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
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THE CURRICULUM PROJECT

In fall 2014, Fairmount Water Works launched a three year Middle School Teacher Fellowship Program to develop an integrated urban watershed curriculum for grades 6-8, aligned with core standards. This curriculum will be completed by June 2017. The Program is supported by the William Penn Foundation and the Philadelphia Water Department. Nine Philadelphia schools were selected to participate for the next three years. Principals of the selected schools were asked to nominate two teachers from their school to participate in the program each year. Each cohort will develop and field-test lessons in their classrooms. These lessons will continue to evolve as teachers gain feedback from their work with students and colleagues. In 2014-15, the program began with 6th grade teachers and students. During the 2015-16 school year, we will continue to work with 6th grade teachers and we will also add a 7th grade cohort. In the 2016-17 school year, 8th grade teachers will join the project.

In order to facilitate the development of the curriculum and accompanying lessons, the teachers receive monthly staff development training, support in the classroom from environmental educators, curriculum specialists, and content experts from the Philadelphia Water Department and its partners. Student teacher volunteers from Temple University’s TU Teach program, University of Pennsylvania’s Graduate School of Education and Bryn Mawr College’s Community Praxis program work with the teachers to help develop, support, and implement lessons with these classroom teachers. Teachers also receive funds to purchase supplies for lessons and activities, bus transportation for field trips and compensation for staff development. Each school year culminates in a Summit, for principals and teachers, and the goal for year 2 and 3 will be to include classroom students, teaching assistants, parents, and community members. An Advisory Board of curriculum experts, informal and formal educators, school administrators, scientists, planners and strategists from PWD and its partners has been formed to provide feedback, advice and guidance as the program is developed.

The program is a dynamic and interactive opportunity for adolescent students as well. Middle school is a unique time to capture the enthusiasm of students through hands-on exploration and project-based learning. The program reached approximately 500 students in the first year alone. By integrating real world environmental experiences into the classroom, the goal is to increase student engagement and academic achievement in step with development of the classroom curriculum.

The project grew out of the Fairmount Water Works’ existing program: Understanding the Urban Watershed Curriculum Guide, a framework for lessons on water, watersheds, and water use in the context of an urban environment. The framework has an online teacher toolbox, at resourcewater.org, available for teachers to access.
explore in order to supplement their lessons. This framework was developed and tested over several years in schools throughout Philadelphia. The William Penn Foundation grant will enable *Understanding the Urban Watershed* to be fully developed for use in the classroom and to accommodate the now fully implemented Common Core Standards as well as Next Generation Science Standards. This unique curriculum is being developed at a time when the need for high quality environmental education is critical for student understanding of the issues faced not only in Philadelphia, but also across the nation.

This curriculum is a pilot project. The following Curriculum Units 1 and 2 were developed and piloted by teachers during the 2014-15 school year. Continuous feedback over the next two years will inform the refinement and adjustments needed to create the very best, practical and usable curriculum for middle school students. Connecting students to their watershed, albeit in their own schoolyard or in the nearest (or furthest) creek will insure that our future environmental protection efforts are in the hands of a well-educated and informed generation.

*Schools, Principals and 6th grade Teachers (Cohort 1):*

**Cook-Wissahickon**
- Melanie Lewin, Principal
- Karen Brinkley, Science
- Ashon Washington, Social Studies

**Dobson**
- Patricia Cruice, Principal
- Kimberly Fullam, Science
- Allison McConnell, Math

**William D. Kelley**
- Amelia Coleman-Brown, Principal
- Pam Redmond, Science and Math

**Chester A. Arthur**
- Kim Newman, Principal
- Michael Franklin, Science
- Frances Wilson, 6th Grade Teacher

**Lea Elementary**
- Jennifer Duffy, Principal
- Kathleen Radebaugh, Literacy

**Andrew Jackson**
- Lisa Kaplan, Principal
- Kevin Konya, Science
- Connie D’Alesandro, Algebra, Intervention, School-based Teacher Leader

**Maritime Academy Charter**
- Dr. Ann Waiters, CEO Emerita
- Robert DiNicola, RELA/Social Studies

**Blaine Academics Plus**
- Gianeen Powell, Principal
- Mary MacMillan, Reading/Writing and Social Studies

**La Salle Academy**
- Teresa Diamond, Principal
- Matt Joram, Science
- Moira Devlin, Math
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 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.

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 URBAN STORY

This curriculum is intended to be a practical guide for middle school educators interested in making a connection for their students 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 and managing it as a city.

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 urban 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 out of problems 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 your students gain a greater understanding of their connection to the urban watershed and the urban water use cycle. Urban 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 storm water runoff and healthy ecosystems.

Ben Franklin’s adage that we do not know the value of water until the well is dry speaks to our goals. Ultimately, the activities in this guide will encourage students of all ages to discuss, assess, calculate and evaluate the worth of water.

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 appears from the tap, it is quite possible for a person to be unaware of where that water originated or how it was made to be safe enough to drink.

This disconnect becomes a problem when water resources are threatened, making urban water education vital. Urban watershed education helps re-connect us 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. Once “consumers” begin to understand that they have an impact on this precious natural water resource, they can make informed decisions about the best way to take care of these resources.

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

INNOVATION AND SOLUTIONS: A CAPTIVATING STORY

This guide presents a variety of ways to help you engage your students in the fascinating and yet complex narrative, with its twists and turns, describing the story of the urban 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 familiar 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 is that it has no ending. It is up to your students to write the next chapters and to pass it on.
ABOUT THIS URBAN WATERSHED CURRICULUM

This curriculum is designed as a series of thematic units that build on each other, starting with the personal perspective. Ultimately, the learning experience will provide students with the broadest view of the development of urban water delivery systems and help them become active participants in 21st century solutions to urban water issues. The final thematic unit, focused on stewardship, will be project based at the school or in the neighborhood community. Students, faculty, administrators, families and community members will help shape it to be 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 lessons that make up the learning experience for the students.

THE 6 E’S OF THE LEARNING EXPERIENCE:

Our curriculum consists of a series of developed, powerful, and extended learning experiences. We use the “6 E’s” to organize each learning experience.

- Engagement
- Exploration
- Explanation
- Elaboration
- Extension
- Evaluation

Each learning experience begins with an activity designed to Engage the students through a provocative question, an outdoor activity or a hands-on experience. The Engage activity is designed to prepare the student to connect new material to past experiences. The Engage activity may take anywhere from 20 minutes to 2 hours! Once the students are engaged, additional opportunities are provided to Explore the concept with depth. These Explorations will lead the students to construct Explanations. The Learning Experience continues with opportunities to Elaborate through reading, writing, viewing, problem solving, researching and learning outside of the classroom. Ideas to further learning through Extensions that feature additional research and problem solving are suggested. Finally, ideas are provided for Evaluation. These evaluative tools will be developed further to include rubrics to help the teacher assess student growth and progress. Over the course of each Learning Experience, students are encouraged to keep a personal “Watershed Journal”. This journal can be used for all forms of written and illustrated responses across the Urban Watershed Curriculum. These responses will include recordings of observations, thoughts, and notes over the course of the Urban Watershed study. This journal can be any type of journal and students can be encouraged to decorate it with images of water. All of the learning experiences are cross-curricular in nature and all of the learning experiences align to Common Core Literacy Standards and Next Generation Science Standards. A number of Common Core Mathematical Standards are also addressed. Each learning experience provides activities that can be done in and around the classroom in an open and flexible style, knowing that the classroom teacher will be able to make the appropriate adaptations and modifications to best address student learning styles, subject areas and assessment tools.

Check out resourcewater.org, our online teacher toolbox of resources for your classroom to complement your lesson plans -- useful videos, books, websites, funding opportunities for projects and more.
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<td>Planning and Carrying Out Investigations</td>
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<td>Analyzing and Interpreting Data</td>
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<td>Using Mathematics and Computational Thinking</td>
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<td>Constructing Explanations and Designing Solutions</td>
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<td>Engaging in Argument from Evidence</td>
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<td>Obtaining, Evaluating, and Communicating Information</td>
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<td>Earth and Human Activity: Natural Resources, ESS3.A</td>
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<tr>
<td>Earth and Human Activity: Human Impacts on Earth's Systems, ESS3.C</td>
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<tr>
<td>Targeted Next Generation Science Standards</td>
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<td>-----------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td><strong>Engineering Design: Developing Possible Solutions, MS-ETS1.B</strong>&lt;br&gt;There are systemic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. A solution needs to be tested, and then modified on the basis of test results, in order to improve it.</td>
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<tr>
<td><strong>Engineering Design: Optimizing the Design Solution, MS-ETS1.C</strong>&lt;br&gt;Although one design may not perform the best across all tests, identifying the characteristics of the design that performed best in each test can provide useful information for the re-design process—that is some of those characteristics may be incorporated into the new design. A solution needs to be tested, and then modified on the basis of test results, in order to improve it. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.</td>
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<tr>
<td><strong>Matter Interactions: Structure and Properties of Matter, MS-PS1.A</strong>&lt;br&gt;Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.</td>
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<tr>
<td><strong>Interdependent Relationships in Ecosystems, LS2.A</strong>&lt;br&gt;Organisms and populations of organisms are dependent on their environmental interactions with both other living things and with non-living factors. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.</td>
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<td>Cross Cutting Concepts</td>
<td>Targeted Next Generation Science Standards</td>
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<td></td>
<td>Interdependent Relationships in Ecosystems LS2.A. Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. By contrast, mutually beneficial interactions may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across eco-systems, the patterns of interactions of organisms with their environments, both living and non-living are shared.</td>
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<td></td>
<td>Cycle of Matter and Energy Transfer in Ecosystems. MS.LS2.B. Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an eco-system. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant and animal matter back to the soil in terrestrial environments or to the soil in aquatic environments. The atoms that make up the organisms in an eco-system are cycled repeatedly between living and non-living parts of the eco-system.</td>
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<td></td>
<td>Ecosystems Dynamics, Functioning and Resilience. LS2.C. Eco-systems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an eco-system can lead to shifts in all of its populations.</td>
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<td><strong>Cause and Effect</strong></td>
<td>Cause and effect relationships may be used to predict phenomena in natural or designed systems</td>
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<td></td>
<td>Energy and Matter</td>
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<td>Energy and Matter</td>
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### Performance Expectations

**Influence of Science, Engineering and Technology on Society and the Natural World**

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

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<th>2.2</th>
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<th>2.4</th>
<th>2.5</th>
<th>2.6</th>
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<tbody>
<tr>
<td>Earth’s Systems. MS-ESS2-4</td>
<td>Students who demonstrate understanding will be able to develop a model to describe the cycling of water through Earth’s systems driven by energy from the sun and the force of gravity</td>
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<td>Earth and Human Activity. MS-ESS3-4</td>
<td>Students who demonstrate understanding will be able to construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems</td>
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<td>Engineering Design Performance Expectation. MS-ETS1-1</td>
<td>Students who demonstrate understanding can define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.</td>
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### Targeted Next Generation Science Standards

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<tr>
<td><strong>NGSS. Engineering Design Performance Expectation, MS-ETS1-2</strong>&lt;br&gt;Students who demonstrate understanding can evaluate competing design solutions using a systemic process to determine how well they meet the criteria and the constraints of the problem.</td>
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<td><strong>Engineering Design Performance Expectation, MS-ETS1-3</strong>&lt;br&gt;Students who demonstrate understanding can analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.</td>
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<tr>
<td><strong>Engineering Design Performance Expectation, MS-ETS1-4</strong>&lt;br&gt;Students who demonstrate understanding can develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.</td>
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<tr>
<td><strong>Ecosystems: Interactions, Energy and Dynamics, MS-LS2-1</strong>&lt;br&gt;Students who demonstrate understanding can analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.</td>
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<td><strong>MS-LS2-2 Ecosystems, Interactions, Energy and Dynamics, MS-LS2-2</strong>&lt;br&gt;Students who demonstrate understanding can construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.</td>
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<td><strong>Ecosystems: Interactions, Energy, and Dynamics, MS-LS2-3</strong>&lt;br&gt;Students who demonstrate an understanding can develop a model to describe the cycling of matter and flow of energy among the living and non-living parts of an ecosystem</td>
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<td><strong>Ecosystems: Interactions, Energy and Dynamics, MS-LS2-4</strong>&lt;br&gt;Students who demonstrate understanding can construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</td>
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**Understanding the Urban Watershed**
<p>| Fairmount Water Works Curriculum | Ecosystems: Interactions, Energy, and Dynamics, MS-LS2-5. Students who demonstrate understanding can evaluate competing design solutions for maintaining biodiversity and ecosystem services. (Example of eco-system service includes water-purification.) | X |</p>
<table>
<thead>
<tr>
<th>Reading</th>
<th>1.1</th>
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<tbody>
<tr>
<td>Cite specific textual evidence to support analysis of science and technical texts,</td>
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<td>Determine the central ideas or conclusions of a text; provide an accurate summary of the</td>
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<td>text distinct from prior knowledge or opinions.</td>
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<td>Follow precisely a multistep procedure when carrying out experiments, taking measurements,</td>
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<td>or performing technical tasks.</td>
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<td>Integrate quantitative or technical information expressed in words in a text with a version</td>
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<td>of that information expressed visually (flow chart, diagram, model, graph, table)</td>
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<td>Distinguish among facts, reasoned judgment based on research findings, and speculation in</td>
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<td>Compare and contrast the information gained from experiments, simulations, video, or</td>
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<td>multimedia sources with that gained from reading a text on the same topic.</td>
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<td>Write arguments focused on discipline content</td>
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<td>Write informative/explanatory texts to examine a topic and convey ideas, concepts, and</td>
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<td>information through the selection, organization, and analysis of relevant content.</td>
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<td>Conduct short research projects to answer a question, drawing on several sources and</td>
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<td>generating additional related, focused questions for further research and investigation.</td>
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<td>Gather relevant information from multiple print and digital sources, using search terms</td>
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<td>effectively; assess the credibility and accuracy of each source; and quote or paraphrase</td>
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<td>the data and conclusions of others while avoiding plagiarism and following a standard</td>
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<td>Draw evidence from informational texts to support analysis, reflection and research.</td>
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<td>Speaking and Listening: Comprehension, Collaboration, Presentation</td>
<td>Connected Common Core Literacy Standards</td>
<td>1.1</td>
<td>1.2 (a,b)</td>
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<td><strong>CCSS.ELA-Literacy.SL.6-8.1</strong></td>
<td>Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade topics, texts, and issues, building on others' ideas and expressing their own clearly. (Unit 2)</td>
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<td><strong>CCSS.ELA-Literacy.SL.6-8.2</strong></td>
<td>Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.</td>
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<td><strong>CCSS.ELA-Literacy.SL.6-8.3</strong></td>
<td>Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence. (Unit 2)</td>
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<td><strong>CCSS.ELA-Literacy.SL.6-8.4</strong></td>
<td>Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation. (Unit 2)</td>
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<td><strong>CCSS.ELA-Literacy.SL.6-8.5</strong></td>
<td>Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. (Unit 2)</td>
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<td><strong>CCSS.ELA-Literacy.SL.6-8.6</strong></td>
<td>Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (Unit 2)</td>
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<td><strong>CCSS.Math.6.RP.A.1</strong></td>
<td>1.1 X (a,b)</td>
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<td>Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.</td>
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<td><strong>CCSS.Math.6.RP.A.2</strong></td>
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<td>Ratios and Proportional Relationships: Understand ratio concepts and use ratio reasoning to solve problems.</td>
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<td><strong>CCSS.Math.6.RP.A.3</strong></td>
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<td>Use ratio and rate reasoning to solve real world and mathematical problems.</td>
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<td><strong>CCSS.Math.6.EE.B.5</strong></td>
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<td>Expressions and Equations: Understand solving an equation or inequality as a process of answering a question: which values from a specified set, if any, make the equation or inequality true?</td>
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<td><strong>CCSS.Math.6.EE.B.6</strong></td>
<td>2.5 X</td>
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<td>Expressions and Equations: Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.</td>
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<td>Expressions and Equations: Solve real-world and mathematical problems by writing and solving equations of the form ( x + p = q ) and ( px = q ) for cases in which ( p, q ) and ( x ) are all nonnegative rational numbers.</td>
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<td><strong>CCSS.Math.6.EE.C.9</strong></td>
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<td>Expressions and Equations: Use variables to represent two quantities in a real-world problem that change in relationship to one another</td>
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<td><strong>CCSS.Math.6.SP.A.2</strong></td>
<td>X(/ext)</td>
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<td>Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape</td>
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<td><strong>CCSS.Math.6.SP.B.4</strong></td>
<td>X(/ext)</td>
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<td>Display numerical data in plots on a number line, including dot plots, histograms, and box plots</td>
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<td><strong>CCSS.Math.6.SP.B.5</strong></td>
<td>X(/ext)</td>
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<td>Summarize numerical data sets in relation to their context. 1.2,1.3</td>
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<td><strong>CCSS.Math.6.G.A.2</strong></td>
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<td>Geometry: Solve real world and mathematical problems involving area, surface area, and volume</td>
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<td><strong>CCSS.Math.NS.B.3</strong></td>
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<td>The Number System: Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation.</td>
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**OBJECTIVES:**
First we (you and your students) must develop an understanding of the value of water in our lives and the way the natural water cycle (the hydrologic cycle) functions. It is important to embrace this basic level of appreciation before exploring subsequent thematic units, which address the growth of cities, and how people adapted and innovated to meet the challenge of providing clean water as the population grew.

