water. Use something to represent gallons as counters and begin to develop different piles or even “buckets” of gallons used. (K–2)

b. Develop a water use log sheet to be completed in a 24–hour time period. Brainstorm what to include on that sheet as part of the activity. (3–8)

c. Track and display the data logged. Use bar graphs, pie charts and other visual displays of information. Compare water usage of cities in the United States by population, geography and climate, and access to supply (source water). Compare usage globally. (6–8)

CONSIDER AND DISCUSS

- Have a conversation about where water comes from before we use it. How aware are we of how much water we use, compared to other people in the group, other cities, or other countries?

ASK THE QUESTION

Why should we care about how much water we use?

Lesson 2: Water for the Federal City: Civic Responsibility for the Public Good

Philadelphia's first public water supply systems, both at Centre Square and at Fairmount were successful experiments in providing citizens with a safe and reliable public water delivery system. The innovative engineering and beautiful architectural design of the Fairmount Water Works, in particular, became a source of civic pride for Philadelphia for nearly a century and once again as a public education center for the 21st century.

VOCABULARY

Civic *(adjective)*: Of or relating to citizen, a city, citizenship or community affairs.

ACTIVITIES

a. Find images of other public buildings and institutions from the early 19th century. Label their function and talk about their significance in a city. Talk about their surroundings. Using blocks or a kit of geometric shapes, design your own landmark. (K–5)

b. Research the life and work of a well-known Philadelphia inventor, architect or designer and create an exhibit. They should be able to articulate what the impact of the innovation or institution had on society. Present to each other and if there is time, to other classes. Research the person who the school is named for. Explore and discuss current day innovations. (6–8)

c. As a class or individually, develop a water appreciation plan and/or a celebration plan for home/school/community to share with others, such as a social media campaign, posters or lawn signs. (4–8)

CONSIDER AND DISCUSS

- Compare the design of water utility buildings of 100 years ago to similar types of functional public buildings today, like airports, railway stations, or public schools.

ASK THE QUESTION

Can you identify any current day public utility buildings?

Lesson 3: Technology and Innovation: Engineering a Public Water System

In the early 1800s, Philadelphians benefited from an engineered solution to their drinking water problem. Engineering a system of pumps, pipes, waterwheels, gears, hydrants and reservoirs made water delivery convenient, accessible and abundant.

VOCABULARY

Engineering *(noun)*: The application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people.

Reservoir *(noun)*: A large natural or artificial lake used as a source of water supply.

ACTIVITIES

a. Set up a model joining two water-tight containers with a flexible tube. Fill one of the containers and raise it up to a higher elevation to regulate the flow into the empty container at a lower elevation. This demonstrates the fundamentals of a gravity-fed system. (K–2)

b. Illustrate and caption, on separate cards, component parts of a water system such as tank, reservoir, pump, waterwheel, aqueduct, and pipe. Arrange sequentially. (3–5)

c. Add to the above activity by introducing the source water component (surface or ground) and its accessibility. Demonstrate and/or fabricate a simple pump and waterwheel that both have a simple function. (3–5)

d. Add the innovation piece to the two activities above by designing a simple machine or a "Rube Goldberg" for fun, or make it a contest. Examine the original pipe plans for Philadelphia or another city of its age and discuss infrastructure. (6–8)

e. Research and report on other public works projects related to water such as canal systems (e.g. Erie, Morris, Schuylkill, public baths in ancient Rome). (5–8)

f. Identify and describe various fields of study and skills needed for civil, sanitary and environmental engineering professions. (7–8)

CONSIDER AND DISCUSS

- Discuss the pros and cons of a public water supply vs. private. Relate this to fire-fighting, public health, cost, etc.
- Discuss comparable public engineering projects such as roads and bridges (transportation systems).

ASK THE QUESTION

How are the natural water cycle and engineered drinking water systems working together in the delivery of water?

Lesson 4: Clean Water and Public Health: Consider the Source

Have you heard the expression "Consider the source"? This applies to the water we drink, whether it is from our rivers and lakes (surface), from an underground aquifer (groundwater) or from a spring. Its drinkability is dependent on many complex factors. One thing we can be certain about is that human beings need clean, fresh water to live.

VOCABULARY

Potable *(noun)*: A liquid that is suitable for drinking.

Source Water *(noun)*: The water from streams, lakes, or underground aquifers that is used for drinking.

ACTIVITIES

a. Read various fables, such as Aesop's Fable *The Crow and the Pitcher*, and other stories about wells and drinking water with magic powers. Discuss and list ways we keep ourselves healthy (include hydration in this discussion). (K–2)

b. Write a fable or other kind of story about a well or drinking water with special properties. (5–8)

c. Interview the physical education teacher or someone who plays sports about the importance of hydration after physical activity. (5–8)

d. Discuss concepts related to contagion, epidemics, water-borne illnesses as well as prevention, immunization and why these are all part of a discussion about water and our collective ("the commons") public health. (3–5)

e. Research and present information that compares various public urban water systems in various locations throughout the United States; identify their drinking water source. Compare to farming communities, and suburban as well as ex-urban communities. (6–8)

CONSIDER AND DISCUSS

- Discuss the relationship of drinking water sources to the people that use it considering such factors as proximity, population, and technology.

ASK THE QUESTION

Do you know the source of your drinking water?


"The Celebrated Works on the Schuylkill
by which the Water
are Beyon

Lesson 5: Public Drinking Water Treatment Process Explained

Access to clean, safe drinking water is considered by many to be a public service, managed by what we call utilities (from the word useful). We know Philadelphia was one of the first cities in the nation to succeed at providing drinking water as a civic responsibility. Today public water suppliers are regulated under the Federal Safe Drinking Water Act to keep tap water safe by monitoring and testing the product continuously. The agencies that are involved in regulating the safety of our tap water are the Environmental Protection Agency and the state's Department of Environmental Protection or Environmental Quality. These agencies keep watch on compliance with the laws and regulations established by the Safe Drinking Water Act. Drinking water utilities monitor and report on the results of about 100 parameters (coliform bacteria, disinfectant and disinfectant by-products, lead, turbidity, etc.) on a consistent basis. All before you turn on the faucet!

VOCABULARY

Raw Water *(noun)*: The natural water found in the environment, such as rainwater, ground water, and water from lakes and rivers.

Filtered Water *(noun)*: Water that has undergone a process to make it cleaner and safer to drink.

DRINKING WATER TREATMENT PROCESS

Sedimentation *(noun)*: The process of matter settling to the bottom of a liquid by gravity.

Coagulation *(noun)*: The process of changing from a liquid to a semi-solid state. (Chemicals are added to the water to bind smaller particles together to encourage them to settle).

Flocculation *(noun)*: The formation of small clumps. (In this process, water is gently mixed to make sure that the chemicals added in coagulation have bonded and that particles combine to form "floc" which will settle).

Filtration *(noun)*: The act of capturing impurities from the water as it passes through a layer of sand, gravel and charcoal now called rapid sand filtration. Philadelphia first introduced a slow sand filtration process in the early 1900s using sand and gravel only.

Disinfection *(noun)*: The process of introducing a chemical or other product added to kill disease causing organisms.

ACTIVITIES

a. Introduce the idea of scientific experimentation. Investigate sedimentation by using items of varying weight to see how they "settle" in water. Do some float to the top, some sink to the bottom and others float around (suspended)? Predict, observe and record what happens in a clear glass container. Look at the items under a magnifying glass. (K–2)

b. Discuss and define some sample rocks and minerals. Investigate the relationship of geology and drinking water. What does it mean to have hard water? Make a solution (solvent, solute) of baking soda and water. Measure alkalinity and hardness. Talk about how minerals can dissolve in nature. Next make a supersaturated solution of baking soda and water. Paint on black paper with the solution. Observe. Let it dry. What happened? (3–5)

c. Plan a visit to a local Drinking Water Treatment Facility. What technologies are being used at the local Drinking Water Treatment Plant? Who works there and what is their training (career path)? (6–8)

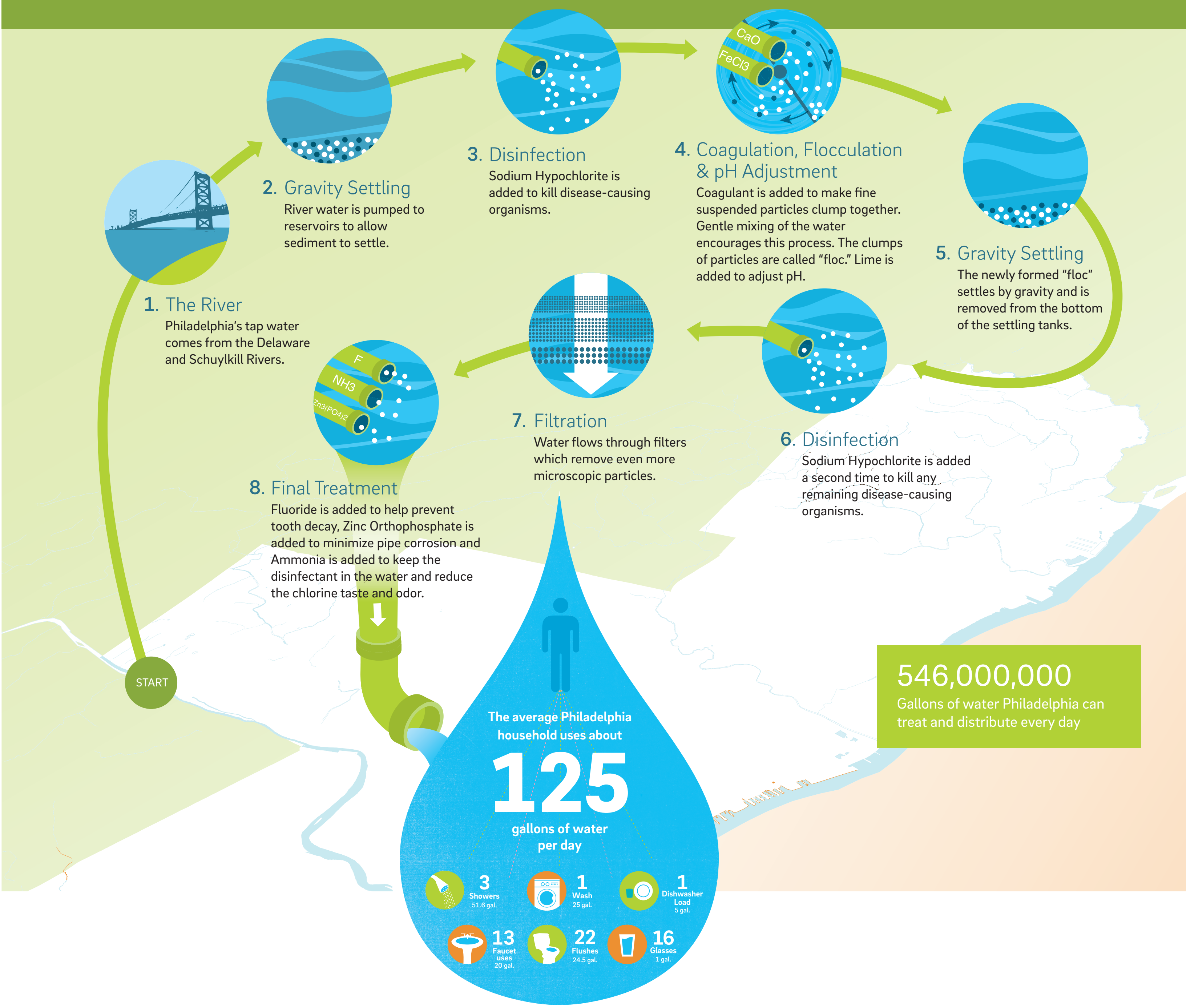
CONSIDER AND DISCUSS

- When did Philadelphia start treating its drinking water? How and why? Compare to other cities in the United States and/or globally.

ASK THE QUESTION

What Federal and State Agencies regulate private and bottled water industries? Ask the same question related to public water utilities?

DRINKING WATER TREATMENT PROCESS



Lesson 6: Testing the Waters: Making it Safe

The Philadelphia Water Department uses a variety of scientific tests to determine the quality of the water before it is determined safe to drink. Measures of pH, alkalinity and chlorine are some measures of the quality of a sample. Using simply prepared solutions and store bought test strips (like those you use to test the water in pools), students can see how chemistry is used to determine if water is safe to drink.

VOCABULARY

Chemistry *(noun)*: A science that deals with the composition, structure and properties of substances and with the transformations that they undergo.

Chlorine *(noun)*: Chemical used for water purification and in the making of chlorine bleach.

pH *(noun)*: In chemistry, pH (power of hydrogen) is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH very close to 7.

ACTIVITIES

a. PWD often conducts taste and odor tests at their central labs. Conduct taste and odor tests using two different samples (such as tap water from two different sources), using a scientific method of observation, hypothesis, prediction, experimentation and conclusion. Record your results. Test again and see if you get the same results. Compare with others using the same samples. (K–8)

b. Using store bought pool test strips and several "mystery" samples, predict and confirm which sample is drinking water and why. Keep it a secret until the end! Demonstrate using four sample cups of water, 1: Tap water; 2: Tap water with a drop or two of vinegar (pH); 3: Tap water with a drop or two of chlorine bleach (chlorine); 4: Tap water with dissolved antacid tablet (alkalinity or hardness). Record data and determine which one is tap water based on data collected. (3–8)

c. In Philadelphia you can look up your school's water testing results at https://www.philasd.org/waterresults. Interpret results and compare it to other schools. (6–8)

CONSIDER AND DISCUSS

- Using PWD's Annual Water Quality Report, which can be found on our website, or any local Drinking Water Quality Report (required by law to publish), talk about the myriad of parameters that are used (required) to determine if water is safe to drink. If you can get two different area reports, compare. PWD's reports can be found at phillyh2o.info/quality. You can find a link to the Water Quality Report on the bottom right of the page.

ASK THE QUESTION

What kind of test would you like your water to take before you drink it?

Lesson 7: Bottled or Tap?

It was not too long ago when the main way to access drinking water in our homes was by turning on the faucet. Today, bottled water is virtually everywhere we look: in homes, offices, airplanes, restaurants and sporting events all over the world. Bottled water is successfully marketed as tasting better and being healthier and more convenient than tap water. Is that really true? What are the environmental implications of such high bottled water use?