**LEARNING EXPERIENCES**

1. Water for Life (or My BFF)
2-A. The Natural Water Cycle and the Natural Watershed Explored and Explained
2-B. How Soils and Vegetation Impact Infiltration and Runoff
3. Stream Ecology

**Thematic Unit 2: Drinking Water and You**

**OBJECTIVES:**
Students will learn about the urban water use cycle and how this is both different from 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). Prominent cities like Philadelphia approached access to a clean drinking water supply as a civic responsibility for the public good.

**LEARNING EXPERIENCES:**

1. Fresh Water and You!
2. Water for the Federal City: Source Water and the Civic Responsibility for the Public Good
3. Technology and Innovation: Engineering a Public Water System
4. Public Drinking Water Treatment Process Explained
5. Testing the Waters: Making it Safe
6. Bottled or Tap?
Thematic Unit 1:

Water in Our World

Objectives:
First, we (you and your students) must develop an understanding of the value of water in our lives and the way the natural water cycle (the hydrological cycle) functions. It is important to embrace this basic level of appreciation before exploring subsequent thematic units about the growth of cities, and how people adapted and innovated to meet the challenge of providing clean water as the population grew.
What the Teacher 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 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 now polluted 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 all a reason to care about protecting them. It is a public responsibility all around - to supply it, clean it up, and protect it at its source.

Water is essential to life and the freshwater resources on Earth are limited. Only about 3% of the water on Earth is freshwater and about 2/3 of that is frozen into icebergs and much of the remaining 1% of available freshwater is being polluted.

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 ground water, 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 in oceans 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 to a particular water body when it rains is called a watershed. Unfortunately, if waterways are not cared for and become polluted, the wildlife will suffer also.

There are two main ways that what happens on the land can affect the water it drains into. The first way is caused by the hard surfaces that cover our cities and towns (e.g. roads, sidewalks, parking lots, and buildings). These hard, impervious surfaces are unable to absorb water, so rain and melted snow run right off them into storm drains. In Philadelphia, 40% of these drains are connected to separate sewers that lead directly to our rivers. The other 60% of storm drains are connected to large combined sewers that collect both rainwater and sewage. In a heavy rain event, these pipes may get too full of this rainwater-sanitary waste mixture and need to overflow into the rivers.

The second way water pollution occurs is from different types of pollution that get washed into waterways in a rainstorm. Rainwater rushes over our streets and carries with it the animal waste, litter, fertilizer, and oil that someone has left behind. This combination problem of too much polluted water running off our streets and into storm drains is called stormwater runoff.

Looking for ways to change the way water is collected, captured or runs off the land is one of the best ways to mitigate this stormwater runoff pollution problem. By integrating more natural surfaces into the urban landscape (hardscape), more water will be allowed to collect and infiltrate slowly into the ground. Specially engineered projects designed to manage stormwater make up what is called Green Stormwater Infrastructure. By planting street trees, installing stormwater planters and green roofs, starting a community garden, or attaching a rain barrel to homes, this water can renew and replenish our waterways and, at the very least, will prevent harmful pollutants from ever getting into them in the first place.
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.

Another way to help ensure the protection of our waterways is to help citizens understand their connection to the **urban water use cycle**. Like the **natural water cycle**, this cycle relies on a process to enable river water to become the city’s tap water, and then, through another process, returns it back to the rivers. The Philadelphia Water Department begins the cycle by pumping water out of the Schuylkill and Delaware Rivers to one of three Drinking Water Treatment Plants where the water is made safe to drink. This water is then distributed to the city where it is used in homes, schools and businesses. As the water is used, it becomes dirty again and must be collected as wastewater by the PWD to be treated once more. Sewage treatment takes place at three different Water Pollution Control Plants. Once it is cleaned, the effluent (water that is cleaner than the river itself) is sent back to the Delaware River. This cycle allows the PWD to provide Philadelphians with plenty of potable (drinkable) water without compromising the health of our rivers.

It is also important to begin any stewardship effort by nurturing a basic appreciation for our natural resources.

“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.”


---

**Sequence of Lessons**

1. Water for Life (or My BFF)

2A. The Natural Water Cycle and the Natural Watershed Explored and Explained

2B. How Soils and Vegetation Impact Infiltration and Run-Off.

3. Stream Ecology

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Understanding the Urban Watershed

Unit One

Introduction
UNIT ONE: WATER IN OUR WORLD
LEARNING EXPERIENCE 1: WATER FOR LIFE (OR MY BFF)

Lesson Plan Overview
   I. ESSENTIAL QUESTION                      PAGE 4
   II. STUDENT UNDERSTANDINGS                 PAGE 4
   III. STUDENT OBJECTIVES                    PAGE 5
   IV. CROSS-CURRICULAR CONNECTIONS          PAGE 5
   V. SETTING THE STAGE AND HELPFUL VOCABULARY PAGE 6
   VI. MATERIALS AND PREPARATION NEEDED      PAGE 7
   VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE, EXTEND PAGE 8
   VIII. EVALUATION                          PAGE 10
   IX. ATTACHMENTS                           PAGE 11
      a. ATTACHMENT A: WATER ISSUE CARDS      PAGE 13
      b. ATTACHMENT B: LEARNING STATION INSTRUCTION CARDS PAGE 16
      c. ATTACHMENT C: GLOBAL AWARENESS FACT SHEET PAGE 17
      d. ATTACHMENT D: PAINTINGS AND PHOTOGRAPHS
   X. RESOURCES FOR TEACHERS AND STUDENTS     PAGE 19

I. ESSENTIAL QUESTION

   How do we know the worth of water?

II. STUDENT UNDERSTANDINGS

   Students will develop a basic appreciation for water. They will recognize that water plays a vital role in our everyday lives in necessary and non-necessary ways. Students will understand that water is essential for all living organisms and that the presence of water on our planet is possibly unique in the universe. Embracing this basic level of appreciation will allow subsequent explorations about water cycle, watersheds, the growth of cities, and how people adapted and innovated to meet the challenge of providing clean water as the population grew.
III. Student Objectives

Students will be able to express the value of water in their own lives.

Students will be able to express why water is a critical natural resource.

IV. Cross-Curricular Connections

| English Language Arts | • Read (and view), analyze, and connect text to personal experiences  
|                       | • Poetry  
|                       | • Descriptive language  
|                       | • Odes—reading and writing  
|                       | • Write reactions to material through notes, letters, poetry, informative text and/or graphic representations |

| Science | • Water as Natural Resource  
|         | • Water as Necessary to Life  
|         | • Power of Water—Cataclysmic events |

| Social Studies | • Global Water Usage  
|               | • Rituals |

| Math | • Calculations and statistics pertaining to percentage of water in living things |

| Art | • Visual literacy  
|     | • Historical context |

| Careers | • Artist, writer, poet, mathematician, scientist, lawyer, doctor, bus driver, car mechanic, physicist...everyone! |
V. Setting the Stage and Helpful Vocabulary

All living things need water to live and all living things contain a certain percentage of water. From the President of the United States 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 which our world would be transformed into a dry, thirsty environment around us. Consider living without rivers and lakes or the summer thunderstorms that refresh the air.

**Helpful Vocabulary:**

**Appreciate (verb)**
To be grateful or thankful for

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

**Essential (adjective)**
Absolutely necessary

**Finite (adjective)**
Having limits or bounds

**Global (adjective)**
Pertaining to the whole word

**Hydrate (verb)**
Cause to absorb water

**Local (adjective)**
Pertaining to a city, town or small district rather than an entire state or country.

**Organism (noun)**
Living thing

**Population (noun)**
The total number of persons inhabiting a country, city or any district or area

**Water Cycle (noun)**
The cycle of processes by which water circulates between the earth’s oceans, atmosphere, and land, involving precipitation as rain and snow, drainage in streams and rivers, and return to the atmosphere by evaporation and transpiration.
### VI. MATERIALS AND PREPARATION NEEDED

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Issue Cards (Attachment A)</td>
<td>Empty Bucket</td>
</tr>
<tr>
<td>Learning Station Instruction Cards (Attachment B)</td>
<td>½ full glass of water</td>
</tr>
<tr>
<td>Global Awareness Fact Sheet (Attachment C)</td>
<td>Water Audio Clips</td>
</tr>
<tr>
<td>Paintings and Photographs (Attachment D)</td>
<td>National Geographic Video: Hurricanes 101</td>
</tr>
<tr>
<td>Writing Utensils</td>
<td>National Geographic Video Tsunami 101</td>
</tr>
<tr>
<td>Large Lined Post-It Paper or Chart Paper</td>
<td>Laptop to play video and audio</td>
</tr>
<tr>
<td>Index Cards and Box</td>
<td>Note: All print URLs can be found under Section X-Teacher and Student Resources.</td>
</tr>
<tr>
<td>Watershed Journal</td>
<td></td>
</tr>
<tr>
<td>Writing Utensils</td>
<td></td>
</tr>
</tbody>
</table>
VII. The Learning Experience: Engage, Explore, Explain, Elaborate, and Extend

A. Engage Students with a Mystery. (20 minutes)

1) Teacher distributes mystery Water Issue cards. (The cards identify qualities and issues, and use the word “it” for “water”.) Save the “easy clues” for the end. Cards can be printed from Water is Life Curriculum or see Attachment A for mystery cards.

   Students read their own card and try to determine what “it” is.
   - Students take turns reading their cards out loud and others use the new clue to figure out what “it” is.

2) Show Water Matters Flash

B. Students Explore and Explain their Relationship with Water. (1-2 class periods)

(These activities can be structured as learning stations for small groups or as whole class activities. Teachers and/or students can choose which activities to pursue. Note that some stations will take longer than others. Model for students how to rotate to an available station when they are ready to move on. Before starting the Learning Stations, students should be introduced to their “Watershed Journal.”)

*Note: One class period = 45 to 60 minutes

Learning Stations: (see Attachment B for student direction cards)

Station 1: Students write down personal definitions of water on large lined post-its. Attach post-its to word wall. ESOL and multi-lingual students can be encouraged to write down “water” in different languages.

Station 2: On chart paper, list uses of water in daily life -- include all types (essential, ritualistic, fun).

Station 3: Read Global Awareness Fact Sheet. (Attachment C) Each student or small group selects one fact presented and in the Watershed Journal explains how it applies to themselves, as consumers of water.

Station 4: Develop captions for paintings and photographs featuring water. Take a guess at location and era of painting and/or photographs. See Attachment D for paintings and photographs.

Station 5: Place empty bucket and ½ glass of water at station. Ask students to write their reactions.

Station 6: Listen to audio clips of water (ocean, river, thunderstorms rain). Challenge students to describe the sound using adjectives. Attempt to pinpoint the sound and to connect the sound to a personal experience.
Station 7: Watch a video about the power of water: Suggestions include:
   a. National Geographic Video: Hurricanes 101
   b. National Geographic Video Tsunami 101
   Discuss national disasters as well as local flooding and climate change issues for Philadelphia.

Station 8: Students can research the percentage of water found in a particular group of living things. Find the average percentage of water within each group. Research the concept of dehydration and answer the question about how dehydration affects the human body.

Station 9: In the Watershed Journal, write descriptive water words that demonstrate how water is essential to life and culture.

Suggested Homework Assignment: Ask students to take note of the different ways that water is used or could be used on the route home. Write a paragraph describing findings.

C. ELABORATE WITH LANGUAGE DEVELOPMENT (1-2 class periods)

   ➢ Read poems from Flow by Beth Kephart. Identify examples of sensory language from the poems. Suggested Poems include: “Rising”, “John Bartram”, “Air”, “Love”.

   ➢ Continue to identify examples of sensory language in the following poems about water. (Poems are available on www.poemhunter.com)
      o “Water” by Ralph Waldo Emerson
      o “Waterfall” by Nette Onclaud
      o “A Divine Cascade” by Connie Marcum Wong
      o “Let the Rain Fall” by Kelly Deschler
      o “Ode to Mi Gatto” by Gary Soto (also available in Elements of Literature—6th Grade Edition)

D. ELL/ESOL AND ART EXTENSIONS

   ➢ ELL and ESOL students can make a video with each student naming the word for water in their native language and describing how they use water in their countries of origin.
   ➢ Take a walk to a nearby body of water. Bring drawing or painting supplies. Create a landscape painting and/or a drawing.
   ➢ Look out the window to the school yard. Add an imaginary water element to the scene. Create a pencil sketch. Add color.
VIII. Evaluation

Students will communicate their relationship to water.

An Ode to Water (Ode to Eau) or A Love Letter to Water: (2-3 class periods)

➢ For an Ode...Read “An Ode to Socks” by Pablo Neruda as an example of an ode. Elicit the idea that an ode is a celebratory poem and focus on its use of sensory language. (Poem can be found on www.poemhunter.com)
➢ Students write an “Ode to Water” in their Watershed Journal. Encourage students to transfer the tone of a celebratory poem to their own personal writing.

➢ For a Love Letter to Water, review the components of a letter and its format.
➢ Provide students with two-sided handout. Side one has a sample letter. Side two has the format for their letter (School address and Water Works address)

   o Homework Assignment: Write an Ode to Water or a Love Letter to Water.
   o Students conference with one another and read letters and odes in order to provide feedback.
     ▪ Students are given teacher generated questions that refer back to the essential question to guide the discussion.
     ▪ Teacher selects the partners by pairing a strong writer with a developing writer.
   o Teacher assists with editing and revising.
   o Students write their final copies on colored paper with option of illustration.
   o Display finished letters and finished odes inside and outside the classroom.
ATTACHMENT A: WATER ISSUE CARDS

1. IT IS THE BASIS OF ALL LIFE
2. YET WE FAIL TO RESPECT IT
3. WHILE WE WASTE IT HERE ON OUR OWN
4. WE SEARCH FOR IT ON DISTANT PLANETS
5. WE’VE SHARED IT WITH ANCIENT DINOSAURS
6. AND IT WILL BE HERE LONG AFTER WE’RE GONE
7. 1 IN 6 PEOPLE DON’T HAVE ENOUGH OF IT
8. OTHERS USE IT LIKE NO ONE ELSE NEEDS IT
9. FOR MANY IT COSTS NEXT TO NOTHING
10. STILL THEY SPEND BILLIONS TO BUY IT
11. SOME WALK HOURS JUST FOR A LITTLE
12. OTHERS SIMPLY REACH OUT FOR MORE THAN THEY NEED
Some people argue it's a basic human right for water.
Others claim it and sell it for profit.
It determines the way we live.
Without most people even noticing, it has the power to form community and the power to start a war.
It gives life.
It can take life too.
You might even say it is life itself.
### Personal Water Definitions

On the large lined post-its, write down as many dictionary definitions of the word, "water" as you can find, including parts of speech. If you know a word for water in a different language, write it down. Place your post-it on the word wall.

**Materials Needed:**
- Writing Utensils
- Large Lined Post-It Paper

### Landscape Paintings

- Look at the landscape paintings and/or the photographs.
- Guess where and when the paintings were completed or when and where the photographs were taken.
- Make up captions for the paintings and/or the photographs.
- Write the caption and your guesses on an index card.
- Leave your completed index card in the basket.

**Materials Needed:**
- Writing Utensils
- Landscape Paintings and/or Photographs
- Index Cards and Box

### Water Usage Chart

In your small group, brainstorm some uses of water in daily life. Include all types of water use...from essential to ritualistic to fun! Add your ideas to the chart paper. Try not to duplicate what has already been written.

**Materials Needed:**
- Writing Utensils
- Chart Paper

### Water – Descriptive Words

In your Watershed Journal, generate a list of descriptive words that demonstrate how water is essential to life and culture.

**Materials Needed:**
- Journal, writing utensils
### Global Awareness Fact Sheet

Read the Global Awareness Fact Sheet. Select one fact presented. In your *Watershed Journal*, explain how that fact applies to you as a consumer (user) of water.

**Materials Needed:**
- Reader Response Journals
- Writing Utensils
- Global Awareness Fact Sheet

### REACT!

Examine the empty bucket and the ½ full glass of water. On the chart paper, write down your reactions.

**Materials Needed:**
- Empty Bucket
- ½ full glass of water
- Chart Paper
- Writing Utensils

### Listen!!

Listen to the audio clips of water. Can you figure out what the water is doing?

Think about words that describe the sound. Can you pinpoint the sound? Connect those sounds to a personal experience.

Share your answers and your personal experiences with the sound with your group members.

**Materials Needed:**
- Water Audio Clips
- Laptop to play audio clips

### The Power of Water

Watch the video about the power of water. Have you ever experienced the power of water in your own neighborhood? Have you seen examples of the power of water on the news? Discuss those experiences with your group.

**Materials Needed:**
- National Geographic Video: Hurricanes 101
- National Geographic Video Tsunami 101
- Laptop to play video
**How Much Water Makes Up a Living Thing?**

What is dehydration?
Find out how dehydration affects the human body.
Choose a “group” of living things to research. Find the percentage of water in each thing and find the average percentage within the group. Record answers in *Watershed Journal.*

*Materials Needed:*
- Laptop
- Journal to record findings
- Writing Utensils
**GLOBAL AWARENESS FACT SHEET**

<table>
<thead>
<tr>
<th>All living creatures, including humans, need water to survive</th>
<th>Despite all the water in the world, only a small amount is available to humans and other creatures that depend on freshwater</th>
<th>Poor people often pay more for water than wealthy people living in the same city</th>
<th>Water can travel from one part of the world to another through the water cycle</th>
<th>Human activities affect water quality all over the world</th>
</tr>
</thead>
<tbody>
<tr>
<td>Many people living in other countries die because they drink the water they drink makes them sick</td>
<td>2.6 billion people in the world lack basic sanitation resources</td>
<td>A person needs 4 to 5 gallons of clean water per day to survive</td>
<td>More than 700 gallons of water are needed to grow the cotton for just one T-shirt!</td>
<td>People living in water-rich regions can affect how people use water in water-deprived areas</td>
</tr>
<tr>
<td>Conserving water helps to preserve the planet’s natural resources</td>
<td>Protecting freshwater resources is difficult because many rivers, lakes, and underground aquifers cross national boundaries</td>
<td>Salt water accounts for more than 97 percent of the water on Earth.</td>
<td>Millions of women and children spend several hours a day collecting water</td>
<td>In many parts of the world, fresh water is being used faster than it can be replaced</td>
</tr>
<tr>
<td>Less than 1% of the world’s fresh water is readily accessible for direct human use</td>
<td>The earth has a limited amount of water. The same water keeps going around and around the planet in a process called the water cycle</td>
<td>A person can live weeks without food, but only about three days without water</td>
<td>All people need access to safe drinking water and improved sanitation conditions</td>
<td>Many people in the world suffer from health problems caused by drinking dirty water</td>
</tr>
</tbody>
</table>

**Sources:** [http://www.amnh.org](http://www.amnh.org) [http://water.org](http://water.org) [http://news.nationalgeographic.com](http://news.nationalgeographic.com)
ATTACHMENT D: PHOTOS AND PAINTINGS

Max Schmitt in a Single Scull  
Thomas Eakins  1871

The Regatta at Argenteuil  
Claude Monet, 1892

The Seine  
Henry Ossawa Tanner, 1902
Fishing on the Schuylkill 21st Century
(From PWD's Flicker Site)

Shad Fishing at Gloucester on the Delaware River
Thomas Eakins 1881
X. RESOURCES FOR TEACHERS AND STUDENTS

For Teachers:

Resourcewater.org Toolbox!


Poemhunter.com Allows user to search for poems by poet, title, and quotations.

The Value of Water Website represents a coalition of public and private water agencies, business and community leaders, and national organizations united in communicating the importance of water to the economic, environmental, and social well-being of America.

For Students:


Rodriguez, Susan. Travels with Monet (Glenview, IL: Crystal Productions, 2010).

Additional Poetry Sources (All available on Poemhunter.com)

“An Ode to Socks” by Pablo Neruda
“Water” by Ralph Waldo Emerson
“Waterfall” by Nette Onclaud
“A Divine Cascade” by Connie Marcum Wong
“Let the Rain Fall” by Kelly Deschler
“Ode to Mi Gatto” by Gary Soto (also available in Elements of Literature—6th Grade Edition)

Global Awareness Fact Sheet
Print URL: http://static.water.org/docs/curriculums/WaterOrg%20ElemCurricFULL.pdf

Visual and Audio Sources:

Water Matters Flash
Print URL: http://watermatters.worldvision.org.nz/documents/WaterForLifeFlash.swf

Max Schmitt in a Single Scull Thomas Eakins 1871

The Regatta at Argenteuil Claude Monet, 1892

Tanner Seine Painting

Historic Photos and Paintings of Shad Fishing on the Delaware
Print URL: https://www.google.com/search?q=historic+shad+fishing+on+the+delaware&rls=com.microsoft:en-US:IEAddress&biw=1003&bih=213&tbs=isch&tbo=u&source=univ&sa=X&ei=2cxCVeTHFsiegwSjEoEg&ved=0CB0QsAQ

Eakins Shad Fishing Painting
Print URL: http://commons.wikimedia.org/wiki/File:Thomas_Eakins__Shad_Fishing_at_Gloucester_on_the_Delaware_River_2.jpg

PWD's Flicker Site
Print URL: https://www.flickr.com/photos/philadelphiawater/sets/
Water Audio Clips
Print URL: http://www.audiomicro.com/free-sound-effects/free-water-sound-effects

National Geographic Video: Hurricanes 101

National Geographic Video Tsunami 101
THEMATIC UNIT 1: WATER IN OUR WORLD

LEARNING EXPERIENCE 2A: THE NATURAL WATER CYCLE AND THE NATURAL WATERSHED EXPLORED AND EXPLAINED

Lesson Plan Overview
I. ESSENTIAL QUESTIONS
II. STUDENT UNDERSTANDINGS
III. STUDENT OBJECTIVES
IV. CROSS-CURRICULAR CONNECTIONS
V. SETTING THE STAGE AND HELPFUL VOCABULARY
VI. MATERIALS AND PREPARATION NEEDED
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, EXTEND *
VIII. EVALUATION
IX. ATTACHMENTS
   ATTACHMENT A MODIFIED KWL
   ATTACHMENT B WATERSHED OVERLAY MAP
X. BACKGROUND MATERIALS FOR TEACHERS AND STUDENTS

*Note: During Learning Experience 2A, students will explore and explain the natural water cycle and the natural watershed. They will explore the roles of the sun, gravity, and topography as influencing the interaction between the natural water cycle and the natural watershed. During Learning Experience 2B, students will elaborate on these concepts by exploring the effects of soil and vegetation on the interaction between the natural water cycle and the natural watershed.

I. ESSENTIAL QUESTIONS

What forces drive the water cycle?
How can you see the water cycle at work?
How do topography and gravity affect the watershed?

II. STUDENT UNDERSTANDINGS

The natural water cycle is a closed loop process involving stages and phase changes as water moves through the environment. A natural watershed is the area of land from ridge top to ridge top that collects water and drains to some place such as a river or a lake. The natural water cycle interacts with the natural watershed and that interaction will be affected by gravity and topography,
III. STUDENT OBJECTIVES

**Students will** construct and/or describe a model of the water cycle in **order to** define and explain the main stages of the water cycle with an emphasis on the roles of sun and gravity.

**Students will** construct and/or describe a watershed model **in order to** explain how topography and gravity affect the flow of water.

IV. CROSS-CURRICULAR CONNECTIONS

<table>
<thead>
<tr>
<th></th>
<th>English Language Arts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science</strong></td>
<td>- Water Cycle</td>
</tr>
<tr>
<td></td>
<td>- Gravity</td>
</tr>
<tr>
<td></td>
<td>- Watershed</td>
</tr>
<tr>
<td></td>
<td>- Develop models</td>
</tr>
<tr>
<td><strong>Social Studies</strong></td>
<td>- Read and create topographic maps</td>
</tr>
<tr>
<td></td>
<td>- Geographic and historical comparisons</td>
</tr>
<tr>
<td><strong>Math</strong></td>
<td>- Calculations related to map scale</td>
</tr>
<tr>
<td></td>
<td>- Calculations related to rainfall</td>
</tr>
<tr>
<td><strong>Careers</strong></td>
<td>- Hydrologist, Geologist, Cartographer</td>
</tr>
</tbody>
</table>
V. Setting the Stage and Helpful Vocabulary

Technically called the “hydrologic” cycle, the natural water cycle is the ultimate sustainable process. As human beings, we absolutely depend on having and using clean, safe fresh water. We can’t make new water on the planet. The water we do depend on exists in a closed system, an endless loop from land to sky and back again. Over the course of that endless loop, the natural water cycle interacts with the watershed. We can think of watersheds as big sinks. Because of the slope, the water flows down the sides to the drain. The watershed consists of the land that sheds or drains its water to a particular body of water.

Helpful Vocabulary:

Aquifer (noun)
A body of permeable rock that can contain or transmit groundwater.

Condensation (noun)
The conversion of a vapor or gas to a liquid

Contour Line (noun)
A line on a map joining points of equal height above or below sea level.

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

Gravity (noun)
The force that attracts a body toward the center of the earth, or toward any other physical body having mass.

Groundwater (noun)
Water held underground in the soil or in pores and crevices in rock.

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

Infiltration (noun)
To pass into or through (a substance) by filtering or permeating or penetrating its pores.

Percolation (noun)
The process of a liquid slowly passing through a porous substance.

Precipitation (noun)
Rain, snow, sleet, or hail that falls to the ground.

Recharge (verb)
The replenishment of an aquifer by the absorption of water.
**Surface Water** *(noun)*
Water that collects on the surface of the ground.