VOCABULARY

Tap Water *(noun)***:** Water that is supplied to a tap. Its uses include drinking, washing, cooking, and the flushing of toilets.

ACTIVITIES

a. Create posters promoting tap water use in schools, or at home, to put up near hydration stations and drinking fountains, or in your kitchen. (K–5)

b. Conduct a taste testing between tap water and bottled water. Describe differences in appearance, smell, cost and taste. Line up a series of cups with water and conduct a test on others, disguising the water's source and see if everyone can guess which one is tap water. (3–8)

c. Calculate the cost of bottled water vs. tap water for a family over 1 week, 1 month or 1 year. (6–8)

d. Write persuasive letters to parents (and friends) convincing them to use bottled or tap water. (6–8)

CONSIDER AND DISCUSS

- Discuss the pros and cons of bottled vs. tap water.
- How does the United State's bottled water use compare with that of other countries?

ASK THE QUESTION

Why should we care if people use bottled or tap water?

Thematic Unit 3:

Down the Drain or Out of Sight, Out of Mind

Just as Philadelphia developed a collective drinking water supply system to ensure the public health of its citizens, it also developed ways to collect and dispose of its waste or “used” water. Students will discover that it was no small task to engineer an effective system of drains and pipes to carry human and industrial waste away from where people lived.

What you should know:

It is hard to imagine, but before Philadelphia was heavily developed with homes, businesses, cars, buses, and factories, it looked like a countryside filled with hills, streams, valleys and farms. Local streams and creeks that ran throughout the city landscape were conveniently used by people and industry for drainage to carry away wastewater. Eventually, too polluted to bear, the stream system was converted to sewer infrastructure. The wastewater was encapsulated in pipes and the valleys that were once cut through with natural waterways, were leveled by fill to accommodate a grid of streets and row houses. These streams have become part of the city's 3,000–mile sewer drainage system. In about 60% of Philadelphia (the oldest parts), these pipes carry human wastewater and stormwater from runoff in the same pipe, and are called a combined sewer. In newer parts of the city, raw sewage and stormwater runoff are separated in two different pipe systems.

Use of urban streams for sewage disposal and ultimately, as the beds of actual sewers, was standard practice for 19th and 20th century engineers. Initially, stream pollution and its deleterious effect on human health was the main reason for undertaking such drastic measures. When a section of the Cohocksink Creek in Philadelphia was "culverted" (or enclosed in a tunnel, thereby reducing access to the surface of the creek from trash and other pollutants) in 1860, the Board of Health applauded the project as "one of the most valuable sanitary improvements ever to be undertaken by the corporate authorities."

However, by the second half of the 19th century, as epidemic diseases (in particular typhoid fever) killed thousands of Philadelphians, the provision of proper sewerage and drainage became a subject of great concern, and city engineers began planning the culverting of creeks in advance of development. As early as 1853, city surveyor Samuel H. Kneass acknowledged that natural watersheds would have to be utilized to provide proper drainage for the city. In the 1880s, when the city engineers drew up their preliminary drainage maps for Philadelphia's 129 square miles, converting many of the city's smaller streams into sewers was an integral part of the plan.

By doing this work in advance of development, the engineers hoped to solve several problems. Since it was then standard sewage disposal practice to direct branch sewers downhill into the nearest stream, they knew that even pristine surface streams would become polluted once the areas around them were developed. Culverting the streams before they became polluted was seen as a positive step to protect the public health.

In undertaking these projects, the engineers also hoped to reduce the cost of the city's infrastructure in a number of ways. Sewage, being mostly liquid, flows most cheaply by gravity—pumping it up a slope is expensive in terms of fuel costs, and is only as reliable as the pumping equipment. By placing sewers in the natural stream valleys, the engineers got the gravity flow they needed, and in the process they managed to avoid the high cost of making extensive, deep excavations. Once the valleys were filled in over the newly built pipes—in some stream valleys in Philadelphia, more than 40 feet of fill was used—the cost of building a bridge each time a main street crossed the stream was avoided as well.

Building sewers in advance of development also gave engineers more freedom in their designs. Since most of the land the sewers traversed was open farmland or woodland, the cost of paying out land damages to property owners was less. Often, building a sewer in a creek bed was to the advantage of private landholders, especially in areas of the city where the rectangular grid system of streets prevailed. A piece of land with a creek cutting through it was impossible to subdivide into regular slices, but with the creek in a sewer, and the grid laid over the valley, real estate speculators could divide their property into the tightly fitted rectangular lots so common throughout Philadelphia. Since the streets were built on top of the new sewers, with water and gas lines put in as well, the developers had a ready-made infrastructure that tended to speed up the sales of these lots. The city, in return, could count on a quick return on its investment in infrastructure from the resulting increase in tax revenue from all the new buildings.

In some watersheds within the area now known as Philadelphia, it took many years to culvert the main stream and its tributaries. In West Philadelphia, the Mill Creek conversion from creek to sewer took more than 25 years. The city's largest such project, the burying of both branches of Wingohocking Creek in Northwest Philadelphia, took about 40 years. Early in the 20th century, city planners realized the benefits of creating parks in stream valleys, but it was too late for most. The modern map of the city's surface streams is now disturbingly blank.

From Creek to Sewer: A historical Overview by Adam Levine http://www.phillyh2o.org/creek.htm

Sequence of Lessons

1. The Growth of the City: Population and Wastewater Systems
2. Industrial Revolution and Environmental Devolution
3. Streams to Sewers: Creating an Underground Infrastructure
4. Sinks, Pipes and Mains: Make the Connection
5. Public Wastewater Treatment Process Explained

Lesson 1: The Growth of the City: Population and Wastewater Systems

Building upon the students' understanding of natural watersheds, they can explore how early drainage systems in cities tried to capture and drain away the increasing volume of wastewater of a growing population. It seemed logical to use the natural flow and order of the streams as a way of "flushing away" human and industrial pollution.

VOCABULARY

Collect *(transitive verb)*: To bring together into one body or place.

Drain *(verb)*: To flow off gradually.

Culvert *(noun)* : A tunnel carrying a stream or open drain under a road or railroad.

ACTIVITIES

a. Compare stream systems to the branches of a tree. Create a box filled with sand, tilt it and pour water from the high spot to the low spot to see how "hills and valleys" form as water meanders to find a path of least resistance. Introduce houses and streets using Legos or other available props or toys to demonstrate the challenges of land development imposed onto natural topography. (K–3)

b. For older students, also explore the idea of branches, stream order, slope and velocity (speed). Create the same type of model as above or re-visit the watershed model in Thematic Unit 1: Lesson 3, but populate it with houses and "paved" surfaces using an impervious material like wax paper, tin foil or plastic recyclables. (3–8)

c. Research and print out maps and create overlays to determine where the historic streams were located in relation to your house, the school or community. Explore in detail some of the well-documented Philadelphia examples such as Dock Creek (now Dock Street). Find historic photographs of farms and mills that now are in city neighborhoods. Explore the names of streets and neighborhoods as clues to the past (e.g. Mill Creek, Overbrook, Valley Green, etc.). Research other cities to see how they developed to find similar patterns of development. (6–8)

CONSIDER AND DISCUSS

- Imagine what the city looked like with natural rolling hills. Identify a place that still retains its original topography or why/how some streets in the city feel and/or act like streams?
- How does nature act like a wastewater system? Why do you think cities like Philadelphia had to create a planned and designed wastewater system?

ASK THE QUESTION

Do you know the name of the stream or creek nearest your school or home?

Lesson 2: Industrial Revolution and Environmental Devolution

The way we use land *can* impact water quality. Farms, factories, shopping centers, and homes are all examples of how we change the natural landscape to meet human needs. Sometimes that means paving over the natural landscape to build streets, houses, and sidewalks. Creating surfaces that are designed to shed rainwater quickly and easily to prevent flooding on the land may cause flooding and erosion downstream.

VOCABULARY

Industrialization *(noun)*: The large-scale introduction of manufacturing, advanced technical enterprises and other productive economic activity in an area, society, country, etc.

Downstream *(adjective)*: Situated in the direction in which a stream or river flows.

Upstream *(adjective)*: Situated in the opposite direction in which a stream or river flows; nearer to the source.

ACTIVITIES

a. Start a conversation about different ways people use land to live, work and play. Talk about what a community of the future might need. With a large sheet of mural paper, and a handful of pre-cut color-coded squares representing these kinds of land use (introduced as places we live—red, places we work—purple, places we play—green), design their own planned community. Start them off with a waterway and few roads. Assign roles and discuss placement and consequences of individual actions on the community as well as the impact on the environment. (K–2)

b. Make the above activity more complex by introducing more parameters such as starting out with an agrarian community that becomes industrialized. Create a modern day, densely populated city. Introduce controversy. Explore different time periods and create a chronology of polluters of water through time. (3–5)

c. Add to the above activities by introducing a discussion about zoning. Divide the group into neighborhood or community groups with connecting waterways. Discuss the impact on upstream/downstream neighborhoods. (6–8)

CONSIDER AND DISCUSS

- Discuss the balance (and imbalance) between the growth and health of cities and its impact on the natural environment.
- Would you prefer to live upstream or downstream from a factory, farm or forest? Why?

ASK THE QUESTION

What changes are happening in your neighborhood that may impact water quality?

Lesson 3: Streams to Sewers: Creating an Underground Infrastructure

Streets, buildings and rooftops, along with the creeks and streams, become part of what we call the watershed in an urban setting. Cities, densely populated and developed, engineered widespread systems of underground pipes (hidden/out-of-sight) to collect and drain the water used by people from homes and workplaces. Cities also developed a pipe/funnel system for draining rainwater from its streets. Sometimes these two systems are COMBINED, other times they are SEPARATE.

VOCABULARY

Infrastructure *(noun)*: The underlying foundation or basic framework (as of a system or organization); the system of public works of a country, state or region.

Sewer *(noun)*: An underground conduit for carrying off drainage water and waste matter.

Combined Sewer *(noun)*: Sewage (unsanitary waste) collection system of pipes and tunnels designed to also collect surface runoff.

Separate Sewer *(noun)*: A drainage system in which sewage and stormwater are carried in separate pipes and to separate places.

ACTIVITIES

a. Begin this exploration of underground systems through fictional characters in books or movies that live or travel by sewer. Create a character that lives in such a place. Write a picture book or narrative story about this character. The character can even be an object (such as a bag of chips) that goes down the storm drain. (K–5)

b. Research and compare other examples of urban infrastructure (“works”) such as electricity, gas, and transportation and the idea of public/private management of these systems locally and in other cities. Make a photo-montage or inventory of the clues/evidence of these systems on the street and in our neighborhoods. (6–8)

c. Take a walk outside and make a map of storm drains around the school or neighborhood. Research whether their school or home drains to a combined or separate sewer system. (6–8)

CONSIDER AND DISCUSS

- Why do cities choose to create underground infrastructure?

ASK THE QUESTION

What are some of the ways a city can deal with an aging infrastructure?

Lesson 4: Sinks, Pipes, and Mains: Make the Connection

There are many component parts of the underground sewer that are molded, manufactured and engineered to create this urban system. They all fit together to keep the city's wastewater flowing, relying on gravity to keep everything moving "downhill".

VOCABULARY

Conduit *(noun)*: A pipe, tube or the like for conveying water or other fluid.

Capacity *(noun)*: The maximum amount that something can contain.

ACTIVITIES

a. Find objects in everyday life that can be used to demonstrate how a conduit works (e.g. bendable or straight straws, paper towel rolls) using beads or water. (K–2)

b. Make a kit of parts using a funnel, various diameter tubing, complex profiles, shapes and forms to create conduits that can accept water and test the velocity using the variables of shape and slope. (3–8)

c. Create individual homes on a street using a collection of shoeboxes. Configure them to create the sidewalk and street. Elevate the model to create some space under the street. Use blue (drinking water) and red (waste water) pipe cleaners to represent the path of water coming into the house from a pipe underground and the waste going to another pipe under the house. Connect the pipes from each house underground to each other. (3–8)

d. Identify films in which the majority of the action/plot takes place/is based on the setting of a sewer (e.g. Phantom of the Opera (1925/2004), The Third Man (1949), Flushed Away (2006)). Write an original story or play of the same. (6–8)

e. Research how other cities, countries, and early civilizations dealt with wastewater and compare to Philadelphia's current system. (6–8)

f. Research a recent water main break news article. Discuss why that happens, what problems they cause, how they are repaired, and what could be done to prevent similar issues. (6–8)

CONSIDER AND DISCUSS

- How are these conduits constructed today, as well as in the past? How are they inspected? Maintained?

ASK THE QUESTION

Where does your wastewater go after you flush?

Lesson 5: Public Wastewater Treatment Process Explained

Wastewater treatment is the process of collecting wastewater and removing pollutants before returning the clean final outflow to a body of water. In any city, it is a big and sophisticated process that runs 24/7 without much notice or fanfare. Everything washed down a drain is collected—from toilets, sinks, tubs, washing machines, dishwashers and floor drains in homes, schools and businesses everyday. Sometimes stormwater runoff collected from streets and properties in underground pipes combines with this wastewater to travel to a Wastewater Treatment Facility. Treating wastewater and returning the cleaned-up water back to the river is a critical step in the urban water use cycle and imperative for protecting the health of our waterways (and our health too!).

VOCABULARY

Influent/Effluent *(noun)*: Inflow/outflow.

Sludge *(noun)*: Solids that settle by gravity in the wastewater treatment process made up of organic materials such as food, feces, paper fibers, etc.

Scum *(noun)*: A layer of grease and oil that rises to the surface of the liquid.

WASTEWATER TREATMENT PROCESS

Pretreatment involves a physical removal such as screening and sedimentation [Screening, Grit Removal].

Primary Treatment relies on suspended solids settling to the bottom by gravity and oil/grease rising to the top before being removed [Gravity Settling].

Secondary Treatment uses local microorganisms to help remove dissolved organics and suspended particles. Once the microorganisms have been removed through a settling process a disinfectant is often added before the clean effluent, or final out flow, is released into a body of water [Aeration & Biological Reduction, Gravity Settling, Disinfection].