**Topography** *(noun)*
The art of 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 process by which water that is absorbed by plants is evaporated into the atmosphere from the plant surface, such as leaf pores.

**Tributary** *(noun)*
A river or stream flowing into a larger river or lake.

**Watershed** *(noun)*
The region or area of land that drains into the nearest river or stream or other body of water.
VI. MATERIALS AND PREPARATION NEEDED

Engage Activity (Outdoor Walk)
- On a sunny day—containers of water to pour on the ground
- On a rainy day, umbrellas and/or rain gear.

Explore and Explain:
Water Cycle:
- Clear Water Bottles (one per group)
- Food Coloring
- Water
- Sunny Window
- Writing and Art supplies – markers, crayons, paper, pencils
- Dictionaries
- Computer / internet access
- Informational Text (see resources for suggestions)

Watershed:
- KWL Sheet (Attachment A)
- Internet connected computer with projector
- Blue and Black Washable markers
- Chart paper
- Spray water bottle or Ice-cream Sprinkles
- Paper towels

Topography
- Beakers
- 50mL graduated cylinders
- Soft modeling clay
- Topographic maps (Philadelphia, Pennsylvania)
- Watershed Maps (available from PWD)
- Watershed Overlays (Attachment B)
VII. The Learning Experience: Engage, Explore, Explain, and Extend

A. Engage Students with a Rainy Day Walk. (30 minutes)

Take students for a walk outside just after a rainstorm. Encourage observations about what is happening to the water. Look for examples of precipitation (rain) and condensation (clouds). Observe what is happening to the water on the ground...is it evaporating, infiltrating into the ground, or is the water running off to the nearest sewer? Can you see plants that are absorbing water and transpiring water vapor? Is water percolating through the soil? Students may or may not know the vocabulary...allow them to describe what they are observing and provide appropriate vocabulary as descriptions arise. If it has not rained recently, take some water with you to pour on various surfaces. Examine what happens to the water and have the same discussion.

B. Explore and Explain: The Water Cycle

1. Explore the Water Cycle with a Simple Model (45 minutes total, but spread over the course of a day)

   ➢ Begin with an opening Graphic Organizer to review the main stages (evaporation, condensation, precipitation) of the water cycle. Use a modified KWL (Attachment A).

   ➢ Preparation of the Water Cycle Model:

     ➢ For each group of students, fill one two liter bottle with 5 inches of water and add a drop or two of food coloring. Cover the bottles.

     ➢ Place the bottles in direct sunlight by a windowsill or outside.

     ➢ Make initial observations in the student’s Watershed Journal.

     ➢ Several hours later, revisit the bottles and record additional observations. The students should notice condensation on the sides and top of the bottle. “Rain” should be running down the sides and the students should notice that the condensation and the rain are not colored.

     ➢ Discuss findings with the students. Highlight:

       1. Evaporation is caused by the sun heating the water,
       2. Only the water evaporates (not pollutants aka food coloring)
       3. Condensation occurs when the warm air comes in contact with the cooler sides of the bottle.

     ➢ Discuss factors that would affect the water cycle in the real world.
2. **EXPLAIN THE WATER CYCLE THROUGH VIEWING AND READING** *(1-3 class periods)*

- Show a Water Cycle video as an introduction. Suggestions include:
  - *The Natural Water Cycle - Magic School Bus*
  - *Co-Co Rah Water Cycle*

- Present students with text information that explains each stage of the water cycle. Suggestions include:
  - *USGS Water Cycle for Kids Intermediate Level Diagram*
  - *IPTV Interactive Reading Material for Water Cycle*
  - *USGS Summary of Water Cycle*
  - *Kid Zone Water Cycle*
  - To help sort out the differences between infiltration and percolation, use *Infiltration vs. Percolation (Pages 4-5)*

- As students read their text, they can use their modified KWL to confirm thoughts and/or dismiss misconceptions. When students come back together as a group, they can discuss what they learned and what they are still wondering about. Appropriate columns of the KWL can be filled out.

- After each stage is explained, students can use index cards to write a description of the stage on one side and to illustrate the stage on the other side. The cards can then be organized on a desk to demonstrate the hydrological cycle. These cards can also be used for Memory and Matching Games.

- Suggested Homework Assignments:
  a. Choose a stage in the water cycle and explain how it is connected to daily life.
  b. What is the driving force behind the water cycle? Explain.
B. **EXPLORE AND EXPLAIN: THE WATERSHED**

1. **EXPLORE THE WATERSHED WITH A SIMPLE MODEL (20 -30 minutes)**

   a. Have students write down their definitions of the term “watershed”. Have students share their definitions with the entire class and write the definitions on the board or on chart paper. Remind students that many people (including adults) do not know the definition and that any answer is a good one for now.

   b. Tell students that before they are told what a watershed is, they will create a model of one and draw conclusions about what a watershed is.

   - Give each group of students a large piece of butcher paper or chart paper. Instruct students to crumple the paper. The paper is then laid on the table without flattening it. If using water, place paper towels or absorbent material on desk top. Students should point out where mountains, hills, valleys, lakes and rivers may be. Students should use a black or brown washable marker to draw a line connecting the highest points on the model. This line will represent the boundary of the watershed. Students can highlight where water will run with a washable blue marker. These areas should be in the lower areas (the valleys) between the ridges and the mountains.

   - Have students discuss how they determined where to highlight bodies of water. Have students hypothesize where they think the water will collect and make sure that those larger rivers and lakes are also highlighted in blue.

   - To model precipitation, use a spray bottle to gently mist the entire paper with water OR pour ice-cream sprinkles over the paper. Instruct students to make observations about how and where the precipitation moves. (EMPHASIZE THAT WATER MOVES FROM THE HIGHER ELEVATIONS TO THE LOWER ELEVATIONS BECAUSE OF GRAVITY.)

   - Remind students that they have just created a model of a watershed. Solicit students to define watershed in their own words using the investigation as a reference. Discuss what features make a watershed. Allow time for students to discuss how these landforms interact to make a watershed. Take time to “stop and jot” ideas down. Have students write similes in their *Watershed Journal*—“A watershed is like a…”

2. **EXPLAIN AND DEFINE WATERSHED (30 minutes)**

   a. Show video, *Chesapeake Unscripted: What is a Watershed?* Discuss video with students.

   b. Have students write the correct definition of watershed in their *Watershed Journal* while watching, *YouTube: What is a Watershed?*
3. **EXPLORE THE WATERSHED THROUGH TOPOGRAPHY (20 minutes)**

- Put a wide flat-bottom plastic container at students’ tables and have students build a mountain of clay that will fit inside the container.
- Have the students trace the bottom of the mountain on paper and then put the mountain in the container.
- Add 30 mL of colored water or milk to the container. Instruct students to draw the mountain from a top view and to the drawing, add a new line representing the base as the part of the mountain at the liquid line.
- Continue to add liquid at 30 mL intervals. Each time, add a line to the map representing the base relative to the new position of the edge of the liquid.
- These lines will create a topographic map.
- Mix up mountains and illustrations and have students try to figure out which illustration belongs with which mountain. *How are the lines different on a gently sloped mountain (big and far apart) from a taller steeper mountain (small circles, close together)?*

4. **EXPLAIN HOW TOPOGRAPHY AFFECTS A WATERSHED (1 class period)**

   a. Teacher can show students a topographic map of the area and can reveal that the students have just created their own topographic map. Each line represents a certain elevation, or height. It’s as if the mountains were all cut into slices at each level or line. These lines are called contour lines. As was seen in the exploration, the topography of a landform gives clues about how water will move around it. Show video link: [YouTube: What is Topography?](https://www.youtube.com/watch?v=ExampleVideo)

   b. Establish a Watershed Address. We all live in a watershed and topography determines our watershed. Use PWD Watershed maps to locate and identify the school’s watershed. Where does the water go from here? Follow the creek or river to the next body of water. (Note: In many cases, you will be following a historic creek that has since been replaced with sewer pipes that carry the water to the next body of water.) Our watershed is a sub-watershed of the larger watershed and our river or creek (or sewer pipe) is a tributary of the larger river downstream. Keep following the water until the ocean is reached. This body of water marks the last portion of the watershed address. For example, if we live in the Wissahickon Watershed...our watershed address could be written as Wissahickon, Schuylkill, Delaware, Delaware Bay, Atlantic Ocean. Use the watershed map overlay with the blank Philadelphia Region Map to show where the regional watersheds are located. *(Attachment B).*
c. Students can also use an internet watershed locator to discover the watershed of their school. The Philadelphia Water Department Watershed Locator gives detailed information about the specific regional watershed. Discuss the waterways in your area. Find out where your local creek or river begins and find out where the water goes as it flows downstream past (or under) your school. Do you cross any streams on your way to school? What roads are taken every day that run along a river or creek? Where are places where creeks and rivers come together? Think about places where rivers or streams come together. In the Watershed Journal, write a paragraph about how a river or stream changes when it comes together with another river or stream.

d. Look at a topographic map of Philadelphia Topoquest: Topo Map of Philadelphia. Write reactions to map and share reactions. Be sure to elicit how water is represented on the topographic map and what one can tell about watersheds from the topographic map.

e. Have students compare and contrast the maps they used to name their watershed to the topographical map. Students can trace the rivers of Pennsylvania. Offer fun facts such as Pennsylvania has more miles of streams and rivers than any other state other than Alaska.

f. Overlay a watershed map on top of the topographical maps to highlight and re-illustrate the defining structure of a watershed. Have students name specific landforms that make-up their watershed.

*Note: Remember that in this Learning Experience, students explore and explain the natural water cycle and the natural watershed. They will explore the roles of the sun, gravity, and topography as influencing the interaction between the natural water cycle and the natural watershed. During Learning Experience 2B, students will elaborate on these concepts by exploring the effects of soil and vegetation on the interaction between the natural water cycle and the natural watershed.*
E. EXTENSIONS

**Math Extension:** Students can use Philadelphia’s monthly precipitation averages in order to find the mean absolute deviation and to describe the data distribution and what it represents.

To develop background knowledge, prepare a lesson to teach students how to find the mean absolute deviation. Use of Common Core Curriculum, Interactive Whiteboard Lesson, Promethean Planet, and Ready Curriculum can help establish this skill. Once students have mastered the ability to find the mean absolute deviation from a set of data, assign the following Constructed Response:

Use the monthly precipitation totals for Philadelphia to find the Mean Absolute Deviation for the set of data. Students should round data to the nearest hundredth.

(The data below comes from 2014 and could be used to compare to the current year. Historical and current data can be found at [Climate Data for Philadelphia](https://www.climate-data.org).)

<table>
<thead>
<tr>
<th>Monthly Precipitation (inches)</th>
<th>Aug. 3.5</th>
<th>Sept. 3.78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 3.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb. 2.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar. 3.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr. 3.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 3.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 3.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 4.33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Students should explain the steps used to find the mean absolute deviation and describe what the mean absolute deviation represents.

Add other cities in the US and other countries to contrast data from areas that are in a drought or experience heavy rainy seasons (or even variations within a state such as east and west Texas).
Social Studies: Topographic Comparison between Pennsylvania and another state.

- Students examine the Topographical Map of Pennsylvania.

- Students discuss the positives and negatives of living close to the Schuylkill and/or Delaware Rivers.

- Students pick a state to research. The students find a topographical map of that state and a map of the watersheds in the state.

- Students compare and contrast the topographical map and watershed map of Pennsylvania to that of their state.

- Where might a major city in the chosen state be? Why? Why is Philadelphia where it is?

- Students discuss findings and discuss where they would choose to live in their chosen state and why.

- Show map of the major watersheds in the United States USGS: Map of Major Watersheds in US—Look at the Continental Divide and consider what divides the Atlantic from the Pacific.
VIII. **Evaluation of the Learning Experience**

**Formative Assessments Along the Way:** (Answers can be spoken or written)

- What is a watershed?
- Why are watersheds important?
- How does elevation affect drainage?
- How does land and water interact to create a watershed?
- Research to find 3 interesting facts about the watersheds in Philadelphia.
- Research to find 3 interesting facts about the watersheds outside of Philadelphia but in Pennsylvania.
- What is a topographic map?

**Summative Assessments:**

- Students can write a “love letter” from a body of water to a landform within the watershed or vice versa.

- Students can begin to develop a model that will depict the interaction of the natural water cycle with the watershed. This project will be completed during Learning Experience 2B and will, at that time, include a more focused analysis on the impact of vegetation and soil upon the interaction between the natural water cycle and the watershed. At this point, the students will be able to develop a model that depicts sun and gravity as the driving forces of the water cycle. The model should also demonstrate the impact of topography and gravity on the interaction between the natural water cycle and the watershed. Students can create a a 3-d model, a song, a rap, a poster, a computer presentation, a written summary, a diorama, a comic strip, etc. The project should include water cycle and watershed vocabulary words such as precipitation, infiltration, percolation, evaporation, transpiration, condensation, tributary, ground water, surface water, elevation, gravity and appropriate landforms.

- After the format of the **You Tube: What is a Watershed?** students can make their own video in their school/neighborhood, providing a proper definition of a watershed at the end.
Since so often our prior knowledge contains misconceptions, we read to either confirm what we think we know or clear up information that is incorrect. We add on important new information. Finally, we jot down questions or wonderings we have that may set ourselves up for further investigation.

NAME: ____________________________ TITLE: ____________________________ AUTHOR: __________________________________________

**READING AND ANALYZING NON-FICTION STRATEGY (RAN STRATEGY)**

<table>
<thead>
<tr>
<th>WHAT I THINK I KNOW</th>
<th>CONFIRMED</th>
<th>MISCONCEPTIONS</th>
<th>NEW LEARNING</th>
<th>WONDERINGS</th>
</tr>
</thead>
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</tbody>
</table>

Understanding the Urban Watershed Curriculum

Unit One
Learning Experience 2A
ATTACHMENT B: WATERSHED OVERLAY MAPS

Make copies of this map on transparency paper. Cut out the watershed shapes for use on blank county map.
Print this blank county map...Encourage students to fill in information such as school, major roads, neighborhoods etc. Place watershed overlays over the map.
X. **RESOURCES FOR TEACHERS AND STUDENTS**

resourcewater.org - Toolbox!

**Video:**

The Natural Water Cycle- Magic School Bus  
*Print URL: http://www.youtube.com/watch?v=AQKdkponoZM*

You Tube: Is a Watershed a Shed that Holds Water?  
Lighthearted animation of watershed  
*Print URL: https://www.youtube.com/watch?v=QOrVotzBNto*

Co-Co Rah Water Cycle  
Animated Water Cycle Video  
*Print URL: https://www.youtube.com/watch?v=ZzY5-NZSzVw*

You Tube: What is a Watershed?  
One minute animation describing watershed.  
*Print URL: http://www.youtube.com/watch?v=f63pwrMXkV4*

You Tube: What is Topography?  
Science expert Emerald Robinson explains what topography is and how we use it to study the Earth.  
*Print URL: https://www.youtube.com/watch?v=K-UXrpAjyl0*

Chesapeake Unscripted: What is a Watershed?  
What is a watershed? Know it or not, it's very important to understand where your local streams and rivers flow and how our actions affect their health. Hear people’s responses in Alexandria, Virginia (yes, Alexandria is in the Chesapeake Bay watershed!) in this video by the Chesapeake Bay Program.  
*Print URL: http://vimeo.com/9887737*

**Watershed Locator:**

Philadelphia Water Department Watershed Locator  
Provides specific watershed by address within Philadelphia City Limits  
*Print URL: http://www.phillywatersheds.org/your_watershed*

**Text:**

EPA: What is a Watershed?  
*Print URL: http://water.epa.gov/type/watersheds/whatis.cfm*

USGS Water Cycle for Kids Intermediate Level Diagram  
Cartoon poster showing how Earth's water is not only always changing forms, between liquid (rain), solid (ice), and gas (vapor), but also moving on, above, and in the Earth. This process is always happening everywhere  
*Print URL: http://water.usgs.gov/edu/watercycle-kids-int.html*

IPTV Interactive Reading Material for Water Cycle  
Definitions and animations for different stages of the water cycle.  
*Print URL: http://www.iptv.org/exploremore/water/in_depth/interactive_version2.swf*
USGS Summary of Water Cycle  Text summary of water cycle. Provides links to different stages of water cycle.
Print URL: http://water.usgs.gov/edu/watercyclesummarytext.html

Kid Zone Water Cycle  Entertaining text summary—covers evaporation, transpiration, condensation, precipitation, collection
Print URL: http://www.kidzone.ws/water/

Infiltration vs. Percolation  Text provides differentiation between infiltration and percolation
Print URL: http://agridr.in/tnauEAgri/eagri50/SSAC121/lec12.pdf

Topoquest: Topo Map of Philadelphia

Topographical Map of Pennsylvania
Print URL: http://geology.com/topographic-physical-map/pennsylvania.shtml

USGS: Map of Major Watersheds in US
Print URL: http://water.usgs.gov/wsc/map_index.html

Climate Data for Philadelphia
Print URL: http://www.usclimatedata.com/climate/philadelphia/pennsylvania/united-states/uspa1276
THEMATIC UNIT 1: WATER IN OUR WORLD
LEARNING EXPERIENCE 2B: HOW SOILS AND VEGETATION IMPACT
INFILTRATION AND RUNOFF

Lesson Plan Overview

I. ESSENTIAL QUESTIONS PAGE 39
II. STUDENT UNDERSTANDINGS PAGE 39
III. STUDENT OBJECTIVES PAGE 40
IV. CROSS-CURRICULAR CONNECTIONS PAGE 40
V. SETTING THE STAGE AND HELPFUL VOCABULARY PAGE 41
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VII. THE LEARNING EXPERIENCE: ENGAGE, ELABORATE, EXTEND* PAGE 43
VIII. EVALUATION PAGE 46
IX. ATTACHMENTS
   ATTACHMENT A STREAM TABLE OBSERVATION SHEET PAGE 47
X. RESOURCES FOR TEACHERS AND STUDENTS PAGE 48

*Note: Learning Experience 2-B elaborates on Learning Experience 2-A by encouraging students to focus on the impact that soil geology and vegetation has on the interaction between the natural water cycle and the watershed. Through this elaboration, students will begin to develop an appreciation for how human development impacts the interaction between the water cycle and the watershed.

I. ESSENTIAL QUESTIONS

How does the natural water cycle interact with the watershed?
How do vegetated transitions (wetlands and riparian buffers) affect the soil geology between land and water?
How do vegetated transitions (wetlands and riparian buffers) help to protect our waterways from storm water?
How does human land development affect the interaction between the water cycle and the watershed?

II. STUDENT UNDERSTANDINGS

The natural water cycle interacts with the watershed and that interaction is affected by gravity, topography, soil geology, vegetation, weather, and human development. The riparian buffers and wetlands play a vital role in that interaction. Riparian buffers and wetlands control erosion, absorb run-off and mitigate pollutants. These natural transitions between land and water capture, store, and release water and help to protect our waterways.
III. STUDENT OBJECTIVE

Students will construct a watershed model in order to explain how riparian buffers and wetlands (or the lack thereof) impact the interactions between natural water cycle and the watershed.

IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts | • Read (and view), analyze and connect scientific text to personal experiences.  
|                       | • Write reactions to material through note-taking, reflecting and informative text  
|                       | • Research riparian buffers and wetlands  
|                       | • Present information  
| Science               | • Water Cycle  
|                       | • Gravity  
|                       | • Watershed  
|                       | • Riparian Buffer  
|                       | • Wetlands  
|                       | • Develop models  
| Social Studies        | • Effects of land development by humans  
| Math                  | • Calculations related to saturating soil and run-off  
| Careers               | • Hydrologist, Geologist, Urban planner, Landscape Architect  

Understanding the Urban Watershed

Unit One

Learning Experience 2B
V. SETTING THE STAGE AND HELPFUL VOCABULARY

The watershed consists of the land that sheds or drains its water to a particular body of water. It is important that not all the water “go down the drain at once.” Soils in the riparian buffers and in the wetlands allow water to infiltrate the ground where it can be captured, stored, and released over time. Nature has developed its own method for filtering pollutants from water by utilizing these soils. Plants and trees in the riparian buffer play a sophisticated and vital role in the water cycle related to infiltration and transpiration. The interactions between plants and soils in the wetlands can help clean storm water runoff, replenish ground water, and prevent flooding. Much of our natural wetlands have been lost to urban development; however, wetlands are tools in the green infrastructure toolbox being used to manage pollution from run-off and help during heavy rain events to prevent flooding. Along the banks of our waterways, plants act as buffers by catching sediment, by preventing erosion, and by using up nitrogen and phosphorous before they reach our waterways. Understanding the fundamental relationship between water, the water cycle, land, and drainage will lead to understandings of the challenges facing the urban watershed.

Additional Helpful Vocabulary: (Note: Please also refer to the vocabulary from Learning Experience 2-A.)

Impervious/Impermeable (adjectives)
Not allowing water to pass through

Permeable/Pervious (adjectives)
Capable of being permeated especially having pores or openings that permit liquids or gases to pass through. Opposite: Impermeable or impervious

Riparian Buffer (noun)
A vegetated area (a "buffer strip") near a stream, usually forested, which helps shade and partially protect a stream from the impact of adjacent land uses. It plays a key role in increasing water quality in associated streams, rivers, and lakes, thus providing environmental benefits.

Stormwater Runoff (noun)
Water from rain or melting snow that “runs off” across the land instead of seeping into the ground.

Wetland (noun)
An area that is saturated by surface or ground water and under normal conditions supports a prevalence of vegetation typically adapted for life in saturated soil conditions.
VI. MATERIALS AND PREPARATION NEEDED

Engage Activity

Infiltration Model:
- 1.5 or 2 liter soda bottles
- Soil, gravel, sand, clay
- Screens (4 square inches) one per bottle
- Rubber bands (one per bottle)
- Plant

Elaboration Activity:

Riparian Buffer Model:

Observation Sheet (Attachment A)
Choose one of the following demonstration models—the set up you choose may be determined by whether you have access to the Foss Landforms kit or the STC Land and Water kit. If you have access to either kit, use the stream table set up and you may choose to follow up with the paint tray demonstration. If you do not have access to either kit, use the paint tray model if making a stream table is not possible.

<table>
<thead>
<tr>
<th>Stream Table Model</th>
<th>Paint Tray Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream Table (Per group)</td>
<td>3 Paint Trays (per demonstration)</td>
</tr>
<tr>
<td>Soil</td>
<td>Absorbent Sponge</td>
</tr>
<tr>
<td>Oak-tag</td>
<td>Scrubber Sponge</td>
</tr>
<tr>
<td>Paper cups (holes in the bottom for sprinkling)</td>
<td>Paper Cups (holes in the bottom for sprinkling)</td>
</tr>
<tr>
<td>Yarn</td>
<td>Model Trees</td>
</tr>
<tr>
<td>Cotton</td>
<td>Grid</td>
</tr>
<tr>
<td>Paper towels</td>
<td>Paper towels</td>
</tr>
</tbody>
</table>
VII. THE LEARNING EXPERIENCE: ENGAGE, ELABORATE AND EXTEND—HOW DO SOILS IN THE RIPARIAN BUFFER AND WETLANDS IMPACT INFILTRATION AND RUNOFF?

A. ENGAGE STUDENTS WITH AN INFILTRATION MODEL: (1 class period)

This model will demonstrate how water infiltrates a natural surface (soil) and it will demonstrate how water percolates through the soil and is filtered in the process.

- To set up the soil filter, cut the bottom off a 2 liter soda bottle. The bottom becomes the water collector.

- Attach the screen to the mouth of the bottle with a rubber band or fill the mouth with gravel.

- Invert the bottle and fill with top-soil, loamy soil, sand, clay, gravel and/or a combination. (Students can experiment with mixtures.)

- Pour dirty water on soil and observe the water infiltrate and percolate through the soil.

- Saturate the soil so that some water starts to drip into the collection cup.

- Make observations about the water that has been filtered through the soil.

- Experiment with different soils and mixes. Are there differences between how different mediums work as filters? As the students experiment with different types of soil (clay, top soil, loam, compost, sand/gravel), note which soils hold more water. One could calculate how much water different types of soils hold. Once the soil becomes saturated, note what happens when more water is added...Does excess water run through the system quickly or does the excess water sit on top of the system? What types of soil can store more water? Which type of soil would you likely find in a wetland? What type of soil might you find on a forested hillside? What happens if you add a plant to the system? Record observations and reflections in the Watershed Journal.
**B) ELABORATE WITH A RIPARIAN BUFFER MODEL** *(30 minutes w/Procedure B, a longer time period is required for Procedure A)*

For Procedure A, students will use stream tables to investigate how soils and vegetation affect how the water cycle interacts with the watershed. Stream tables can be found in the Foss Landform kit and they can be found in the STC Land and Water Kit. Stream tables can also be made from aluminum foil roasting pans or from clear plastic sweater boxes. A drainage hole can be drilled or cut in the corner and covered with duct tape. Stream tables can be filled with soil, sand, gravel and/or diatomaceous earth. The stream table model can be followed with a quick demonstration using Procedure B’s paint tray model. Procedure B’s paint tray model does not require soil. In Procedure B, different types of sponges are used to model soils found under different types of vegetation. If stream tables are not available, use Procedure B’s paint tray model and allow the students to explore the model themselves.

- Explore the Stream Table Model the Paint Tray Riparian Buffer Demo Model to show students the effects of the riparian buffer on infiltration and run-off. (The paint tray riparian buffer model can be borrowed from FWW.)

<table>
<thead>
<tr>
<th>Procedure A: (Stream Table Model)</th>
<th>Procedure B: (Paint Tray Model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create a model of a stream bank using a stream table and soil. (Make a plateau of soil that slopes down to the river)</td>
<td>Create a model of a stream bank using paint trays.</td>
</tr>
<tr>
<td><strong>Group A:</strong> Cover soil with oak tag to represent pavement (an impervious surface).</td>
<td><strong>Group A:</strong> Pavement: Do nothing to the paint tray (or cover it with plexiglass or black oaktag)</td>
</tr>
<tr>
<td><strong>Group B:</strong> Cover soil with yarn (mowed lawn).</td>
<td><strong>Group B:</strong> Mowed Lawn: Cover the paint tray with a large scrubber sponge</td>
</tr>
<tr>
<td><strong>Group C:</strong> Cover soil with cotton balls (forest).</td>
<td><strong>Group C:</strong> Forest: Put sponges on top of paint tray. Put grid on top of sponges. “Plant” trees in the grid.</td>
</tr>
</tbody>
</table>
➢ Place sequins and/or food coloring on the models to represent trash, waste, and pollution.

➢ Pour water on models to represent precipitation.

➢ Elicit what happens when rain lands on different types of surfaces. Does the water infiltrate the surface? When water does not infiltrate the surface, does it pool or flood low areas?

➢ Which surfaces are permeable or pervious? Which surfaces are impermeable or impervious? Record observations of what happens to the water on the three different surfaces. (See Attachment A for Observation Sheet)

➢ As students note the differences between a paved surface and a forested surface, use the term, “Riparian Buffer”. A riparian buffer is a zone of vegetation located along the bank of a waterway that serves to protect the water from harmful runoff. The roots of plants and trees in the riparian buffer stabilize the soil and control erosion. Without these plants, the soil will wash away leaving a less pervious surface! The plants slow water flow, reducing the threat of downstream flooding after heavy precipitation. By slowing water flow, riparian buffers allow more water to infiltrate the soil. As a result, more water enters the underground water system where it is filtered as it slowly passes through the soil.

C. EXTENSIONS

Engineering: Engineer a Drainage System: Use the stream table with the impervious surface (oak-tag). Note the flooding that occurs in low points on the paved surface. Flooded roads and flooded basements are a problem for an urban community. Students will design and build a drainage system to carry away excess water. Materials for drainage could include black oak tag and straws of different sizes.

Ecology: Plant a Riparian Buffer: Plant stream table with plants and experiment with rain on the riparian buffer. As students observe that plants lessen the erosion, the teacher can also un-pot a root bound plant to demonstrate that roots hold the soil in place.
VIII. EVALUATION OF THE LEARNING EXPERIENCE

(Estimated Time: 1-4 class periods)

Students will complete a model that depicts the hydrological cycle and how it interacts with the watershed. If the students started this project in Learning Experience 2-A, the project should be updated to depict an understanding of how soil geology and vegetation affect the interaction between the water cycle and the watershed. If the students are just beginning work on the project, they can choose to create a 3-d model, a song, a rap, a poster, a computer presentation, a written summary, a diorama, a comic strip, etc. The project should include the forces that drive the water cycle (sun and gravity). It should include water cycle and watershed vocabulary words such as precipitation, infiltration, percolation, stormwater runoff, evaporation, transpiration, condensation, ground water, surface water, riparian buffer, wetland, permeable/pervious, impermeable/impervious, and vegetation. The project should also include topographic elements of the watershed.
A riparian buffer is a zone of vegetation located along the bank of a waterway that serves to protect the water from harmful runoff. The roots of plants and trees in the riparian buffer stabilize the soil and control erosion. **Without these plants, the soil will wash away leaving a less pervious surface!** The plants slow water flow, reducing the threat of downstream flooding after heavy precipitation. By slowing water flow, riparian buffers allow more water to infiltrate the soil. As a result, more water enters the underground water system where it is filtered as it slowly passes through the soil.