ACTIVITIES

a. Discuss the idea that people make this process work! Discuss the various jobs and what gets sent to their Wastewater Treatment Plant. Recreate the journey of a flush verbally by having each individual add to the story to create a suspenseful narrative from the perspective of something you flush, what it feels like to be in a sewer, or the arrival at the Plant. Next, let them illustrate or record their story. (K–2)

b. To help demonstrate the wastewater treatment process, fill up a container with water and add things such as a few sheets of toilet paper, dirt, rocks, foods, and oil – shake it up. Do things separate? What sinks? What floats? What stays suspended? Collect information and create a poster display of animals and plants that act as natural filters. (3–5)

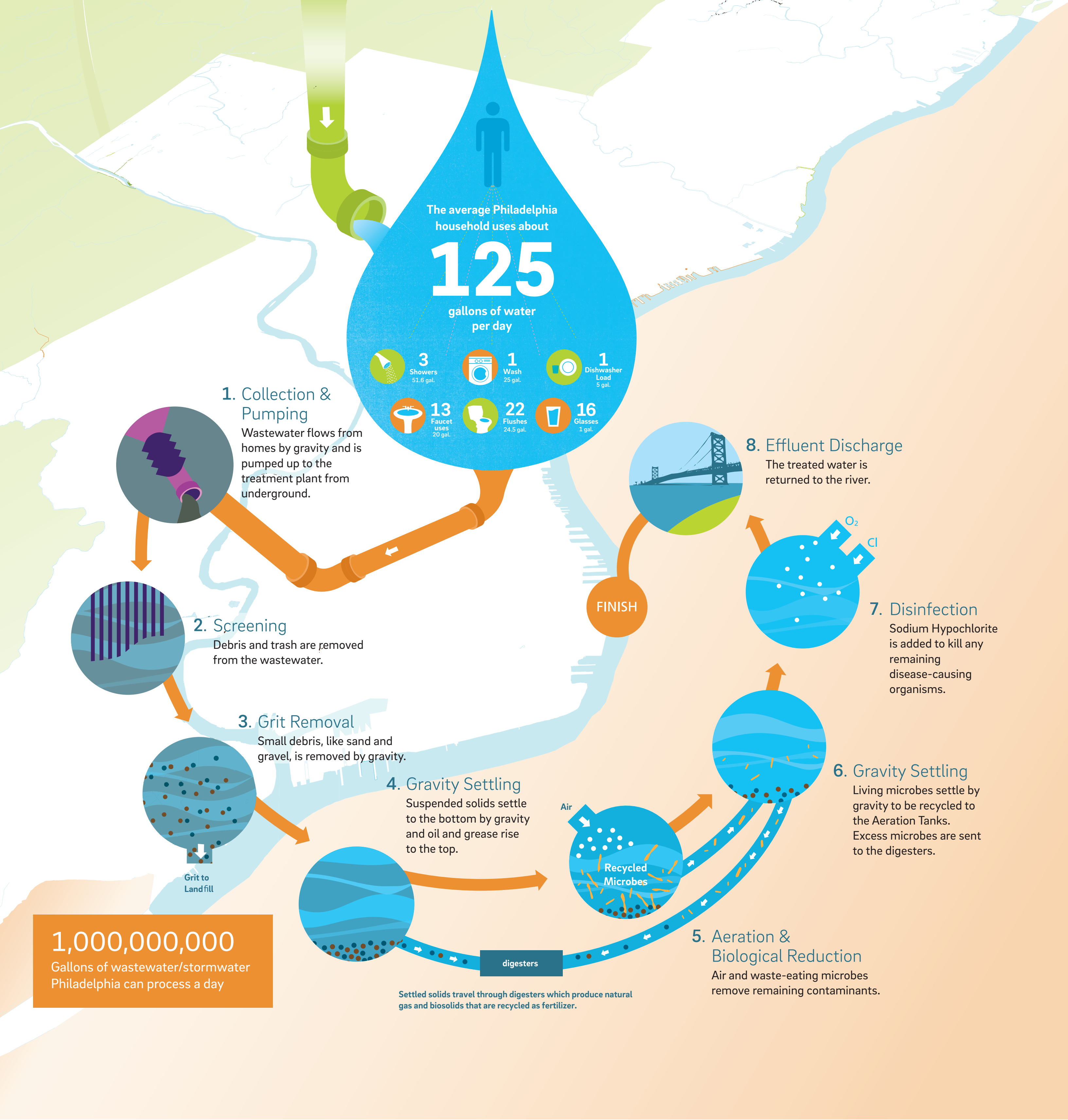
c. Plan a visit to a local Wastewater Treatment Facility. Research a current event related to severe weather events and sewage or wastewater. Investigate the microorganisms that ingest suspended particles and dissolved organics in secondary treatment. What do they look like? What do they need to survive? (6–8)

CONSIDER AND DISCUSS

- Discuss the history of wastewater and its treatment in Philadelphia.
- Discuss or research what changes they can personally make to help the process at the wastewater treatment plants to improve overall water quality (organic cleaners, picking up after dogs, not littering).
- What can be done with the byproducts of wastewater treatment?

ASK THE QUESTION

What are natural ways to clean and manage wastewater?



WASTEWATER TREATMENT PROCESS

Thematic Unit 4:

Land and Water: A Delicate Balance (or Can't We All Just Get Along?)

Homes, markets, factories, parks and roadways—these are many of the ways land has been transformed to create our cities and affect water quality. Students will learn how the relationship of land to water is an ecological balancing act, both for humans and for the natural environment. At many points throughout the last two centuries, the balance has been tipped, equilibrium lost. They will discover not only the consequence of pollution (making people sick), but also how public health prevailed and we are moving towards equilibrium being restored.

What you should know:

"No matter where you happen to live…I'm here to say that you should dramatically raise your expectations. You have a right to pure water, clean air, and a healthy environment. This right is inherent and indefensible. It belongs to you."
–Maya K. van Rossum, The Green Amendment: Securing our Right to a Healthy Environment

There has always been an inseparable connection between people and water. Personally, we need to drink water to keep us healthy. We also need it to keep ourselves clean, to cook with, and to carry our waste away. Collectively, we use water to keep our streets clean, and to keep our homes and businesses safe from damaging fires. We enjoy the beauty of our waterways for fishing, boating, and hanging out with friends and family. In earlier times, we depended on our waterways for food, to transport vital (and luxury) goods and to power our mills. Water was an integral part of the industrial age, used in the manufacture of everything from clothing and blankets to toys and locomotives. Philadelphia has always depended on the Delaware and the Schuylkill Rivers and their tributaries for industrial and commercial uses, drinking water and to carry its wastewater away.

For a long time, settlers could rely on nature to take care of keeping that water supply clean. But, as the population grew, so did pollution, and the city became more and more dependent on a utility to keep things healthy. Now, nature needs help from the Philadelphia Water Department to supply clean drinking water to its residents and carry away wastewater to sanitize it before reentering the river.

Ironically, the rapid growth and development of the city in the industrial age both helped the city prosper and posed a grave public health threat as the very source of healthy drinking water became contaminated with industrial waste. By looking at the watershed during this time period, students will see how the land use changed from a predominantly agricultural use, with scattered farms and small water-powered mills along the creeks to residential use, with densely packed neighborhoods of row houses as we see it today. They will discuss what impact the land use changes had on individuals, their communities, and their environment.

In order to protect our common resources, such as our water supply, part of the responsibility has shifted to government entities. We now have important laws and regulations in place for industries and public water and sewer departments that help ensure we keep our streams healthy. Today, the biggest source of water pollution is the pollutants that run off the land during rainfall or snow melt, into the nearest stream. We can be optimistic about the future if we understand the dependent relationship between land use and water quality and do something to ensure its balanced and maintained.

Sequence of Lessons

1. The Rain Drain: Stop Trash in its Tracks
2. What is the Point: Exploring Point Source and Non-point Source Pollution
3. What's Combined Sewer Overflow?
4. Ecological Imbalance: The Effects of Pollution
5. The Environmental Movement: Empowering People, Creating Change
6. The Clean Water Act: A Policy Solution

Lesson 1: The Rain Drain: Stop Trash in its Tracks

One of the greatest threats to water quality today is pollution from stormwater runoff. This happens when rain washes whatever is on our streets and sidewalks into the rivers either directly or through the storm drains that lead right to the river. This is a current day issue and therefore, one of the best ways to engage your students in this topic is through observation in and around their neighborhoods and schools.

VOCABULARY

Pollute *(verb)*: Contaminate with harmful or poisonous substances.

Pollution *(noun)***:** The presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects.

Pollutant *(noun)*: A substance that pollutes something.

ACTIVITIES

a. Take a walk outside and make note of what and how much trash is nearby (use the storm drain map created in Unit 3, Lesson 3 if available). Complete at two different times during the week (Monday morning vs. Friday afternoon) and compare results. (K–8)

b. Assess the condition of nearby storm drains in dry weather and in the rain. Write a diary entry or letters home, or to school or local officials, about the problem and the solution. (3–5)

c. Develop an anti-trash campaign and storm drain marking project to raise awareness. Investigate how other cities mark their storm drains; propose a design for a new way to mark Philadelphia's and have a design contest. Make posters, write slogans and create public service announcements for the school or neighborhood community defining the problem and advocating for the solution. (6–8)

d. Organize a litter cleanup around the school or in your neighborhood. Catalog and track data using Litterati. Be sure to provide gloves and garbage bags for all. (K–8)

e. Watch a video on the Great Pacific Garbage Patch and discuss. (4–8)

f. Work in teams to create an innovative design (or Rube Goldberg contraption) for a trash removal device. (6–8)

CONSIDER AND DISCUSS

- Discuss the words pollute, pollution, and pollutants, and what they mean in relation to each other. Give examples and collect images of each.
- What potential sources of pollution do you see in your neighborhood? What can we do about it?

ASK THE QUESTION

What is the relationship between trash on my street and in my watershed?

Lesson 2: What's the Point: Exploring Point-Source and Non-point Source Pollution

Before we can work at reducing pollution in our waterways, we need to identify its source. Sometimes it is easy to tell the source—something dumped directly into the water would be considered point-source pollution. Other times it is not as obvious—some kind of waste deposited on the land makes its way into the water indirectly and you cannot identify its source – this is considered non-point source pollution.

VOCABULARY

Point-Source Pollution *(noun)*: Pollution discharged through a pipe or some other discrete source from municipal water- treatment plants, factories, confined animal feedlots, or combined sewers.

Non-Point Source Pollution *(noun)*: A contributory factor to water pollution that cannot be traced to a specific spot; for example, pollution that results from water runoff from urban areas, construction sites, agricultural operations, and Silvicultural operations and so forth.

Source *(noun)*: The point of origin at which something begins its course.

ACTIVITIES

a. Brainstorm and make a list of things that can cause pollution in our waterways. Now separate this list into point-source and non-point source pollutants. Describe the difference. Illustrate the items or cut out pictures from magazines. Create a story about the travels of a character named "Non-point Source Pollution." (K–2)

b. Create an inventory of the sources of pollution, including trash, around your school or in your neighborhood. Mark and label the different sources using the map of storm drains created in Unit 3, Lesson 3. Discuss the issues, and plan and implement a solution. (3–8)

c. Develop a school or neighborhood campaign to raise awareness about water pollution and how individual actions can make a difference (e.g. reduce dog waste, clean-up plan). (6–8)

CONSIDER AND DISCUSS

- Do you think other cities are working to reduce water pollution?

ASK THE QUESTION

How do I play a part in solving the problem?

Lesson 3: What is Combined Sewer Overflow?

In Thematic Unit 3, students learned about the vast infrastructure system engineered to convey waste, both stormwater and sanitary (which means unsanitary!) sewage (often in the same tunnel) away from where we live, work and play. During dry weather, the combined sewer system conveys waste water through pipes to treatment plants, which have the capacity to treat all the sewage entering the system. However, when flow in the sewer increases as a result of heavy rainfall and/or rapid snowmelt, the treatment plants may not be able to process the wastewater fast enough. When this happens, to avoid overwhelming the system, the sewer pipes have to discharge combined sewage into nearby water bodies from combined sewer outfalls (164 of them) to prevent backflow, and protect homes and neighborhoods, and wastewater plants from flooding.

VOCABULARY

Outfall *(noun)*: The outlet of a body of water.

Convey *(verb)*: To move in a continuous stream or mass.