3) Which area had a Riparian Buffer?

4) Why are Riparian Buffers important to the waterway?

5) Think about a river or a creek that you have seen—did it have a riparian buffer?
X. RESOURCES FOR TEACHERS AND STUDENTS

resourcewater.org - Toolbox!

Pennsylvania Wetlands  This article provides information about wetlands in Pennsylvania and it points out that most natural wetlands in Pennsylvania are forested. Thinking of wetlands as wet wooded areas can help to remind us that a forested wetland is also a riparian buffer. Print URL: http://www.paoutdoorrecplan.com/cs/groups/public/documents/document/d_002734.pdf

PWD: Waterway Restoration Article describes riparian buffers and wetlands and what PWD is doing to restore them. Print URL: http://www.phillywatersheds.org/what_were_doing/waterways_restoration/tool
I. ESSENTIAL QUESTIONS

• How do we know the health of our local river/creek? Why do we care?
• Why is diversity a positive ecological indicator?
• What are the benefits of macro-invertebrates studies?
• What evidence demonstrates ecological interdependence between organisms in the stream and organisms in the riparian buffer and/or wetlands?
II. Student Understandings

The abundance and diversity of species, including native, non-native and invasive species, can inform us about the health of our waterways. Microscopic life and macro-invertebrates play vital roles in the health of the river and are critical links in the food web. Macro-invertebrate populations, along with fish populations and microorganism populations can serve as bio-indicators that can indicate the health of the waterway.

The stream community, the riparian buffer and the wetlands are ecologically interdependent. In addition to controlling erosion, absorbing run-off and mitigating pollutants, riparian buffers and wetlands provide habitat and food for the stream and stream bank inhabitants. Changes to the riparian buffer and/or to the wetlands will have consequences for the stream community and vice-versa.

III. Student Objectives

Students will use real data in order to characterize diversity and abundance of fish species

Students will engage in a real or virtual macro-invertebrate study in order to determine the health of a waterway

Students will express the vital role that microscopic life plays in the food web of a waterway.

Students will begin to delineate between native, non-native, and invasive species and will discuss the role and impact of native, non-native, and invasive species on the health of the aquatic eco-system.

Students will express how organisms in the stream community interact with and are ecologically interdependent with the organisms in the riparian buffer and in the wetlands.
### IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts | • Read (and view), analyze and connect scientific text to personal experiences.  
| • Write reactions to material through note-taking, reflecting and informative text.  
| • Research organisms  
| • Present information |

| Science | • Ecology—producers, consumers, decomposers, abiotic factors.  
| • Macro-Invertebrate Study  
| • Diatoms  
| • Microscope Skills  
| • Riparian Buffer/Wetlands  
| • Diversity |

| Social Studies | • Diversity  
| • Human alteration and impact upon riparian buffers and wetlands |

| Math | • Graph and analyze data associated with fish counts and macro-invertebrates |

| Art | • Diatoms |

| Careers | • Researcher  
| • Aquatic Biologist  
| • Landscape Architects and Engineers  
| • Urban Planners |

### V. SETTING THE STAGE AND HELPFUL VOCABULARY

Fish, migratory birds, reptiles and amphibians, macro-invertebrates, riparian and aquatic plants are important indicators of the health of our waterways. There is an integral connection between the health of the river and the abundance and diversity of living things in it. Diversity and abundance are the “watchwords” of our scientists who monitor fish, macro-invertebrates and wildlife to measure the health of our waterways. That diversity and abundance 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. In addition, changes to the ecology of the riparian buffer and/or to the wetland community can also have a profound impact to the stream community as these communities are ecologically interdependent on each other. Professional and citizen scientists can help to monitor the health of our streams through physical and chemical tests of our waterways, micro-organism studies, macro-invertebrate studies and fish census projects. Macro-invertebrates can be classified according to their tolerance for pollution as can certain populations of fish and micro-organisms. As macro-invertebrates are an important food source for many types of fish, the ability of fish to thrive in certain areas will correlate to the health of the macro-invertebrate population.
Helpful Vocabulary:

Abiotic (adjective)
Physical, not biological; Not derived from living organisms

Adaptation: (noun)
A physical or behavioral change or process of change by which an organism or species becomes better suited to its environment

Biodiversity (noun)
The variety of life in the world or in a particular habitat or ecosystem

Biotic: (adjective)
Of, relating to, or resulting from living things, especially in their ecological relations

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

Consumer (noun)
Animal

Decomposer (noun)
Organism that helps to break dead things down into soil.

Detritus (noun)
Decaying bits of leaves that are covered with fungi and bacteria

Diatom (noun)
A single-celled alga that has a cell wall of silica

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

Filterer/Collector (noun)
Organism that filters water and catches or traps organic microscopic matter (fresh water clam, black fly larva, some caddisfly larvae)

Fish Census (noun)
Fish Count

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

Macro-Invertebrate (noun)
Organism that can be seen with the naked eye, but has no backbone.
**Native (adjective)**
Describes an animal or plant of indigenous origin or growth

**Plankton (noun)**
The small and microscopic plant and animal organisms that float or drift in sea or fresh water.

**Pollution Intolerant (adjective)**
Not capable of living in polluted waters

**Pollution Tolerant (adjective)**
Capable of living in polluted waters

**Predator (noun)**
An animal that preys on others

**Producer (noun)**
Green plant

**Scraper/Grazer (noun)**
Organisms that scrape and graze upon algae from surfaces in the water. Examples: Water Penny, Mayfly nymph

**Shredder (noun)**
Organism that shreds and eats decaying leaf matter. Examples: Stonefly nymph, scuds

**Species (noun)**
A group of living organism consisting of similar individuals capable of exchanging genes or interbreeding.

**Waterway (noun)**
Body of water such as river, stream, creek
VI. MATERIALS AND PREPARATION NEEDED

**Engage Activity (Community Web)**
- Ball of twine or yarn
- Wearable Job Cards *(Attachment A)*

**Explore and Explain: (Research Stream Community Organisms)**
- Computer/ internet access
- Organism Cards *(Attachment B)*
- Research Guide *(Attachment C)*

**Elaborate: (The Creek as Classroom)**

**Microscopic Life Study:**
Field Trip visit to the Fairmount Water Works for *Seeing is Believing* Lesson
Water Sampling
Virtual field trip lesson with water sampling and id cards (to be developed)

**Macroinvertebrate and Fish Study:**
A Field Trip visit to an environmental organization for a macroinvertebrate study (these materials are generally provided by the environmental organization)
- Plastic Containers (one per pair of students)
- Water Color Paint Brushes (one per pair)
- Magnifying Boxes (about 10)
- Dish pans (2)
- Chemical Testing Strips or tablets (pH, Nitrate, Phosphate, DO)
- Thermometers
- Meter Sticks
- Macro-Invertebrate Identification Chart *(Attachment E)*

**Virtual Field Trip for Bio-Indicator Studies of Fish and Macro-Invertebrates**
- Computer
- Fish Cards *(Attachment F)*
- How Tolerant is your Fish? *(Attachment G)*
- Bin for Fishing
- "Fishing License" *(Attachment F)*
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE AND EXTEND

A. ENGAGE STUDENTS WITH A HUMAN COMMUNITY WEB. (20 minutes) (Adapted from the Perkiomen Watershed Conservancy’s Field And Stream Community Lesson)

This lesson introduces students to the notion that members of a community depend upon each other and are depended upon...

- Form a circle. Elicit student understandings of the term, “Community”. Define community as a place where organisms live together and interact and are often dependent upon one another.

- Hand out Community Cards. (Attachment A) Each card has one person’s job in the community. Students should wear the cards around their necks so others can read the cards. Teacher gets a card too.

- Teacher starts with a ball of yarn. S/he looks for the community card of someone else in the circle upon whom s/he depends for his/her job and/or for his/her personal life. The teacher announces the community card and why s/he depends upon that person and s/he tosses the ball of yarn to that person. The person, to whom the yarn is passed looks for someone else s/he might depend upon, announces the community card and why s/he depends on that person and passes the yarn. This pattern continues until all the students are connected.

- Tell students to put the yarn on the ground and describe what they have made. Define the result as a Community Web that shows how we are interconnected and how we depend upon one another.

- Explore what happens if the balance within the community gets out of whack…. ask the last student who was chosen in the web to “leave town” by stepping back Then ask the person who chose that last person if they would be willing to live in a town w/o ___________. If not, they should also leave town… Follow this pattern until you, the teacher, are left without any community at all. (There may be a few students who realize that they can adapt, but most will leave town.) Compare this scenario to the natural world when changes happen and organisms need to move, adapt, or die. Examine what happens if you decide to poison one group of nuisance organisms (like mosquitoes). What depends on the mosquito and how will the eco-system be affected if we poison the mosquitoes?

- Explain to students that we will create a similar Community Web for the Stream Community based on research that is conducted about members of the stream and the stream bank community.
B. EXPLORE AND EXPLAIN: A STREAM COMMUNITY FOOD WEB

- **Stream Community Organism Research:** (2-5 class periods) Assign organisms found in the Schuylkill and Delaware Watershed waterways to research. See *Attachment B* for organism cards. To help develop the idea of interdependence and food-webs, make sure that the organisms chosen or assigned are well distributed across the food web. Take a few minutes each day to explain new concepts... Native, Invasive, Tolerance to Pollution, Functional Feeding Groups or Feeding Type, Range, Class, etc... Students should keep notes in their *Watershed Journal* using the research guide as they complete their research. *(Attachment C)* Students can make a poster or a 3D model of their organism. Present results.

C. ELABORATE: MACROINVERTEBRATES, FISH AND MICROSCOPIC LIFE AS INDICATORS OF STREAM HEALTH

*Schedule a trip to a stream and schedule a trip to Fairmount Water Works*

**Macroinvertebrate Study:** (Full Day)

The [Schuylkill Center for Environmental Education](https://www.schuylkillcenter.org/) and the [The Wissahickon Environmental Center](https://wissahickoncenter.org/) and the [Pennypack Environmental Center](https://www.pennypackcenter.org/) provide opportunities for a hike through a riparian buffer and wetlands to reach a body of water. At the stream, educators will facilitate physical and chemical tests and the students will have the opportunity to conduct a macro-invertebrate indicator study.

You can also contact the FWW and an environmental scientist will take you to a local creek near your school and will lead your students in physical, chemical and biological tests of the creek.

As you hike through the riparian buffer, be sure to note its physical and ecological importance to the stream. Look for examples of different types of producers such as trees, bushes, vines, wildflowers and native grasses. Look for examples of consumers and evidence that they have been there. Look for examples of decomposers and abiotic factors. Look for native, non-native and invasive species. Discuss the implications of each. Bring a camera to take pictures of flora and fauna...these photographs can be used to help identify plants, animals, and decomposers once the class returns to the classroom.

At the stream, collect data. Use Macroinvertebrate Identification Sheets to determine pollution tolerance. *(See *Attachment E*) Most environmental education organizations will provide students with an appropriate data sheet. Upon returning to school, analyze data and determine the health of the stream. Students can write an explanation of the quality of the creek based on the types of macro-invertebrates that were found. Review and discuss why the riparian buffer and the forested wetland are vital in protecting the waterway.
Trip to Fairmount Water Works for Bio-indicator and Microscopic Life Study: (1/2 Day)

When requesting lessons, ask for a guided walk to the Fish Ladder and the “Seeing is Believing” lesson.

Fish Ladder:
Walk to the fish ladder. Look for different species of consumers (birds, turtles) along the way. At the fish ladder, discuss the importance of the ladder and discuss why the fish have returned to the Schuylkill over time. While the students will most likely not have an opportunity to look though the observation window of the fish-way, they may be able to watch the video cam of the fish entering the fish-way back at Fairmount Water Works. While watching the video cam, students can identify the fish as they swim by. Record fish data. If your class has a good day, use the data to create a scatter plot when the class returns to school. Back at school, compare results from your small scale fish data project to the PWD Fish Census. Discuss how else we can know what kinds of fish are in the water. View Electro-Fishing Video.

“Seeing is Believing”
In this lesson, students will collect water from Schuylkill in real time to observe and identify microorganisms. With an educator’s directions and assistance, the students will create wet-mount slides of the water and will able to observe using a microscope. Between the educator’s expertise and provided identification cards, students will be able to identify different microscopic organisms. Information will also be provided about diatoms and the role they play in the eco-system. Information will also be provided about the tolerance of microorganisms to pollution and the effect that pollution has on the eco-system and our drinking water supply.

Virtual Bio-Indicator Studies:

If you can’t schedule a trip to a stream or to FWW, here are some suggestions to help you conduct “virtual” bio-indicator studies:

For macroinvertebrates: (1 class period)
- NPS Macro-Invertebrate Virtual Study: This website classifies macro-invertebrates according to pollution tolerance and will allow students to conduct a virtual macro-invertebrate study.
- Students can write an explanation of the quality of their “water sample” based on the types of macro-invertebrates found in the sample. They should be able to explain in detail the reasoning behind their justification. Exemplar response: “Our water sample indicates an ecosystem that is very polluted. We believe that it is very polluted because of the types and variety of macro-invertebrates that we found in the sample. We found …… which are pollution tolerant species. We found no pollution intolerant species, which means that they can’t survive in this environment”.

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For fish: (1-2 class periods)

- Set up a bin of fish (Use the fish illustrations from Attachment F) for each table. The bin can be covered with construction paper or filled with shredded paper to “hide” the fish. Pass a fishing license (Attachment F) around...when students get the fishing license, they can go fishing. Once everyone has had a turn or two, students can fill out the “How Tolerant Is Your Fish to Pollution?” sheet (See Attachment G). They should check off the fish they found and determine the health of the river by the collection of fish that are pulled out.