ACTIVITIES

a. Share examples of something overflowing—the bathtub, the sink, a glass of milk or juice. What were the consequences? How did they or someone they know deal with the clean up? Relate this to our waterways during a heavy rainstorm. (K–2)

b. Watch the animation of a combined sewer overflow. Set up a demonstration (or have the older students work in teams to create a model themselves) of combined sewer overflow. Start with two separate plastic tubes outfitted with a funnel on top. These two tubes are connected to another larger tube. Pour water dyed with food coloring – blue for rain water and red for waste water—into the separate tubes and see the water turn purple and spill out the bottom. Now divert some of the water from the larger tube (simulating the journey to the treatment plant). Now pour larger quantities of water down the stormwater tube and simulate overflow. (3–8)

c. Visit the Schuylkill River before and after a heavy rainstorm. Describe what you see and smell. Write about it. (6–8)

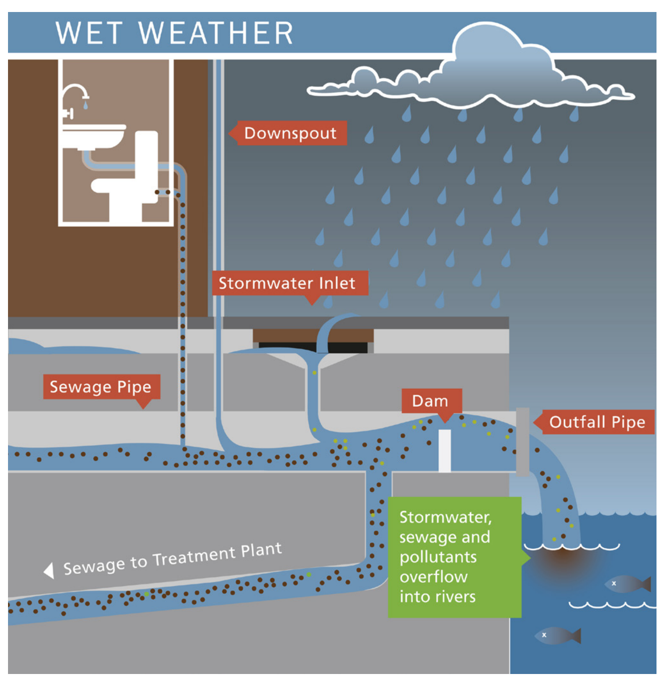
d. Make a mind map of the interconnections between the problems associated with impermeable surfaces in Philadelphia, human health and the health of the waterways. Now map what can be done to address those problems. (6–8)

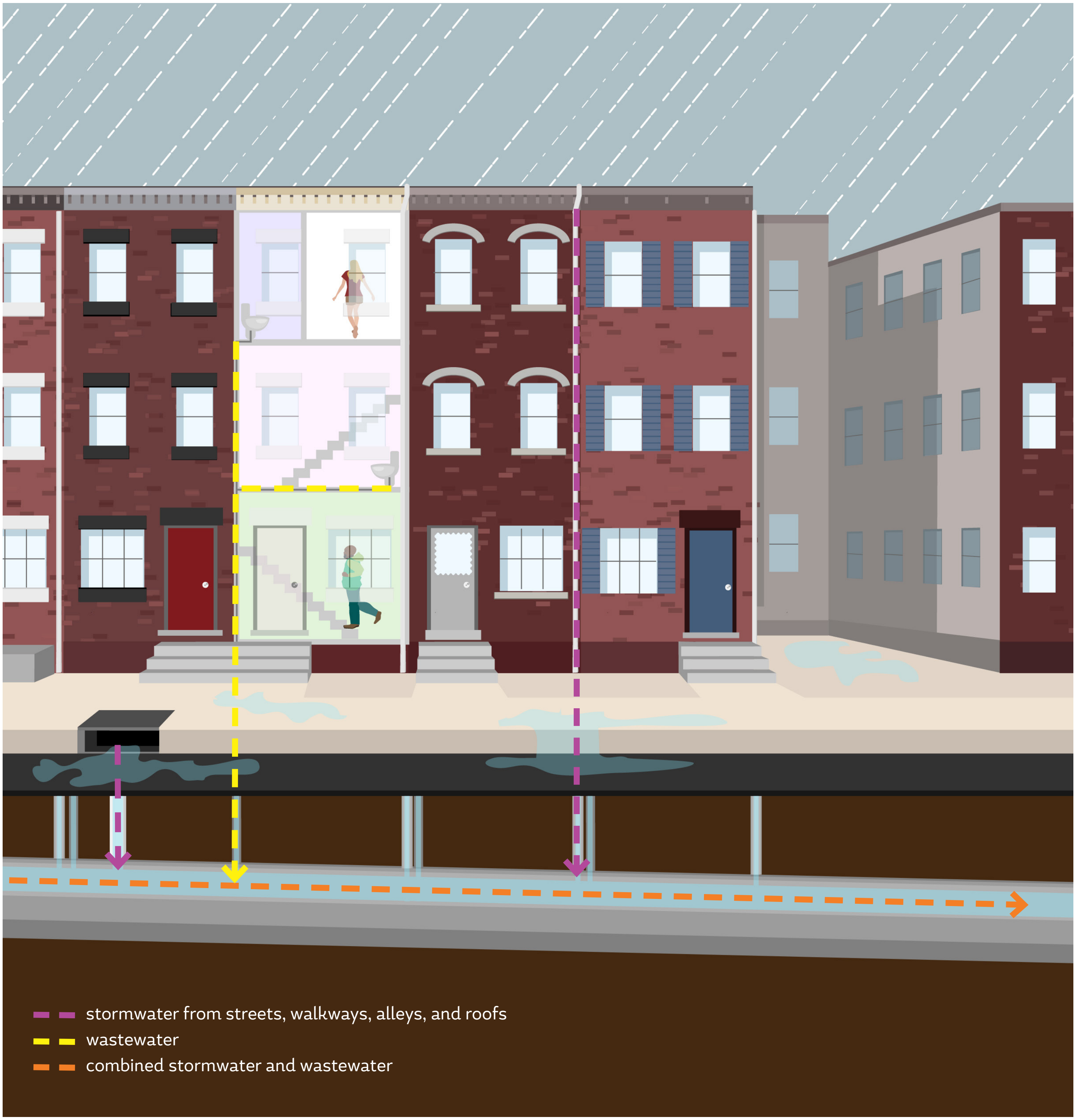
CONSIDER AND DISCUSS

- Discuss why the combined sewer infrastructure exists in older neighborhoods.
- Visit http://www.phillyrivercast.org and discuss why such a service was developed for the Schuylkill River above the dam (hint: where you see rowers!).
- Visit http://water.phila.gov/maps/csocast/ to view locations of the combined sewer outfalls and recent overflow events.

ASK THE QUESTION

How many outfalls are there along the Schuylkill and Delaware Rivers and why are they numbered?





COMBINED SEWER SYSTEM

A combined sewer system (CSS) is simply a single sewer system that carries both sewage and stormwater in one pipe, to a water pollution control plant for treatment before being released to a waterway. During moderate to heavy rainfall events, the system will reach capacity, overflow, and discharge a mixture of sewage and stormwater directly to our streams and rivers from the 164 permitted Combined Sewer Over-flow (CSO) outfalls within the City. Sixty percent of the City of Philadelphia, or about 64 square miles, is within the combined sewer system drainage areas.

Lesson 4: Ecological Imbalance: The Effects of Pollution

When trash, chemicals, and other types of pollution reach our waterways, the ecological balance suffers. Trash creates a risk for wildlife that might mistake it for food. Chemicals, such as motor oil and pesticides, can be toxic to those same animals. Fertilizers can cause algae to grow out of control and hog the oxygen supply in the water. Too much animal waste can introduce unhealthy levels of bacteria into the water system. These all can affect the health of our waterways.

VOCABULARY

Nutrient *(noun)*: A substance or ingredient that promotes growth, provides energy, and maintains life.

ACTIVITIES

a. Explore Poo-lution, and the effect dog waste can have on nearby streams. Create posters or a Public Service Announcement for the school or neighborhood explaining what pet waste can do waterways and how people should properly "Scoop the Poop." (K–5)

b. Create posters or write letters advocating for people to dispose of their household waste properly, such as cutting plastic beverage rings or the bands on a face mask before disposal, or bringing motor oil or other chemicals to proper waste facilities. (3–8)

c. Watch this video on Nutrient Pollution and discuss the various impacts pollution has on the environment and humans. Discuss what can be done by all to minimize those impacts. (6–8)

CONSIDER AND DISCUSS

- Discuss when and where you may have seen the effects of pollution in our waterways.
- What are the human impacts of a polluted waterway (health, recreation, aesthetic, etc.)?

ASK THE QUESTION

How can your actions restore ecological balance?

Lesson 5: The Environmental Movement: Empowering People, Creating Change

Starting in the mid 1900s, people became increasingly aware of the negative environmental conditions of their neighborhoods and beyond, including in Philadelphia. Rachel Carson, and her book *Silent Spring*, acted as one catalyst for a new environmental movement by exposing the detrimental effects of pesticides on bird species. While some actions were taken and laws enacted to produce change, they did not go far enough. Seeing waterways on fire, people began to understand the urgency of immediate action, and found it to be their civic responsibility to engage with environmental matters. On April 22, 1970, the first Earth Day was celebrated by nearly 20 million Americans as a nationwide protest to demand thorough environmental action.

VOCABULARY

Leadership *(noun)*: The act or an instance of leading.

Participate *(verb)*: To have a part or share in something.

ACTIVITIES

a. Draw something you love in nature. Make a poster about its value and how to protect it. (K–5)

b. Explore what it takes for a movement to be successful. Find examples of movements from within your school, neighborhood, or city and write about them. (4–8)

c. Read an excerpt from Rachel Carson's *Silent Spring* (or the whole book!) and discuss the impact it had on the environmental movement. (6–8)

d. Research the history, mission, and goals of environmental advocacy organizations, such as The Sierra Club, the National Audubon Society, World Wildlife Fund, or Greenpeace and share with others. (6–8)

CONSIDER AND DISCUSS

- Consider how early activists of the environmental movement felt and why they fought for change.
- What has changed in the environmental movement since 1970? What has stayed the same? How do you feel?

ASK THE QUESTION

How are you part of the environmental movement today?

Lesson 6: The Clean Water Act: A Policy Solution

The Clean Water Act, as we commonly call it today, was enacted in 1972, and the Safe Drinking Water Act was enacted in 1974. Both set up regulations for controlling pollution and maintaining water quality in America's waterways. Established by President Nixon in 1970, the Environmental Protection Agency has put into place regulations that make it unlawful to discharge any pollutant directly (point source) into navigable waters without a permit. This generally applies to industrial, municipal and other facilities that could dump wastewater directly into surface waters.

VOCABULARY

Regulation *(noun)***:** A rule or order issued by an executive authority or regulatory agency of a government and having the force of law.

Policy *(noun)***:** A course or principle of action adopted or proposed by a government, party, business, or individual.

Permit *(noun)*: An official document authorizing permission to do something.

ACTIVITIES

a. Brainstorm, develop and "enact" a regulation for the classroom that benefits the entire group. Determine how and who will enforce the regulation, and what, if any, consequences there will be for violations. (K–2)

b. Add to the activity above with role-play as citizens and lawmakers. Review how a bill becomes a law. Perform the song from "I'm Just a Bill" from Disney's Schoolhouse Rock. (3–5)

c. Research the Environmental Protection Agency and other regulatory agencies that oversee and protect public health. Look into recently passed or amended environmental regulations and discuss why they were added. (6–8)

d. Connect the role of the Clean Water Act and the timing and expansion of the sewage treatment plant facilities. (6–8)

e. Explore the difference between the words "safe" and "clean" and how they relate to water. Research and create a list of all the substances that may be found in water (calcium, nitrates, bacteria, etc.); decide what is okay to leave in the water, and what should be removed and why (adapted from WSSC Water). (6–8)

CONSIDER AND DISCUSS

- What other laws help protect the common resources, upon which the public's health and well-being depend (such as water, air, land, etc.)? Are there any rules school-wide/as a class that are made to help protect all students? At home to protect your family?
- What rules could be implemented in your school, in your home, or around your neighborhood to help protect your watershed or minimize the detrimental effects of polluted stormwater runoff?

ASK THE QUESTION

How do such big laws come about? How are they enforced? How are they protected?

This page was intentionally left blank.

Thematic Unit 5:

Green (and Blue) Plan for the Future: Playing a Part

The greatest threat to our water resources in the 21st century is pollution carried off by stormwater runoff. As students have learned by now, past solutions and innovations for the collective good have moved the story forward. Next they will explore how individuals and communities play a key role in shaping the future environmental health and well-being of their city. “Sustainability,” “greening” and “stewardship” are not just vocabulary words, but will become an integral part of our future story. New ways of living, that is, vocabulary that has been written into our story.

What you should know:

The earth has a very efficient method of cycling water through the atmosphere and the land, as evidenced through the natural water cycle. One of the seven key components of the natural water cycle is stormwater runoff. Today, our towns and cities are full of impervious surfaces, like roads, sidewalks and parking lots; therefore, urban areas cannot absorb as much rain water as their natural counterparts. Because infiltration is inhibited, stormwater will flow downhill seeking the lowest point, which in many cases is a waterway or a man-made storm drain. The runoff that does not infiltrate, flows over impervious surfaces, gathering pollutants like litter, pesticides, fertilizers, animal waste, loose dirt, and motor oil as it drains.

The problems caused by both the quality and quantity of stormwater runoff impact everything and everyone who depend on the river, including humans. In Philadelphia, the source of the public drinking water supply is the Schuylkill and Delaware Rivers. The Philadelphia Water Department is responsible for cleaning the raw water from these rivers and making it safe enough to drink before they send it to consumers; the more polluted the water is, the greater the job the PWD has to clean it up. In addition, the rivers don't begin and end along city boundaries but extend far beyond Philadelphia into other areas within our collective watershed. Therefore, we also need to work with our upstream and downstream neighbors to ensure safe water for all. Towns and cities upstream from Philadelphia discharge stormwater runoff and wastewater into the same rivers that become our source of drinking water; we do the same for people downstream. Everyone must work together to help ensure the quality of our waterways and play a part to keep others healthy.

In 1989, Congress passed an amendment to the Clean Water Act that required municipal operators of sewer systems to develop infrastructure that would reduce non-point source pollution and combined sewer overflows during rain events. In order to keep stormwater runoff from polluting our waterways, the Environmental Protection Agency (EPA) implemented practices that change the way water runs off the land by absorbing or holding water, rather than having it rush into our creeks and rivers at high speeds and volumes.

These practices that mimic the natural water cycle and therefore help mitigate, or reduce the impact of stormwater were formerly called Best Management Practices (BMPs) but now are referred to as Green Stormwater Infrastructure (GSI). We know that trees and plants are especially good at absorbing these large volumes of water, so they have become the basis for many of these projects. Due to the success of implementing GSI throughout Philadelphia, the PWD has become a model for other cities to emulate.

In June of 2011, The City of Philadelphia and the Environmental Protection Agency entered into a Consent Order and Agreement, thereby officially committing to the implementation of green stormwater infrastructure in Philadelphia. The Water Department's plan to fulfill this commitment, "Green City, Clean Waters," is a 25–year plan aimed at adopting a "green" approach to stormwater management. This program encourages property owners to implement different projects on their land to help capture the first one inch (or "first flush") of stormwater that carries the most pollutants. The more of these GSI we have on our land, the healthier our waterways will be.

Our rivers are gateways to Philadelphia, bridging the past and the future. How we care for them is a reflection of us, our innovation and our commitment to the natural world. They provide the majority of freshwater available for our everyday needs. Protection of our rivers is essential to a shared future.

Sequence of Lessons

1. How to Slow the Flow: Properties of Soil and Plants
2. Green Stormwater Infrastructure: Following Nature's Lead
3. Calculating Rainwater
4. Restoring Urban Waterways
5. Reimagining your Schoolyard, Backyard or Streetscape
6. Freshwater Mussels: Nature's Water Quality Engineers

Lesson 1: How to Slow the Flow: Properties of Soil and Plants

Changing an urban *streetscape* to an urban *landscape* is one of the long-term goals of water quality protection. The transformation of streets, rooftops and parking lots (or impervious surfaces) to green roofs, tree trenches, rain gardens and porous paving (or pervious surfaces) requires some understanding of the key components of success – soil and plants.

VOCABULARY

Vascular *(noun)*: Of or relating to a channel for the conveyance of a fluid.

Absorbency *(adjective)*: Capable of taking in/soaking up moisture.

Infiltration *(noun)*: The seepage of water into soil or rock.

ACTIVITIES

a. Explore how soil affects the rate of water infiltration by creating some simple soil compositions and timing water flow through these soil types (sand, silt and clay). Use a funnel, coffee filter and conical tube or clear measured container to catch the water. Add compost to the soil and observe and record what happens. (K–8)

b. Explore how water gets transported through a plant through some simple experiments, such as putting celery stalks into water with food coloring. (K–8)

c. Grow simple vascular plants (bean plants work well) in small test tubes by the window or with a grow light and observe and record the emerging root and leaf systems. (K–8)

d. Observe the growing plants once a week and write poetry from observation. (K–8)

CONSIDER AND DISCUSS

- What are our perceptions of nature in the urban environment?

ASK THE QUESTION

What is the benefit of a "green" city?

Lesson 2: Green Stormwater Infrastructure: Following Nature's Lead

The Philadelphia Water Department (PWD) wants to transform Philadelphia's landscape into a vibrant, green community where people want to live, work and play and can thrive over time. By merging the vision of a "green city" with "clean water" we can help not only our watershed environment, but the region's economic health, quality of life and sustainability.

VOCABULARY

Stormwater Runoff *(noun)*: Water from rain or melting snow that "runs off" across the land instead of seeping into the ground. Generally speaking, in cities, stormwater is rain (also melting snow and ice) that washes off driveways, parking lots, roads, yards, rooftops, and other hard surfaces.

Green Stormwater Infrastructure (GSI) *(noun)*: Includes a range of soil-water-plant systems that capture stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air, and in some cases, release a portion of the captured stormwater slowly back into the sewer collection system. GSI treats stormwater runoff as a resource to be incorporated into the urban environment instead of as a waste product requiring removal and treatment.

ACTIVITIES

a. Take a walk outside for one block directly across from your home or school building. Take individual photos that capture the entire block when "stitched" together. Create a mural streetscape of the block outside using the photos. Highlight any green practices on the street (street trees, window boxes, rain barrels, etc.) and add some to the photographs if needed. Discuss the benefits. (K–8)

b. Make a list of all the different surfaces around home, school, or in the neighborhood, and classify as impervious or pervious. (3–5)

c. Watch this animation, and discuss how green stormwater infrastructure projects work to mimic the natural environment. (3–8)

CONSIDER AND DISCUSS

- What is green stormwater infrastructure and how does/can it benefit the street/neighborhood?

ASK THE QUESTION

Why is all this planting and greening and collecting of rain called "infrastructure"?

GREEN STORMWATER INFRASTRUCTURE

Green stormwater infrastructure manages the first inch of rainfall which would normally flow along its street gutters and into its storm drains. These vegetated features, such as those pictured above, manage rain where it hits the ground similar to the way a natural system such as a forest or a meadow would handle the rain runoff.

Examples of Green Stormwater Infrastructure:

- **Downspout Planter (or Flow-through Planter):** Connected to the roof downspout, these planters slow water down before entering the sewer while irrigating plants and removing pollutants.
- **Green Roof:** A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems.
- **Pervious Paving:** Specially designed paving stones, bricks, or pavers that allow water to soak into the ground below.
- **Rain Garden:** This shallow, planted depression absorbs the water that flows from a roof, patio, or yard.
- **Stormwater Tree Trench:** A system of trees that are connected by an underground infiltration structure. On the surface, a stormwater tree trench looks just like a series of street tree pits. However, under the sidewalk, there is an engineered system to manage the incoming runoff.
- **Swale/Bioswale:** A long, gently sloped, vegetated ditch designed to filter pollutants from stormwater.

Lesson 3: Calculating Rainwater

Rainwater landing on the city streets and rooftops is often measured in volume. Help students visualize just how much water falls on a single row home by calculating gallons of rain. There are different categories of storms, some which will drop more water than others. If this water is not captured on the land, gallons of polluted water may end up in our waterways.

VOCABULARY

Pervious/Permeable *(adjective)*: Surfaces that allow the penetration of water into the ground.

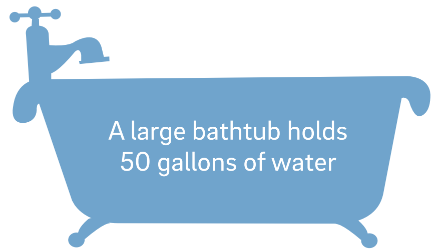
Impervious *(adjective)*: A hard surface area that either prevents or slows the entry of water into the soil as under natural conditions prior to development.

ACTIVITIES

a. Use the chart below to explain precipitation volumes and that it all adds up along one street, in one neighborhood, across one city...and on and on. (K–8)

Row Home Calculations:					
Rain Event (in)	Square Footage (ft2)	Rain (ft)	Cubic Feet (ft3)	Conver-sion (ft3/gal)	Gallons
1/10	1000	0.008	8	7.5	60
1/4	1000	0.021	21	7.5	157.5
1/2	1000	0.042	42	7.5	315
1	1000	0.083	83	7.5	622.5
2	1000	0.166	166	7.5	1245

b. Look up a recent rain event (or measure yourself by making a homemade rain gauge) and calculate how many gallons of water fell over a particular area, such as your schoolyard or home. Estimate how much infiltrated and how much went into storm drains by calculating the percentage of impervious or pervious surface. (6–8)



An Olympic sized swimming pool holds 660,000 gallons of water

CONSIDER AND DISCUSS

- Did you ever envision rain as a volume of water?

ASK THE QUESTION

Why is capturing the first one inch of rainfall on the land so important in this discussion about water quality?

Lesson 4: Restoring Urban Waterways

Urbanization has contributed to waterway degradation in Philadelphia's streams. Increases in impervious surface area and runoff have negative effects on stream flow. Once the natural physical condition of a waterway is compromised by pollution or excessive runoff, it sets off a chain of degradation from erosion to water temperature changes to habitat loss.

VOCABULARY

Erode *(verb)*: To wear away by the action of water, wind or glacial ice.

Sediment *(noun)*: Solid material that is moved and deposited in a new location. Sediment moves from one place to another through the process of erosion.

Stream Restoration *(noun)*: Set of activities that help improve the environmental health of a river or a stream.

ACTIVITIES

a. Create a very simple stream by filling a plastic container with sandbox sand and "make it rain" using a spray bottle or other gentle method. You can start with a light rain shower. At first they will see how channels naturally form. Now introduce heavier rain conditions by more aggressive pouring and see how that erodes the "banks" of your stream. Discuss what could be done to keep the stream from eroding (plants, trees). (K–2)

b. Take a field trip to the nearest stream and observe and record its condition. Key points to consider are flow, water temperature, habitat, erosion, pollution, etc. Connect with community groups or PWD scientists. Organize volunteer efforts to clean up the stream and a plan for long-term stewardship of the stream. (3–8)

c. Create a story, a photographic essay, or a documentary video about life in and around the stream. (K–8)

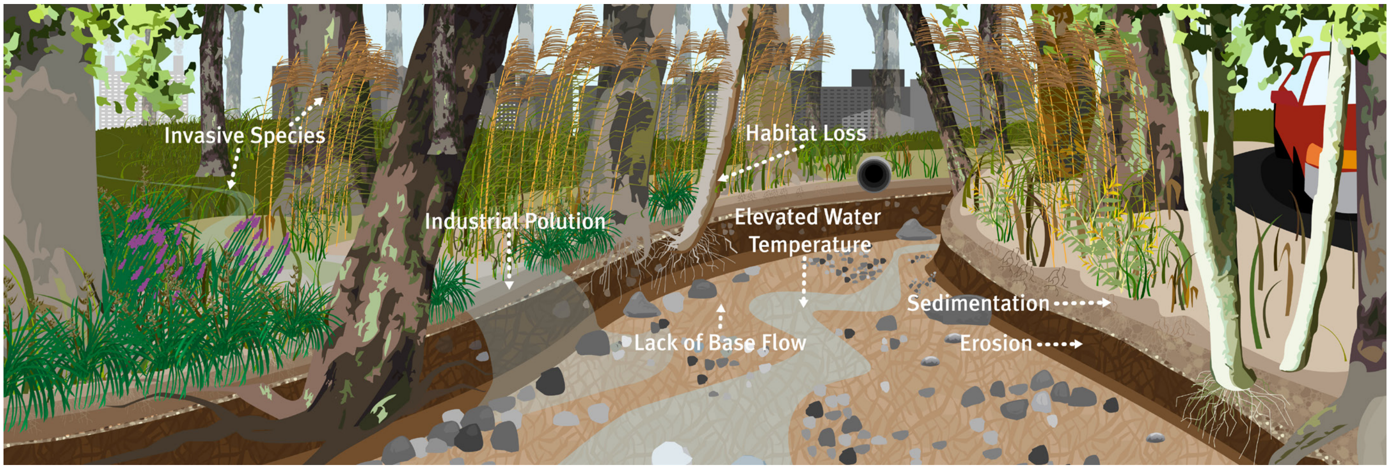
CONSIDER AND DISCUSS:

- Discuss the differences in the three stream images on the following page and how the restorative practices taken improve the quality of the stream.

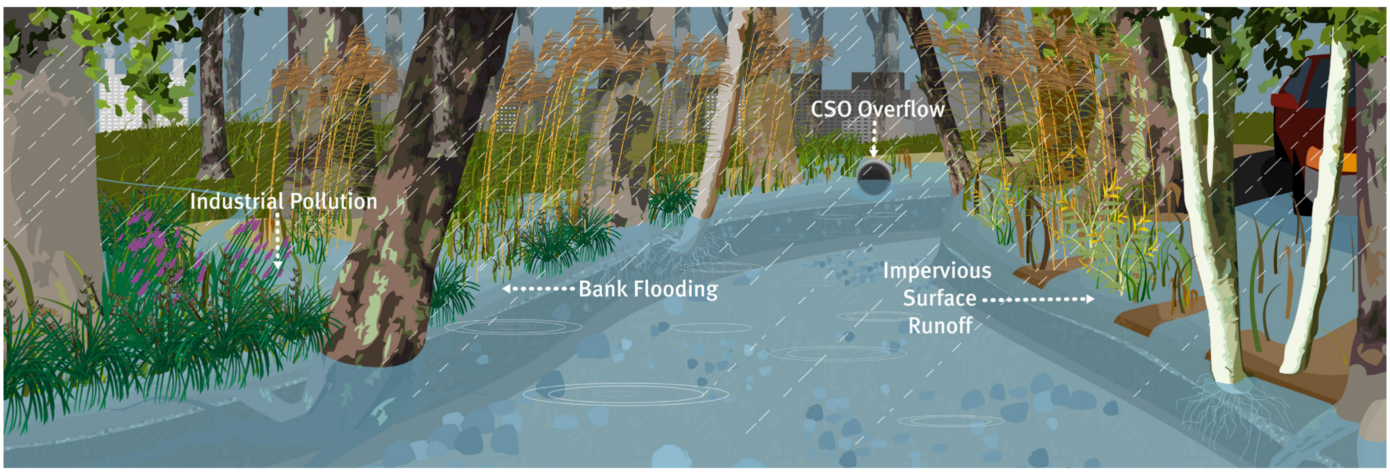
ASK THE QUESTION

What are the long-term benefits for people as well as wildlife of restoring urban streams?

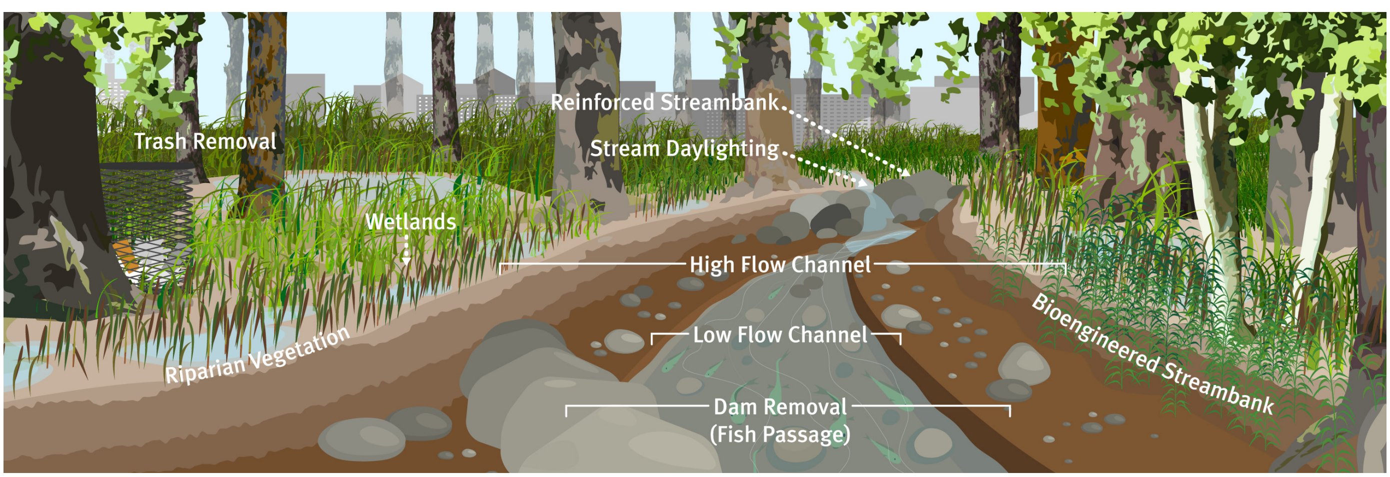
DEGRADED WATERWAY IN DRY CONDITIONS



DEGRADED WATERWAY IN STORM CONDITIONS



WATERWAY RESTORATION TOOLS



Lesson 5: Reimagining your Schoolyard, Backyard or Streetscape

This is an introduction to action projects and becoming an active environmental steward. Envisioning the future is the first step to acting on behalf of the long-term health of your community's environment. The goal of this lesson is to document the built environment, record how water behaves on the surfaces of your schoolyard, backyard, or streetscape and create green space to capture or collect the water and help it infiltrate into the ground in order to mitigate some of the negative impacts of stormwater runoff. This lesson is for dreamers. Unit 6 will be your opportunity to roll up your sleeves and create a real project, fund it, monitor its benefits and ensure its long-term care.