- If available, view the Live Fish Ladder Video. Identify and count fish. Compare results from the classroom small scale fish data project to the PWD Fish Census. Discuss how else we can know what kinds of fish are in the water. View Electro-Fishing Video.

E. Extensions

- Diatoms as Victorian Art (1 class period)
  
  Review what a diatom is with students as follows: Where do diatoms live? Is a diatom a plant or animal? What role do they play in the food web? Review physical and chemical factors that could affect health of diatomic community. What part of the diatom can be found long after they are dead?

  Give students three petri dishes (or circles of paper stacked and held together with a brad). Provide images of the various types of diatom from Images of Diatoms that students can cut out and arrange and glue as they wish in their dish. Challenge students to use the Diatom Identification Chart to identify their diatoms.

- A Trophic Cascade: (1 class period)
  
  View How Wolves Can Alter the Course of Rivers. In this video, George Monbiot poetically explains how reintroducing wolves to Yellowstone National Park after a 70-year absence set off a “trophic cascade” that altered the movement of deer, sent trees soaring to new heights, attracted scores of new animals to the area (think: beavers, rabbits, bears, bald eagles and more), and stabilized the banks of rivers making them less susceptible to erosion.

  Compare the re-introduction of wolves in Yellowstone to the return of the Shad to the Schuylkill. How does the return of the Shad affect the ecology of the Schuylkill River? Explore how the loss of organisms have changed an ecosystem. (Example: Research how the loss of the buffalo affected the grasslands ecosystem.)
VIII. Evaluation of the Learning Experience

- Organism Research Project (For Rubric, see Attachment D)

- Analysis of data related to Fish Counts and Macro-Invertebrate Studies. Is the stream healthy? Answer should be explained based on data collected.

- Re-visit the Community Web, but this time use Stream Community members. Students can develop the cards—cards should include aquatic members of the stream, of the riparian buffer and of the wetlands. Cards should include abiotic factors, producers, consumers, and decomposers. As students choose where to toss the ball of yarn, they should explain their choice and how their community member interacts with the chosen member. (Note: Some community members will have to be used more than once.) After completing the activity as a large group, students should create their own individual or small group stream community web.

*Students at Dobson did research about individual species to help students understand food webs and the health of the river.*
# Attachment A: Community Cards

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Fire Fighter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police Officer</td>
<td>Grocery Store Clerk</td>
</tr>
<tr>
<td>Letter Carrier</td>
<td>Garbage &amp; Recycling Collector</td>
</tr>
<tr>
<td>Dentist</td>
<td>Nurse</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Veterinarian</td>
<td>Ice Cream</td>
</tr>
<tr>
<td>Convenience Store Clerk</td>
<td>Store Clerk</td>
</tr>
<tr>
<td>Drinking Water Treatment Plant Worker</td>
<td></td>
</tr>
<tr>
<td><strong>Waste Water Treatment Plant Worker</strong></td>
<td><strong>Website Designer</strong></td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Construction Worker</strong></td>
<td><strong>Road Construction Worker</strong></td>
</tr>
<tr>
<td><strong>Electric Company Worker</strong></td>
<td><strong>Computer &amp; Electronic Salesperson</strong></td>
</tr>
<tr>
<td>Musician</td>
<td>Bus Driver</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>Car Mechanic</td>
<td>Banker</td>
</tr>
<tr>
<td>Gas Station Attendant</td>
<td>Farmer</td>
</tr>
</tbody>
</table>
ATTACHMENT B: ORGANISM CARDS

AMERICAN SHAD

LARGEMOUTH BASS

REDFIN PICKEREL

WHITE SUCKER

BROWN TROUT

BROWN BULLHEAD CATFISH
STRIPED BASS

AMERICAN EEL

WHITE PERCH

CHANNEL CATFISH
<table>
<thead>
<tr>
<th>BIRDS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>REDKNOT</td>
<td>RED WINGED BLACKBIRD</td>
</tr>
<tr>
<td>GREAT BLUE HERON</td>
<td>OSPREY</td>
</tr>
<tr>
<td>KINGFISHER</td>
<td>CORMORANT</td>
</tr>
</tbody>
</table>
**AMPHIBIANS AND REPTILES**

<table>
<thead>
<tr>
<th>NORTHERN WATER SNAKE</th>
<th>AMERICAN TOAD</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Northern Water Snake" /></td>
<td><img src="image2" alt="American Toad" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RED SPOTTED NEWT</th>
<th>BULL FROG</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Red Spotted Newt" /></td>
<td><img src="image4" alt="Bull Frog" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SNAPPING TURTLE</th>
<th>PAINTED TURTLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Snapping Turtle" /></td>
<td><img src="image6" alt="Painted Turtle" /></td>
</tr>
</tbody>
</table>
### MACRO-INVERTEBRATES (INDICATORS)

<table>
<thead>
<tr>
<th>MAYFLY</th>
<th>WATER PENNY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NYMPH</strong></td>
<td><strong>ADULT</strong></td>
</tr>
<tr>
<td><img src="image" alt="MAYFLY NYMPH" /></td>
<td><img src="image" alt="WATER PENNY ADULT" /></td>
</tr>
<tr>
<td><strong>ADULT</strong></td>
<td><strong>LARVA</strong></td>
</tr>
<tr>
<td><img src="image" alt="MAYFLY ADULT" /></td>
<td><img src="image" alt="WATER PENNY LARVA" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CADDIS FLY</th>
<th>BLACK FLY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LARVA</strong></td>
<td><strong>ADULT</strong></td>
</tr>
<tr>
<td><img src="image" alt="CADDIS FLY LARVA" /></td>
<td><img src="image" alt="BLACK FLY ADULT" /></td>
</tr>
<tr>
<td><strong>ADULT</strong></td>
<td><strong>LARVA</strong></td>
</tr>
<tr>
<td><img src="image" alt="CADDIS FLY ADULT" /></td>
<td><img src="image" alt="BLACK FLY LARVA" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DAMSEL FLY</th>
<th>DRAGON FLY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NYMPH</strong></td>
<td><strong>NYMPH</strong></td>
</tr>
<tr>
<td><img src="image" alt="DAMSEL FLY NYMPH" /></td>
<td><img src="image" alt="DRAGON FLY NYMPH" /></td>
</tr>
<tr>
<td><strong>ADULT</strong></td>
<td><strong>ADULT</strong></td>
</tr>
<tr>
<td><img src="image" alt="DAMSEL FLY ADULT" /></td>
<td><img src="image" alt="DRAGON FLY ADULT" /></td>
</tr>
</tbody>
</table>
### MACRO-INVERTEBRATES (INDICATORS)

<table>
<thead>
<tr>
<th>CRAYFISH</th>
<th>LEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Crayfish" /></td>
<td><img src="image2" alt="Leech" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FRESH WATER CLAM</th>
<th>SCUD</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Fresh Water Clam" /></td>
<td><img src="image4" alt="Scud" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLANARIA</th>
<th>AQUATIC SNAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5" alt="Planaria" /></td>
<td><img src="image6" alt="Aquatic Snail" /></td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td></td>
</tr>
<tr>
<td><strong>BEAVER</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image1" alt="Beaver" /></td>
<td></td>
</tr>
<tr>
<td><strong>WOLF SPIDER</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image2" alt="Wolf Spider" /></td>
<td></td>
</tr>
<tr>
<td><strong>RIVER OTTER</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image3" alt="River Otter" /></td>
<td></td>
</tr>
<tr>
<td><strong>ZOO-PLANKTON</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image4" alt="Zoo-Plankton" /></td>
<td></td>
</tr>
<tr>
<td><strong>PERIPHYTON</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image5" alt="Periphyton" /></td>
<td></td>
</tr>
<tr>
<td><strong>ALGAE</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image6" alt="Algae" /></td>
<td></td>
</tr>
</tbody>
</table>
Research your organism using the chrome book. (One useful website is Delaware River Organisms Fact Sheets)

**Description:**
- Include class (fish, insect, bird…), physical description and adaptations that help the organism to survive in a lotic (moving water environment).

**Diet:**
- Include what it eats and how it eats
- If relevant, feeding type from PWD Fish Data
- If relevant, feeding type from PWD Macro-invertebrate Data

**Environment & Range:**
- Type of habitat it likes
- Where it lives in the world (range)
- Is the organism native to the Delaware Watershed? If not, where does it come from and what effects has it had on the local ecology?

**Life Cycle & Mating:**
- Length of life
- How it reproduces
- Life stages

**Pollution Tolerance Level: (if relevant)**
- PWD Fish Data
- PWD Macro-invertebrate Data

Sources:

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ATTACHMENT D: ORGANISM RESEARCH SCORING

Name: _________________________________________
Date: _____________________

Organism Research Scoring Guideline:

Common and scientific name of organism ___ out of 5
Picture or illustration of organism ___ out of 5
Physical description (includes: class, size, markings, adaptations, etc.) ___ out of 10
Diet (include feeding type when relevant) ___ out of 10
Environment and Range (habitat, native or non-native) ___ out of 10
Life Cycle and Mating (e.g., length of life, behaviors, reproduction, stages) ___ out of 10
Pollution Tolerance (when relevant) ___ out of 5
Sources ___ out of 5
Spelling, grammar, and presentation ___ out of 10

Total: ___ out of 70 = ___%
### ATTACHMENT E: STREAM MACROINVERTEBRATE IDENTIFICATION CHART

**Macro Invertebrate Identification Chart**

Print Url: http://www.discovercarolina.com/html/s05nature09a02b.pdf

<table>
<thead>
<tr>
<th>GROUP 1</th>
<th>LARVA OR NYMPH</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mayfly</strong> - As adults, mayflies live only a few hours or days, living only long enough to mate and lay eggs. The nymphs live under water up to two years, move to land, and shed as adults. The legs have a single claw and there may be two to three tails.</td>
<td><img src="image1" alt="Mayfly Larva" /></td>
<td><img src="image2" alt="Mayfly Adult" /></td>
</tr>
<tr>
<td><strong>Stonefly</strong> - As a nymph, the stonefly lives under water for one or more years. Nymphs live under rocks in the fast-moving water. Adult stoneflies live only a short time, then die. They possess two tails and each leg has a pair of hooks at the end. The gills are often visible on or behind each leg.</td>
<td><img src="image3" alt="Stonefly Larva" /></td>
<td><img src="image4" alt="Stonefly Adult" /></td>
</tr>
<tr>
<td><strong>Water Penny</strong> - The adult lives on land, but the flat, round larva securely clings to the underside of rocks in cold-water streams. The segmented, plate-like covering protects the insect’s head, legs, and gills on the underside. Their color is brown, black, or tan.</td>
<td><img src="image5" alt="Water Penny Larva" /></td>
<td><img src="image6" alt="Water Penny Adult" /></td>
</tr>
<tr>
<td><strong>Caddisfly</strong> - The unusual larva build cases of sand or plant debris, composted together by silk. Cases built by different species are quite distinctive. Larvae feed on small water plants and animals, and in turn are food for fish and other predators.</td>
<td><img src="image7" alt="Caddisfly Larva" /></td>
<td><img src="image8" alt="Caddisfly Adult" /></td>
</tr>
<tr>
<td><strong>Dobsonfly (heggrammite)</strong> - These insects spend up to three years as larvae before turning into adults. Larvae live under stones in the swift part of the stream and may grow to be 4 inches long. As their large jaws suggest, they are carnivorous and may bite.</td>
<td><img src="image9" alt="Dobsonfly Larva" /></td>
<td><img src="image10" alt="Dobsonfly Adult" /></td>
</tr>
<tr>
<td><strong>Gilled snail</strong> - These snails have gills and rely on cold fast-moving water. With the opening facing you and the shell tip pointing up, the opening will be on the right side. The shells have an operculum (plate-like door), are black and are easily seen attached to rocks.</td>
<td><img src="image11" alt="Gilled Snail Larva" /></td>
<td><img src="image12" alt="Gilled Snail Adult" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GROUP 2</th>
<th>LARVA OR NYMPH</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crayfish</strong> - Crayfish have five pair of legs, the first being armed with large claws. If a leg is lost, another will grow in its place. If threatened a crayfish will flip its fan-like tail down, propelling itself backwards to escape.</td>
<td><img src="image13" alt="Crayfish Larva" /></td>
<td><img src="image14" alt="Crayfish Adult" /></td>
</tr>
</tbody>
</table>
### GROUP 2: Somewhat sensitive to pollution

<table>
<thead>
<tr>
<th>LARVA OR NYMPH</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crane fly</strong> - Crane fly adults look like large mosquitoes but do not bite. They are long and slender, with long legs. Larva are plump, have a segmented body, and appear to be transparent.</td>
<td><img src="image1" alt="Crane fly larva" /></td>
</tr>
<tr>
<td>1-2”</td>
<td>2”</td>
</tr>
<tr>
<td><strong>Dragonfly</strong> - The commonly seen adult is slender and holds their large, clear wings out flat when at rest. The nymph has a wide abdomen and no gills. Nymphs may spend up to a year underwater before becoming adults. Adults and nymphs are carnivorous.</td>
<td><img src="image3" alt="Dragonfly larva" /></td>
</tr>
<tr>
<td>1”</td>
<td>2-4”</td>
</tr>
<tr>
<td><strong>Damselfly</strong> - Adults hold their wings together and above the body when at rest. The nymph stage may range from several weeks or months to 4 years and are usually found in slower moving water. Like a dragonfly, damselflies are predators but the body is more slender. Three tail structures serve as gills.</td>
<td><img src="image5" alt="Damselfly larva" /></td>
</tr>
<tr>
<td>1-2”</td>
<td>2-3”</td>
</tr>
<tr>
<td><strong>Scud</strong> - Scuds resemble freshwater shrimp. They are lighter in color and 7 pairs of tiny segmented legs. Scuds swim rapidly on their sides and are scavengers of plant and animal matter.</td>
<td><img src="image7" alt="Scud larva" /></td>
</tr>
<tr>
<td>1/3”</td>
<td></td>
</tr>
</tbody>
</table>