VOCABULARY

Mitigation *(noun)*: Measure taken to reduce adverse impacts on the environment.

ACTIVITIES

a. Reimagine what your schoolyard, backyard or streetscape may look like by building a model:

   i. Measure and draw a plan of the space you will reimagine:

      1. Use your own body as units of measure. (K–2)

      2. Use your own feet as relative units of measure and proportion. (3–5)

      3. Find a scale drawing or map, and duplicate or scale up or down, depending on the drawing. (6–8)

   ii. Transfer to a base. First with a pencil, label the base to locate all prominent features, including the buildings, play areas, parking lots, sidewalks and streets. (K–8)

   iii. Make this three-dimensional using whatever building materials are best suited to the model, age and abilities of the participants (e.g. shoeboxes, foam board, cardboard, blocks.) (K–8)

   iv. Using crumpled tissue paper, straws, pipe cleaners, etc., make the grass areas. (K–8)

b. Take note of green areas or features that are present around their home or in their community that they would like to see more of. Discuss the feasibility of adding them to the schoolyard or in their neighborhood. (3–8)

c. Research different types of green stormwater infrastructure and share the pros and cons of each. Collectively decide what systems could work in their schoolyard or around their neighborhood. (6–8)

CONSIDER AND DISCUSS:

- How will changes to the schoolyard or streetscape change your feelings toward the outside space of the school or your neighborhood?
- What are the benefits of the natural environment, including wildlife, water, and air in your life?

ASK THE QUESTION

How do you envision changing your schoolyard or neighborhood?


Greenfield Elementary School, Philadelphia, PA

Lesson 6: Freshwater Mussels: Nature's Water Quality Engineers

A healthy balanced ecosystem can provide many benefits for people. Think about the many flowering plants and food crops that depend on animal pollinators to reproduce. Or that trees absorb CO_2 from the atmosphere and can store that carbon for long periods of time resulting in sequestering approximately 10% of US carbon dioxide emissions. Other essential services the natural world provides us with include purification of air and water, mitigation of floods and droughts, generation and renewal of soil and natural vegetation, etc. These services are called ecosystem services.

One such service working in our urban watershed is provided by the freshwater mussel, who has a great capacity for natural water filtration. One adult mussel can filter up to 20 gallons of water per day. They suck in water through their incurrent siphon and trap organic matter such as dirt, algae or other pollutants. They release the clean filtered water through their excurrent siphon back into the water.

VOCABULARY

Ecosystem services *(noun)*: Any beneficial natural process arising from healthy ecosystems, such as purification of water and air, pollination of plants and decomposition of waste.

Stability *(noun)*: The property of a body that causes it, when disturbed from a condition of equilibrium or steady motion, to develop forces or moments that restore the original condition.

ACTIVITIES

a. Show and listen to the Mussels in the Wild Read-Aloud. Create pictures and stories about how fish and mussels interact in flowing rivers. (K–4)

b. Explore the Mighty Mussel website to learn more about freshwater mussels and other species that inhabit the flowing river. (4–8)

c. Watch this time-lapse video of freshwater mussels at work:

   i. Discuss how mussels provide an ecosystem service. (4–8)

   ii. Create advertisements promoting the different services they provide. (4–8)

d. Create a list of things that people get from nature for free that help us to sustain life. Separate the items into different categories, such as provisioning, regulatory, cultural and supporting. (6–8)

e. Explore Staten Island's Bluebelt System, a series of engineered streams, ponds and wetlands designed to manage stormwater and prevent flooding (and watch this video). Create a list of the ecosystem services these projects provide and discuss how they could be used in Philadelphia as well. What would be the same or different from their use in New York? (6–8)

CONSIDER AND DISCUSS:

- Why is it important to have many diverse species of mussels in our local waterways? How do they create stability in our environment?
- Discuss how your reimagined schoolyard or neighborhood could provide additional ecosystem services to your community.

ASK THE QUESTION

What is the cost benefit of these ecosystem services?

This page was intentionally left blank.

Thematic Unit 6:

Environmental Stewardship and Civic Engagement

In order to sustain life on the planet and protect the health of our environment, we all must play an active role. Whether we aim to improve our waterways by restoring a natural balance between stormwater runoff and infiltration or reduce the effects of climate change by planting tress and increasing green space, every action adds up. Through their own hands-on project, students will learn the roles and responsibilities of being part of the solution as they become environmental stewards and climate activists.

What you should know:

Students have the power to act as environmental stewards of our shared resources and embrace civic responsibility. Every action adds up. Individual by individual, block-by-block, school by school, and neighborhood by neighborhood. We want the students to develop a growth mindset and apply their knowledge and learning by taking action. We want them to know that they make a difference—and to be prepared for the process of democratic participation—specifically the process of using their voices to organize work individually and collectively—to develop visions for a sustainable future, distinguish problems from symptoms, address issues to protect what they want to preserve and change what needs to change.

Students will "tap" prior knowledge to prepare for their action project related to conserving, protecting and restoring our environment. They will do this so that in the long run, they will be able, on their own, to transfer their attitudes and behaviors to the lifelong stewardship of our waterways.

In this Thematic Unit, rather than Lesson Plans, you will see a menu of ideas to help catalyze creative thinking about practical and impactful projects for home, school, or neighborhood. Likewise, we will lay out a framework for action, and explain how different models can be used to organize the project from conception to implementation to monitoring results. Keep in mind, although implementing the project will be a critical step in improving the quality of water in your watershed, always remember in the broader context that watershed problems do not begin or end at only one place. Try and identify the most "upstream" problem. Bank and streambed erosion, litter along the creeks, degraded aquatic and riparian habitats and limited diversity of fish and other aquatic life are some of the many issues PWD along with their many public and private partners are working to improve, which affects the quality of life for all urban dwellers, young, middle and old.

This unit gives power to student voices for change. Through this process, students will gain a deeper understanding of how they can bring about change for the future they want to live in, through their voice and actions.

FRAMEWORK FOR CHANGE

By taking action to improve the quality of their watershed, students will become environmental stewards and learn how to be a part of the civic engagement process. In order to make such a change, students must go through the steps of planning, implementation, and monitoring results: students develop an action plan, communicate their overall goal, identify roles and responsibilities based on strengths, determine what success will look like, and plan a timeline for action.

The first step in creating an action plan is to decide what the goal of the project will be. This starts with making observations in the neighborhood, school community, and throughout the watershed to identify what changes could be made. Maybe they are concerned about all the litter covering the nearby park or overuse of plastic water bottles at lunch or during team sports. Use these observations and creativity to decide what issue to address and articulate what change can be made. Take into account everything students have learned in the prior units about what a healthy watershed and community looks like. Now that you know the watershed, they can work to improve it and understand why! For some inspiration and potential projects, refer to the section on page 69 called Watershed Stewardship and Civic Action Examples.

Once they have an idea of the action they will take and the goal they hope to achieve, it is important to determine who is involved in the process of getting there. Have a discussion of everyone's individual strengths, or use a more formalized strengths assessment. Use this information as the basis for assigning specific roles and responsibilities within the project. Next, determine a way to measure progress towards the goal. How will they know their efforts are headed in the right direction and they are making positive change? How will they know if they need to make adjustments during the process in order to reach their goal? With these ideas in hand, you can plan out a timeline of events and activities that will be taken to fulfill the project goals. All of the information collected during the planning process should be well documented in a format that works for those involved. Consider using simple checklists, such as the one offered below:

Action Planning Checklist Example

- ❑ **Goal:** Reduce non-point source pollution in our neighborhood
- ❑ **Action:** Run a litter campaign
- ❑ **Indicator(s) of Success:** The amount of litter we track one month after campaign
- ❑ **Who else will we need involved?:** School administrators, parents, other students
- ❑ **How will we involve them?:** Classroom visits, lunch room tabling, after school clubs.
- ❑ **Who will do what when?:** Individual/group roles and responsibilities (organizing, seeking permission, artwork, tracking data.)
- ❑ **Timeline:** Calendar of activities from beginning to end.

After the planning process is substantially complete (remember, you can always revisit your work and make adjustments during the implementation period!) it is time to start implementing your action or project. Follow your timeline and work together with all the involved parties to make progress towards your goal. Refer back to your success indicators to evaluate how you are doing, and what changes may need to be made. When you think your actions or project are complete, reflect on the work you have done, and what the next steps may be. How will you ensure that the progress you made is not lost? How can people in the community continue to contribute to your efforts?

Action Planning Checklist

Plan

- ❑ Articulate our goal and the action we will take
- ❑ Determine our strengths
- ❑ Determine roles and responsibilities based on our strengths
- ❑ Determine how to measure progress
- ❑ Plan out the timeline and activities for the action/project

Do

- ❑ Implement action/project
- ❑ Measure progress
- ❑ Reflect and determine next steps

One of the most critical components of being civically engaged and an environmental steward, is working to ensure that the changes you've made remain, and continue to have a positive impact. This may require long-term care or monitoring, depending on the type of project you have selected. For example, if you have chosen to implement an anti-littering campaign in your neighborhood, you could perform weekly cleanups, taking note of how many bags of litter you obtain each week to measure impact. If you have chosen to plant trees in your schoolyard, you could take temperature measurements or check soil saturation to identify impacts. Whatever action you implement, and goal you hope to achieve, it is important to think through the long-term application of your work, to ensure your plan and vision have a lasting impact. Refer to the Action Planning Checklist for an outline of planning and implementation steps

For those interested in more guidance in developing and implementing an action plan, consider utilizing resources provided by Eco-Schools USA or completing a Meaningful Watershed Educational Experience. A list of local organizations in the Resource section on page 73, may be of assistance throughout the action planning process.

ECO-SCHOOLS USA

Administered by the National Wildlife Federation, Eco-Schools USA is a nationwide green schools program designed to help incorporate sustainability into your school. It utilizes a Seven Step Framework to guide the implementation of a project related to diverse, but interconnected subject areas. The steps include: Form an Eco-Action Team, Conduct a Pathway Audit, Create an Eco-Action Plan, Monitor and Evaluate Progress, Link to Existing Curriculum, Involve the Community, and Create an Eco-Code. While the program is designed to be used by students, teachers, and school administrators in K–12 Education, it can be easily adapted to at-home and community use as well.

One of Eco-Schools' 12 dedicated pathways is Watersheds, Oceans, and Wetlands (WOW). Online resources, such as the pathway-specific audit and action plan template are available to assist in organizing your work and designing your project. For those interested in focusing on Watersheds within the WOW pathway, the following steps are recommended:

1. Conduct a Watershed Audit
2. Learn About your Watershed
3. Conduct a Watershed Litter Audit
4. Develop and Implement an Action Plan

For resources, worksheets, and more information about implementing the Watersheds Pathway within a school environment, please visit https://www.nwf.org/Eco-Schools-USA/Pathways/WOW/Watersheds.

For resources, worksheets, and more information about implementing the Watersheds Pathway within a home or community environment, please visit https://www.nwf.org/Eco-Schools-USA/Pathways/At-Home.

MEANINGFUL WATERSHED EDUCATIONAL EXPERIENCE (MWEE)

A MWEE describes an approach to learning that activates student voice, encourages student-led investigations, results in student-driven solutions and measures of success as an integral part of the experience. The experience is an environmental exploration of the interaction and interdependence of the natural and human-made environment around them that leads to the sustained protection of water systems upon which all living things depend. The basic components of the MWEE experience include: Issue Definition, Outdoor Field Experiences, Synthesis & Conclusions, and Stewardship & Civic Action, which includes Watershed restoration or protection, civic action, or community engagement.

For young people ready to take action and design a watershed project, the following questions can guide their planning:

1. What is the issue or problem in your outdoor zone that you would like to fix?
2. What needs to change to address the problem?
3. What is our ultimate goal? What does success look like?
4. What do we need to do to make it happen?
5. What steps do we need to take to get it done?
6. What's the timeline?

For more information and resources related to Meaningful Watershed Education Experiences, please visit https://

www.cbf.org/join-us/education-program/mwee/.

WATERSHED STEWARDSHIP AND CIVIC ACTION EXAMPLES

1. Design and implement your own green stormwater infrastructure project in your schoolyard or around your home. Consider planting trees, creating a rain garden, installing rain barrels and more!
2. Transform empty space in your schoolyard or backyard into an edible or aesthetic garden. Use materials you may have on hand, such as buckets, pots, or wood, to create a container, pallet, or raised bed garden. Plant herbs, vegetables, or flowers, depending on the space available.
3. Organize a weekly litter cleanup around your schoolyard, in a local park, or right on your street. Provide gloves and bags for all participants. Take inventory of the quantity and types of litter that you are collecting. Develop a project to address a particular item that seems to be a problem within your community.
4. Develop a tap water promotion campaign within your school (or your own household). Encourage students to bring their own reusable water bottles to school with posters, a PSA, or social media campaign.
5. Make signs for your schoolyard or neighborhood that promote good stewardship such as a creative anti-littering campaign.
6. Already have GSI in your schoolyard or community? Create a video describing how the system works and what other students and neighbors can do to take care of it.
7. Think about what you could do at your home or in your community to be a watershed steward. The possibilities are endless!

RESOURCES TO GET YOU STARTED

Alliance for Watershed Education: The Alliance for Watershed Education of the Delaware River is a regional initiative of twenty-three partnering environmental education centers that is funded and supported by the William Penn Foundation. The Alliance offers a wealth of opportunities to get involved in stewardship projects, including volunteer projects, visits to education centers, and their River Days event series.

Drink Philly Tap: Drink Philly Tap is a campaign formed to empower residents of Philadelphia with information and knowledge to choose drinking tap water over bottled water. They provide information about frequently asked questions regarding Philly's tap water and how it compares to bottled water. Join the movement by taking the pledge to drink tap water on their website!

GreenFutures: GreenFutures is the sustainability plan for the School District of Philadelphia and works to improve schools in five primary focus areas: Education for Sustainability, Consumption & Waste, Energy & Efficiencies, School Greenscapes, and Healthy Schools, Healthy Living. They offer student contests, educational resources, and professional development all to help make your school a green school.

Litterati: Litterati is on a mission to eradicate litter. This citizen science app can be used during neighborhood cleanups to catalog litter based on material and brand in order to gather information about what types of litter are most common within your school or community. You can then use your data to create a project to address a specific litter issue and inspire change within your community.

Pennsylvania Horticultural Society: The Pennsylvania Horticultural Society (PHS) aims to use horticulture to increase four building blocks of health and well-being: access to fresh food, healthy living environments, deep social connections, and economic opportunities. PHS offers resources related to tending community gardens, planting trees, and managing stormwater through the Rain Check Program.

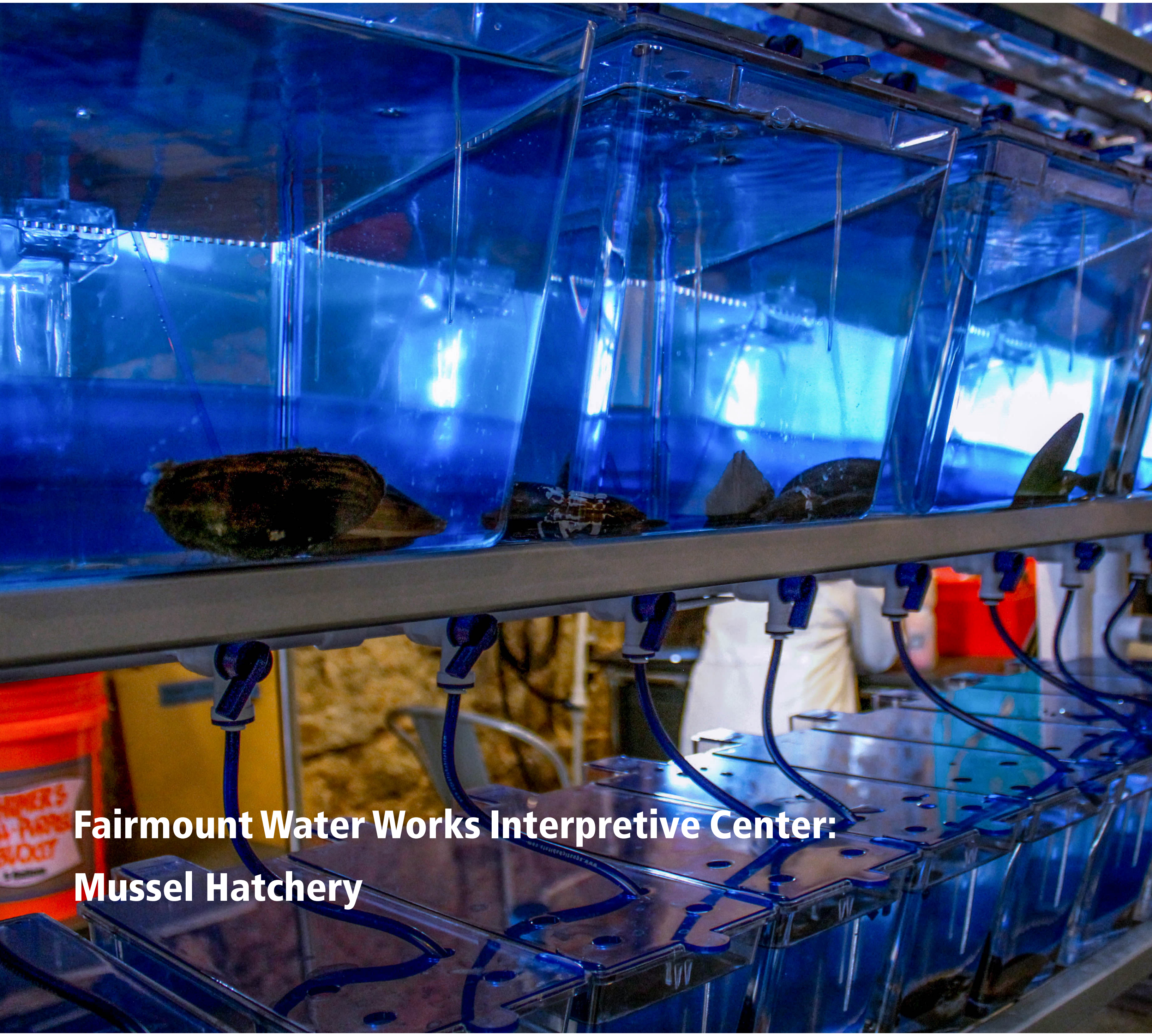
We are all climate activists:

The impacts of climate change are inherently connected to every water, watershed, and environmental action we take. When we learn about the impacts of climate change and global warming, we mostly hear about the negative impacts of our behavior, but rarely about ways we can reverse global warming and restore health and well being to ourselves and the planet. However, people all over the world, of all ages, are taking action into their own hands, and focusing on what they can do to sustain a healthy and balanced ecosystem for generations. Young people in Philadelphia have an important role to play in the climate movement, and have demonstrated the vast impact they can have in making positive change.

While planning your watershed stewardship project, it is important to consider how climate change currently contributes to the issue or how it may contribute in the future. By incorporating climate considerations into your action planning process, you will help to ensure that your project is not only more comprehensive, but its impacts more long-lasting.

An important component of this process is reflecting on two essential questions. First, what actions can young Philadelphians take to reverse global warming? Think about how your watershed stewardship project may already be contributing to the climate movement, and how you could expand or deepen your efforts to make more significant change. Making these connections between watershed and climate change will help to strengthen your project. Second, how do you feel about your role as a climate activist? Think back to prior discussions about civic responsibility, protecting the commons, and the early environmental movement. How can you leverage your knowledge, understanding and appreciation for your watershed to make changes that will positively impact our climate? Addressing these questions with your students, and integrating their responses in their stewardship project will make for a greater end result.

Drawdown Ecochallenge can be used as a resource to help identify potential climate solutions that you can participate in, and put them into action. Create a team, document your progress, and measure your impact. Many of the challenges already created directly relate to protecting our watersheds, such as reducing single-use plastics or nutrient rich fertilizers, protecting wetlands, and planting trees to increase green space.



Fairmount Water Works Interpretive Center: Mussel Hatchery

Connection to Academic Standards

The guide is intended for all who hope to bring watershed education to young people, including classroom teachers K–5, subject area teachers 6–8, informal educators and parents. For some audiences, it may be necessary to acknowledge and document how these lessons and activities connect with required standards; others may have more flexibility in both what and how they offer this material to young people. Therefore, information on relevant standards considered when creating this Activity Guide is included below. Should you be interested in more deeply aligning specific watershed education with Academic Standards and implementing this material as a curriculum, please refer to the **Understanding the Urban Watershed** Curriculum at resourcewater.org.

Grade levels are suggested for each activity in order to provide guidance on appropriate content and skill development for specific ages. However, the facilitator should use their own experience and understanding of their individual audience to adapt the activities as needed. As an interdisciplinary approach to urban watershed education, this guide will naturally connect science, history, language arts, art, and math in all lessons and activities.

COMMON CORE STATE STANDARDS (CCSS)

"Pennsylvania's Core Standards in English Language Arts and Mathematics are robust and relevant to the real world and reflect the knowledge and skills our young people need to succeed in life after high school, in both post-secondary education and a globally competitive workforce." The Common Core State Standards (CCSS) indicate that all content-area teachers need to plan for and implement a variety of literacy strategies. Reading, writing, speaking, and listening are the four areas emphasized in the standards. https://www.pdesas.org/Page/Viewer/ViewPage/14

NEXT GENERATION SCIENCE STANDARDS

"The Next Generation Science Standards (NGSS) are K–12 science content standards. Standards set the expectations for what students should know and be able to do.
The NGSS were developed by states to improve science education for all students.

A goal for developing the NGSS was to create a set of research-based, up-to-date K–12 science standards. These standards give local educators the flexibility to design classroom learning experiences that stimulate students' interests in science and prepares them for college, careers, and citizenship." https://www.nextgenscience.org

EDUCATION FOR SUSTAINABILITY STANDARDS

"The knowledge, skills, attitudes and habits of mind of Education for Sustainability (EfS) are embedded in The Cloud Institute's EfS Standards and corresponding Performance Indicators.

Aligned to national and state educational standards, each EfS Standard has a set of coded Performance Indicators used to guide educators as they infuse their school culture, curriculum, instruction and assessment practices with Education for Sustainability. We believe that by meeting these EfS standards, young people will be prepared to participate in, and lead with us, the shift toward a sustainable future."
https://cloudinstitute.org/cloud-efs-standards

The nine core content standards are:

1. Cultural Preservation & Transformation
2. Responsible Local & Global Citizenship
3. The Dynamics of System & Change
4. Sustainable Economics
5. Healthy Commons
6. Natural Laws & Ecological Principles
7. Inventing & Affecting the Future
8. Multiple Perspectives
9. Strong Sense of Place

TYPE OF RESOURCE	COLOR-CODE
Literature (L)	
General Content Information (G)	
Links to online activities/ lessons and Apps (A)	
Video (V)	

Resources and Links by Unit

UNIT 1: WATER IN OUR WORLDS

- Water Dance by Thomas Locker (L)
- Flow: The Life and Times of Philadelphia's Schuylkill River by Beth Kephart (L)
- Meadowlands: A Wetlands Survival Story by Thomas Yezerski (L)
- Stroud Water Resource Center Dichotomous Key: Use this dichotomous key to identify different macroinvertebrates. (A)
- The Value of Water: Explore how water is valued and its connections to all living things. (G)

UNIT 2: DRINKING WATER AND YOU

- The Crow and the Pitcher a fable by Aesop (L)
- Fever 1793 by Laurie Anderson (L)
- Water Footprint Calculator: Determine your water footprint by taking this interactive quiz. (A)
- School District of Philadelphia Water Testing: Learn about the District's water testing program and look up results for your school. (G)
- PWD Annual Water Quality Reports: Explore past and present Drinking Water Quality Reports and learn more about the process of delivering safe drinking water to the people of Philadelphia. (G).

UNIT 3: DOWN THE DRAIN, OR OUT OF SIGHT, OUT OF MIND

- From Creek to Sewer: A Historical Overview by Adam Levine: Learn about the topographical history of Philadelphia as its streams were transformed into sewers. (G)

UNIT 4: LAND AND WATER: A DELICATE BALANCE (OR CAN'T WE ALL JUST GET ALONG)

- Litterati: Use the Litterati App to track litter pickups and use data to inspire change. (A)
- Great Pacific Garbage Patch: See where trash ends up when it flows down creeks and streams in this short video. (V)
- How green tools protect Philly's waterways: Discover what happens during combined sewer overflows and how green tools, such as tree trenches and rain gardens can help to improve Philly's waterways in this video. (V)
- Philly Rivercast: Check river water quality for the Schuylkill River and recommendations for suitable activities. (G)
- Public Notification of Combined Sewer Overflows: Explore the CSOcast to view locations of the combined sewer outfalls and recent overflow events. (G)
- Poo-llution: Explore how dog waste can impact waterways and what pet owners can do to help. (G)
- Nutrient Pollution Video: Learn how excess nutrients can impact the environment and harm waterways. (V)
- The Modern Environmental Movement: Explore the history of the Modern Environmental Movement in this extensive timeline. (G)
- Silent Spring by Rachel Carson (L)
- "I'm Just a Bill" from Disney's Schoolhouse Rock: Learn how a bill becomes a law with this fun and educational song! (V)
- National Primary Drinking Water Regulations: Learn about drinking water regulations for various chemicals, including their imposed limits, potential health effects, and sources of contamination. (G)

UNIT 5: GREEN (AND BLUE) PLAN FOR THE FUTURE: PLAYING A PART

- Stream to sewers to green again: Philly's story: See how the city of Philadelphia has changed over hundreds of years with regard to infrastructure and green space in this short video. (V)
- Homemade Rain Gauge: Make a rain gauge to track precipitation and help calculate rainfall rates. (A)
- Mussels in the Wild by Victoria Prizzia: Enjoy this video read-along of the book, Mussels in the Wild. (L)
- Mighty Mussel Website: Learn about freshwater mussels and explore other species that inhabit the flowing river. (G)
- Mussels at Work: See how freshwater mussels filter water in this time-lapse demonstration video. (V)
- Staten Island Bluebelt System: Explore how Staten Island uses a system of engineered water features to manage stormwater. (G)
- Sweek Brook Bluebelt: Tour an example of the Bluebelt System in this video from NYC Water. (V)
- Green City, Clean Waters: Explore Philadelphia's 25 year plan to transform the health of the city's creeks and streams through primarily land-based approaches. (G)
- Big Green Map: Use this interactive map to discover where green stormwater infrastructure can be found across Philadelphia. (G)

UNIT 6: ENVIRONMENTAL STEWARDSHIP

- Eco-Schools USA Watersheds Oceans and Wetlands (WOW) Pathway: Implement the WOW Eco-Schools pathway in a school environment to teach about watersheds and guide student action planning. (A)
- Eco-Schools USA Watersheds at Home: Integrate watersheds learning in a school or community environment using these Eco-Schools resources. (G)
- Meaningful Watershed Educational Experience (MWEE): Utilize the MWEE framework to guide the creation and implementation of a watershed action project. (G)
- Drawdown Ecochallenge: Identify, participate in, and track progress towards climate solutions any individual can take. (G)

Additional Water-Themed Lessons and Activities

Properties of Water: Polarity of H2O (6-9): Experiment with the characteristics of water and learn how water molecules behave.

Tree Diversity Booklet - About Trees (3-8): Calculate tree diversity and observe different tree species through leaf rubbings and drawings.

Measuring a Tree Activity - About Trees (5-9): Learn how to take key tree measurements and explore the function of stem flow.

Properties of Matter: Sink or Float (K-5): Predict and observe the density properties of matter in water.

Freshwater Mussel Survey 101: Home Version (3-5): Learn to identify different freshwater mussel species by shape.

Powered by Water: How Water Wheels Works (K-5): Create a water wheel and discover how technology is used to increase efficiency.

Windowsill Farming: Just Add Water (K-8): Regrow food from seeds or scraps.

Green City, Clean Waters: How Green Is my (Delaware River) Valley (3-8): Distinguish between impervious and pervious surfaces and categorize known surfaces.

Tip Top Tap: Taste and Odor (3-8): Discover the connection between sense of smell and taste for tap water.

Whatever Floats Your Boat (K-5): Create a paddlewheel and learn about buoyancy.

Go Fish: A Healthy River is Teaming with Diversity (K-3): Distinguish between fish species in the Schuylkill and color some too!

Drinking Water Treatment Process: Simple Water Filtration (3-5): Test a simple water filtering process and learn about the process used by the Philadelphia Water Department.

Run Water Run: Growing a Lifelong Love of Reading and the Environment (3-8): Explore how water interacts with the city and some of the species that rely on it with these fun activities.

Videos and other Visual Resources

Award-Winning Movie on the Historic Fairmount Water Works: This 16 minute film explores the history of the Fairmount Water Works from the early 17th century to it's opening in 2003 as an education center.

The Natural Water Cycle: Explore the interconnected steps of the Natural Water Cycle.

Drinking Water Treatment Process: Learn about the steps of the Urban Water Cycle related to the drinking water treatment process.

Waste Water Treatment Process: Learn about the steps of the Urban Water Cycle related to the waste water treatment process and pollution control.

Then and Now Photographs of the Fairmount Water Works: Take a walk through history with these photographs of the Fairmount Water Works from the past, some dating back to the 1800s, and today.

DIAGRAMS

- Natural Water Cycle
- Urban Water Cycle
- Drinking Water Treatment Process
- Wastewater Treatment Process
- Combined Sewer System
- Green Stormwater Infrastructure
- Degraded Waterways and Restoration Tools

Agencies and Organizations

- Alliance for Watershed Education: The Alliance for Watershed Education is comprised of 23 environmental education centers throughout the Delaware River Watershed. Their goal is to support each center in providing engaging opportunities to their visitors of all ages, including through their annual River Days event series.
- Cobbs Creek Environmental Center: A member of the Alliance for Watershed Education, the Cobbs Creek Environmental Center is located in Southwest Philadelphia. Featuring access to Cobbs Creek, wetlands, and a meadow, this center offers hands-on student activities as well as teacher training opportunities.
- Drink Philly Tap: The Drink Philly Tap Partnership is comprised of the Philadelphia Water Department, PennEnvironment, and The Water Center and Impact Ed, both at the University of Pennsylvania. The goal of this partnership is to educate Philadelphians about the safety of the city's drinking water and promote the use of tap water over bottled water.
- GreenFutures: GreenFutures is the sustainability program for the School District of Philadelphia and focuses on five key areas: Education for Sustainability, Consumption & Waste, Energy & Efficiencies, School Greenscapes, and Healthy Schools, Healthy Living. GreenFutures aims to provide students with green and healthy schools while equipping students with the knowledge and skills needed for a changing world.
- Litterati: Litterati is an interactive app used to classify and geolocate pieces of litter during pickup. By cataloging the litter based on object, material, brand, and location, users can analyze their data to determine trends and make a plan for actionable change.
- Partnership for the Delaware Estuary: The Partnership for the Delaware Estuary is an environmental nonprofit organization focused on efforts to improve the tidal Delaware River and Bay through both science-based and engagement-based approaches. In addition to providing resources and workshops for teachers, the Partnership offers information and programming related to freshwater mussels.
- Pennsylvania Horticultural Society: The Pennsylvania Horticultural Society aims to build healthier communities and increase access to fresh foods. PHS offers workshops and resources related to gardening, stormwater management, and tree tending.
- Schuylkill Center for Environmental Education: A member of the Alliance for Watershed Education, the Schuylkill Center is located in Northwest Philadelphia. The Center offers educational programming to schools for students in preschool through Grade 12 in addition to housing a Wildlife Clinic, hiking trails, after-school programs, and summer camps.
- Tookany/Tacony-Frankford Watershed Partnership: A member of the Alliance for Watershed Education, the Tookany/Tacony-Frankford Watershed Partnership is located in Lower Northeast Philadelphia. TTF offers online watershed resources, educational workshops, and hands-on restoration projects, including plantings, storm drain marking, mussel surveying and park cleanups.
- Wissahickon Environmental Center: The Wissahickon Environmental Center is located in Northwest Philadelphia and offers educational programming for students in preschool and older. Topics range from maple sugaring and Native American history to birding and plant identification.

Vocabulary

UNIT 1: WATER IN OUR WORLD

Buffer *(noun)*: Something that serves as a protective barrier.

Community *(noun)*: A group of organisms that live together and interact.

Condensation *(noun)*: The part of the water cycle in which a vapor or gas is converted to a liquid.

Diversity *(noun)*: The variety of life in the world or in a particular habitat or ecosystem.

Ecology *(noun)*: A branch of science concerned with the interrelationship of organisms and their environments.

Evaporation *(noun)*: The process by which liquid changes into vapor.

Hydrology *(noun, from Latin hydrologia)*: A science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

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

Invasive Species *(noun)*: Non-native organism that does harm to our environment.

Native *(adjective)*: Describes an animal or plant of indigenous origin or growth.

Niche *(noun)*: The job or role of an organism in its environment; how it fits in the food web.

Percolation *(noun)*: The part of the natural water cycle in which water moves slowly downward through the porous ground.

Precipitation *(noun)*: The part of the natural water cycle in which rain, snow, sleet, or hail falls from the atmosphere to the ground.

Riparian *(adjective, Latin, riparius first known use c.1841)*: Relating to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater.

Stormwater Runoff *(noun)*: The part of the water cycle in which water flows off the land into the nearest body of water.

Topography *(noun, from Greek topographein* - to describe a place; topos, place and graphein, write): The physical or natural features of an object or entity and their structural relationships; the art or practice of graphic delineation in detail usually on maps and charts of natural and man-made features of a place or region especially in a way to show their relative positions and elevations.

Transpiration *(noun)*: The part of the water cycle in which water is absorbed by living things, like plants and trees and evaporates into the atmosphere.

Water *(noun and verb)*: The liquid that descends from the clouds as rain, forms streams, lakes, and seas, and is a major constituent of all living matter and that when pure is an odorless, tasteless, very slightly compressible liquid oxide of hydrogen H_2O which appears bluish in thick layers, freezes at 0° C and boils at 100° C, has a maximum density at 4° C and a high specific heat, is feebly ionized to hydrogen and hydroxyl ions, and is a poor conductor of electricity and a good solvent.

Watershed *(noun)*: The region or area of land that drains into the nearest river or stream or other body of water.

Wetland *(noun)*: An ecosystem that is saturated with water, such as a swamp, marsh or bog.

UNIT 2: DRINKING WATER AND YOU

Chemistry *(noun)*: A science that deals with the composition, structure and properties of substances and with the transformations that they undergo.

Chlorine *(noun)*: Chemical used for water purification and in the making of chlorine bleach.

Civic *(adjective)*: Of or relating to citizen, a city, citizenship or community affairs.

Coagulation *(noun)*: The process of changing from a liquid to a semi-solid state. (Chemicals are added to the water to bind smaller particles together to encourage them to settle).

Disinfection *(noun)*: The process of introducing a chemical or other product added to kill disease causing organisms.

Engineering *(noun)*: The application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people.

Filtered Water *(noun)*: Water that has undergone a process to make it cleaner and safer to drink.

Filtration *(noun)*: The act of capturing impurities from the water as it passes through a layer of sand, gravel and charcoal now called rapid sand filtration. Philadelphia first introduced a slow sand filtration process in the early 1900s using sand and gravel only.

Flocculation *(noun)*: The formation of small clumps. (In this process, water is gently mixed to make sure that the chemicals added in coagulation have bonded and that particles combine to form "floc" which will settle).

Hygiene *(noun)*: A science of the establishment and maintenance of health. Conditions or practices (as of cleanliness) conducive to health.

pH *(noun)*: In chemistry, pH (power of hydrogen) is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH very close to 7.

Potable *(noun)*: A liquid that is suitable for drinking.

Raw Water *(noun)*: The natural water found in the environment, such as rainwater, ground water, and water like lakes and rivers.

Reservoir *(noun)*: A large natural or artificial lake used as a source of water supply.

Sedimentation *(noun)*: The process of matter settling to the bottom of a liquid by gravity.

Source Water *(noun)*: The water from streams, lakes, or underground aquifers that is used for drinking.

Tap Water *(noun)*: Water that is supplied to a tap. Its uses include drinking, washing, cooking, and the flushing of toilets.

UNIT 3: DOWN THE DRAIN, OR OUT OF SIGHT, OUT OF MIND

Capacity *(noun)*: The maximum amount that something can contain.

Collect *(transitive verb)*: To bring together into one body or place.

Combined Sewer *(noun)*: Sewage collection system of pipes and tunnels designed to also collect surface runoff.

Conduit *(noun)*: A pipe, tube or the like for conveying water or other fluid.

Culvert *(noun)*: A tunnel carrying a stream or open drain under a road or railroad.

Downstream *(adjective)*: Situated in the direction in which a stream or river flows.

Drain *(verb)*: To flow off gradually.

Industrialization *(noun)*: The large-scale introduction of manufacturing, advanced technical enterprises and other productive economic activity in an area, society, country, etc.

Influent/Effluent *(noun)*: Inflow/outflow.

Infrastructure *(noun)*: The underlying foundation or basic framework (as of a system or organization); the system of public works of a country, state or region.

Pretreatment *(noun)*: Involves a physical removal such as screening and sedimentation.

Primary Treatment *(noun)*: Suspended solids settle to the bottom by gravity and oil/grease rise to the top before being removed.

Scum *(noun)*: A layer of grease and oil that rises to the surface of the liquid.

Secondary Treatment *(noun)*: Uses local microorganisms to help remove dissolved organics and suspended particles. Once the microorganisms have been removed through a settling process a disinfectant is often added before the clean effluent, final out flow, is released into a body of water.

Separate Sewer *(noun)*: A drainage system in which sewage and stormwater are carried in separate sewers and to separate places.

Sewer *(noun)*: An underground conduit for carrying off drainage water and waste matter.

Sludge *(noun)*: Solids that settle by gravity in the wastewater treatment process made up of organic materials such as food, feces, paper fibers, etc.

Upstream *(adjective)*: Situated in the opposite direction in which a stream or river flows; nearer to the source.

UNIT 4: LAND AND WATER: A DELICATE BALANCE (OR CAN'T WE ALL JUST GET ALONG)

Convey *(verb)*: To move in a continuous stream or mass.

Leadership *(noun)*: The act or an instance of leading.

Non-Point Source Pollution *(noun)*: "A contributory factor to water pollution that cannot be traced to a specific spot; for example, pollution that results from water runoff from urban areas, construction sites, agricultural operations, and Silvicultural operations and so forth." - National Water Quality Monitoring Council, 2007

Nutrient *(noun)*: A substance or ingredient that promotes growth, provides energy, and maintains life.

Outfall *(noun)*: The outlet of a body of water.

Participate *(verb)*: To have a part or share in something.

Permit *(noun)*: An official document authorizing permission to do something.

Point Source Pollution *(noun)*: Pollution discharged through a pipe or some other discrete source from municipal water-treatment plants, factories, confined animal feedlots, or combined sewers.

Policy *(noun)*: A course or principle of action adopted or proposed by a government, party, business, or individual.

Pollutant *(noun)*: A substance that pollutes something.

Pollute *(verb)*: Contaminate with harmful or poisonous substances.

Pollution *(noun)*: The presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects.

Regulation *(noun)*: A rule or order issued by an executive authority or regulatory agency of a government and having the force of law.

Source *(noun)*: The point of origin at which something begins its course.

UNIT 5: GREEN (AND BLUE) PLAN FOR THE FUTURE: PLAYING A PART

Downspout Planter (or Flow-through Planter) *(noun)*: Connected to the roof downspout, these planters slow water down before entering the sewer while irrigating plants and removing pollutants.

Ecosystem Services *(noun)*: Any beneficial natural process arising from healthy ecosystems, such as purification of water and air, pollination of plants and decomposition of waste.

Erode *(verb)*: To wear away by the action of water, wind or glacial ice.

Green Roof *(noun)*: A roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems.

Green Stormwater Infrastructure *(noun)*: Includes a range of soil-water-plant systems that capture stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air, and in some cases, release a portion of the captured stormwater slowly back into the sewer collection system. GSI treats stormwater runoff as a resource to be incorporated into the urban environment instead of as a waste product requiring removal and treatment.

Impervious *(adjective)*: A hard surface area that either prevents or slows the entry of water into the soil as under natural conditions prior to development.

Mitigation *(noun)*: Measure taken to reduce adverse impacts on the environment.

Pervious/Permeable *(adjective)*: Surfaces that allow the penetration of water into the ground.

Pervious Paving *(noun)*: Specially designed paving stones, bricks, or pavers that allow water to soak into the ground below.

Rain Garden *(noun)*: This shallow, planted depression absorbs the water that flows from a roof, patio, or yard.

Sediment *(noun)*: Solid material that is moved and deposited in a new location. Sediment moves from one place to another through the process of erosion.

Stability *(noun)*: The property of a body that causes it when disturbed from a condition of equilibrium or steady motion to develop forces or moments that restore the original condition.

Stormwater Runoff *(noun)*: Water from rain or melting snow that "runs off" across the land instead of seeping into the ground. Generally speaking, in cities, stormwater is rain (also melting snow and ice) that washes off driveways, parking lots, roads, yards, rooftops, and other hard surfaces.

Stormwater Tree Trench *(noun)*: A system of trees that are connected by an underground infiltration structure. On the surface, a stormwater tree trench looks just like a series of street tree pits. However, under the sidewalk, there is an engineered system to manage the incoming runoff.

Stream Restoration *(noun)*: Set of activities that help improve the environmental health of a river or a stream.

FAIRMOUNT WATER WORKS

PHILADELPHIA WATER DEPARTMENT