### GROUP 3: Generally tolerant to pollution

<table>
<thead>
<tr>
<th>LARVA OR NYMPH</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lunged snail</strong> - These snails obtain oxygen from air trapped in their shell. The shell has no operculum (plate-like door). With the shell opening facing up, and the tip pointing up, the opening will be on the left side. Lunged snails prefer slower moving waters.</td>
<td><img src="image9" alt="Lunged snail larva" /></td>
</tr>
<tr>
<td>1/2”</td>
<td></td>
</tr>
<tr>
<td><strong>Aquatic worms</strong> - Most are small and thread-like. Their color may be red, tan, black, or brown. Movement is done similar to earthworms, stretching and pulling its body slower moving waters.</td>
<td><img src="image11" alt="Aquatic worms larva" /></td>
</tr>
<tr>
<td>1-5”</td>
<td></td>
</tr>
<tr>
<td><strong>Midge Fly</strong> - Can be found in all but the most polluted waters. Their length is up to 1/2 inch long. The body is slightly curved and segmented, often with a distinct dark head. One tiny pair of legs exist below the head and another pair is at the back end.</td>
<td><img src="image13" alt="Midge Fly larva" /></td>
</tr>
<tr>
<td>1/2”</td>
<td></td>
</tr>
<tr>
<td><strong>Black Fly</strong> - The segmented body may be up to 1/3 inch long with a small sucker at the end of the widened abdomen. Tiny gills filter food from the water. These larva are often found attached to rocks and sticks.</td>
<td><img src="image15" alt="Black Fly larva" /></td>
</tr>
<tr>
<td>1/3”</td>
<td></td>
</tr>
</tbody>
</table>
ATTACHMENT F: FISH CARDS

Ablewife
*Alosa pseudoharengus*

Length at maturity: 8 inches
Food: heavy diet of zooplankton, larval crustaceans, marine macroinvertebrates, and small fish
Mating season: early May
Migration: for salmon run

Pumpkinseed
*Lepomis gibbosus*

Length at maturity: 8 inches
Food: heavy diet of insects, crustaceans, and other invertebrates
Mating season: late April to early May
Migration: for spawning

Channel Catfish
*Ictalurus punctatus*

Length at maturity: 20 inches
Food: small fish, snails, crayfish, and aquatic insects
Mating season: April to June
Migration: for spawning
WHITE PERCH

**Average Weight:** 1 pound  
**Average Length:** 8-10 inches  
**Facts:**  
- They are carnivores and their diet mainly includes other fish as well as fish eggs  
- Live in tidal estuaries  
- Closely related to striped bass

LARGEMOUTH BASS

**Average Weight:** 2-8 pounds  
**Average Length:** 12-18 inches  
**Facts:**  
- Popular fish with catch and release anglers  
- Can live up to 16 years in the wild  
- Predatory fish: they like to eat small fish, salamanders, and other small creatures
Understanding the Urban Watershed Curriculum

Unit One
Learning Experience Three

Water in Our World: Stream Ecology

Quillback
_Carpiodes cyprinus_

Length at maturity: 24 inches
Food: Bottom feeders on aquatic insects, larval and other small organisms, mollusks, and some aquatic vegetation
Travel: in schools, live in slow-moving pools
Lay eggs: in Spring

American Shad
_Alosa sapidissima_

Length at maturity: up to 30 inches
Food: Shad eat microinvertebrates, zooplankton, as well as some worms and small fish
Travel: in schools, in larger rivers
Lay eggs: in schools in saltwater, but spawn in fresh water to lay eggs in early Spring.
ATTACHMENT G: HOW TOLERANT IS YOUR FISH?

HOW TOLERANT IS YOUR FISH TO POLLUTION?

VERY TOLERANT OF POLLUTION
- Carp
- Quillback
- Banded Killifish

SOMEWHAT TOLERANT OF POLLUTION
- White Perch
- Channel Catfish
- Pumpkinseed Sunfish
- Hickory Shad
- Largemouth Bass

INTOLERANT OF POLLUTION
- Walleye
- Rainbow Trout
- Smallmouth Bass
- American Shad
- Alewife
X. Resources for Teachers and Students

resourcewater.org Toolbox!

Places to Visit:

- Schuylkill Center for Environmental Education (Philadelphia)
  Print URL: http://www.schuylkillcenter.org/
- The Wissahickon Environmental Center and the Pennypack Environmental Center (Philadelphia)
  Print URL: http://www.phila.gov/ParksandRecreation/environment/environmentaleducation/Pages/WissahickonEnvironmentalCenter.aspx
  Print URL: http://www.phila.gov/ParksandRecreation/environment/environmentaleducation/Pages/PennypackEnvironmentalCenter.aspx

Organism Research:

- Delaware River Organism Fact Sheets (Note: Unless the organism makes its home very close to Delaware Bay, if the organism is found in the Delaware, it will also be found in the Schuylkill)
  Print URL: http://www.state.nj.us/dep/fgw/artdelstudy_factsheets.htm

- PWD Fish Data
  Print URL: http://www.phillywatersheds.org/what_were_doing/documents_and_data/biological_data/fish_data

- PWD Macro-invertebrate Data
  Print URL: http://www.phillywatersheds.org/what_were_doing/documents_and_data/biological_data/macroinvertebrate_data

Bio-Indicator Studies

- Macro-Invertebrate Chart
  Print URL: http://www.discovercarolina.com/html/s05nature09a02b.pdf

- Electro-Fishing Video
  Print URL: https://www.youtube.com/watch?v=peSzPa-ynpk

- Live Fish Ladder Video (Under Construction)
  Print URL: http://fairmountwaterworks.com/fishcam.php

Virtual Macro-Invertebrate Study

- NPS Macro-Invertebrate Virtual Study
  Print URL: http://www.nps.gov/webrangers/activities/waterquality/

Extensions

- How Wolves Can Alter the Course of Rivers
  Print URL: http://blog.ted.com/video-how-wolves-can-alter-the-course-of-rivers/

- Images of Diatoms
  Print URL: http://westerndiatoms.colorado.edu/taxa

- Diatom Identification Chart
  Print URL: http://www.yukonenvirothon.com/uploads/1/0/5/2/10529729/diaton_ident__chart1.pdf
Thematic Unit Two

Drinking Water and You

Objectives:

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

Philadelphia began using the river (surface water) for drinking water supply over 200 years ago. The City’s first public water supply system, which opened in 1801, pumped water from the Schuylkill River at 24 and Chestnut Street by steam engine to a water works at Centre Square. From here it was distributed to the city through wooden pipes made from hollowed out logs. Difficulties with the machinery and management of the facility hampered the operation of the Center Square Water Works and improvements were needed. The banks of the Schuylkill were chosen as the ideal location for a new and improved system.

The engine house was constructed at Centre Square and housed two steam engines—there was a low-pressure design built by Samuel Richards and a new high-pressure engine, designed by Oliver Evans. Both engines were made locally. The reservoir had a 3 million gallon capacity. Five wooden distribution mains, each six-inches in diameter, led to the cast-iron distribution chest at the Center Square works where water continued to flow to hydrants, pumps, 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 site was chosen for its close proximity to the river and more importantly to Fairmount, one of the highest points in the city to create a gravity-fed system, where reservoirs were constructed. The high cost of fuel and increasing demand for clean water led the Watering Committee to find a new and less expensive technological solution. Water both as energy to pump and supply for drinking was the solution. On October 24, 1822, the steam engines were stopped and by the 1830s the old engine house was converted to a public saloon.

From 1815 through 1854 Fairmount Water Works was the sole pumping station, supplying Philadelphia with water, and for part of that time it also supplied the districts of Spring Garden, Northern Liberties, and Southwark. After water power replaced steam power, which used expensive fuel to power the pumps, the financial rewards for the city were considerable. 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.

People notable for the creation and operation of the Water Works were Frederick Graff (1774-1847) and his son Frederic Graff, Jr. (1817-1890). As a young man, the elder Graff was an assistant to the architect and engineer Benjamin Henry Latrobe. Graff served as superintendent of the first water works at Center Square and continued at Fairmount until his death in 1847. He is responsible for designing the buildings, most of the machinery, the distribution system, and the gardens immediately surrounding the water works. His son continued to serve as civil engineer and played a major role in the development of Fairmount Park.

The technological innovations that were employed at Fairmount to pump water from the river to the reservoirs were: steam power (1815-1822), waterwheels (1822-1860s), and hydraulic turbines (early 1860s-1909) until the Fairmount Water Works was decommissioned.

Sequence of Lessons

1. Fresh Water and You!
2. Source Water and Water for the Federal City: Civic Responsibility for the Public Good
3. Technology and Innovation: Engineering a Public Water System
4. Public Drinking Water Treatment Process Explained
5. Testing the Waters: Making it Safe
6. Bottled or Tap?
THEMATIC UNIT 2: DRINKING WATER AND YOU
LEARNING EXPERIENCE 1: FRESH WATER AND YOU!

Lesson Plan Overview

I. ESSENTIAL QUESTIONS  PAGE 85
II. STUDENT UNDERSTANDINGS  PAGE 85
III. STUDENT OBJECTIVES  PAGE 86
IV. CROSS-CURRICULAR CONNECTIONS  PAGE 86
V. SETTING THE STAGE AND HELPFUL VOCABULARY  PAGE 87
VI. MATERIALS NEEDED  PAGE 88
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE, AND EXTEND  PAGE 88
VIII. EVALUATION  PAGE 92
IX. ATTACHMENTS
   ATTACHMENT A: DATA SHEET FOR DAILY WATER USE  PAGE 93
   ATTACHMENT B: DATA SHEET FOR FOLLOW UP TO DAILY WATER USE  PAGE 94
   ATTACHMENT C: UNITED NATIONS MILLENNIUM PLANNING GOALS  PAGE 95
X. RESOURCES FOR TEACHERS AND STUDENTS  PAGE 96

I. ESSENTIAL QUESTIONS

How much fresh water exists on our planet and how much of that fresh water is accessible for human consumption?

Why should we care about how much water we use?

II. STUDENT UNDERSTANDINGS

Water is essential for almost everything we do as humans. Water is used in obvious daily ways and is also a hidden component of many processes from food production to industry to manufacturing. Fresh water is a finite resource representing a small fraction of water on the planet. Water is stored in aquifers, glaciers, and bodies of water. Water can not always be easily accessed for human use. The finite nature of the resource makes it imperative that we make wise decisions regarding its use.

Understanding the Urban Watershed Curriculum  
Unit Two  
Learning Experience One  
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III. STUDENT OBJECTIVES

**Students will** calculate how much water they use individually and as a community using individualized sampling and water footprint data.

**Students will** research, collect, and compare data in order to understand and communicate how much water we use and how much water is available.

**Students will be able to** construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.

**Students will be able to** explain why potable water is a managed resource in Philadelphia and therefore needs to be valued through protection and conservation.

IV. CROSS-CURRICULAR CONNECTIONS

<table>
<thead>
<tr>
<th></th>
<th>English Language Arts</th>
<th>Science</th>
<th>Social Studies</th>
<th>Math</th>
<th>Career Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Read (and view), analyze, and connect text to personal experiences</td>
<td>• Ask questions, analyze and interpret data, engage in argument</td>
<td>• Ask questions, analyze and interpret data, engage in argument</td>
<td>• Measurement using Metric and English systems</td>
<td>PWD Employees</td>
</tr>
<tr>
<td></td>
<td>• Write reactions to material through notes, reflections, informative text, raps, political cartoons</td>
<td>• Water as natural resource</td>
<td>• Water consumption and global implications</td>
<td>• Calculating percentages and related statistics pertaining to water footprint and accessibility of fresh water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Research water consumption and availability</td>
<td>• Water footprint and hypothesis Development</td>
<td>• Water consumption across cultures</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Present Information</td>
<td>• Impact of human activity on availability of fresh water.</td>
<td>• Water consumption in developed and undeveloped countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Water usage in agriculture, industry, and manufacturing</td>
<td></td>
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</tr>
</tbody>
</table>
V. Setting the Stage and Helpful Vocabulary

Most American cities enjoy abundant clean water resources for drinking, cooking, and bathing. There is no doubt that the seemingly endless supply is, in fact, a finite resource. While the Earth's surface is covered with massive oceans, only three percent of the water on the planet is actually fresh water. Of that amount, much less than one percent is actually accessible, on the surface, and clean. The simple acts of both discovering how much accessible fresh water we have on the planet as well as calculating our own personal water footprint will enlighten, inform, and perhaps modify how and what we take for granted.

Helpful Vocabulary:

**Conserve (verb)**
Prevent the wasteful or harmful overuse of a resource

**Drought (noun)**
A prolonged period of abnormally low rainfall; a shortage of water resulting from this

**Efficiency (noun)**
Performance in the best possible manner with the least waste of time, effort, and material

**Gray Water (noun)**
The relatively clean waste water from baths, sinks, washing machines, and other kitchen appliances

**Potable (adjective)**
Safe to drink

**Reduce, Reuse, Recycle (verbs)**
Three essential components of environmentally responsible consumer behavior—reduce waste, re-use waste and recycle waste

**Resilience (noun)**
The capacity to recover quickly from difficulties

**Sustain (verb)**
Strengthen or support

**Water Footprint (noun)**
The amount of fresh water utilized in the production or supply of the goods and services used by a particular person or group
VI. MATERIALS LIST

Materials:
Engage Activity: Washing a Plate
  ● Sink
  ● Plate
  ● Dish Soap
  ● Condiments (to dirty the plate)
  ● Container with soapy, dirty water
  ● Computer

Explore and Explain: How much fresh water is there?
  ● 1-L container (a soda bottle will work)
  ● 100-ml graduated cylinder
  ● eyedropper
  ● ice cube tray
  ● small container (a dish will work)
  ● colored markers
  ● cash register receipt paper
  ● salt

VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE, EXTEND

A. ENGAGE THE STUDENTS BY EXPLORING WATER USAGE FOR ROUTINE DAILY ACTIVITIES. (EXPECTED DURATION: 2 HOURS—THOSE HOURS CAN BE DIVIDED BETWEEN THE MATH AND SCIENCE CLASS)

➤ Assign students the task of washing a plate. If you plan to calculate mean, mode, and range, you will need a substantial amount of student data, so each student should wash a plate. (If time is a limiting factor, use one volunteer and rather than calculating statistics, calculate how much water would have been used if each student in the class used the same amount of water as the volunteer.) See Attachment A for data recording sheet.

➤ Students will state a hypothesis about the amount of water that they expect to use in the activity.

➤ To calculate the amount of water used to wash the plate, plug sink and assume sink is a rectangular prism. Students will measure (in centimeters) sink-water dimensions (length, height, width) so that they can later calculate the volume of water that they used to wash their dish. (If a sink is not convenient, the plate washing task can be assigned for homework and statistics can be compiled the following day or the teacher can provide statistics on water use from Water Calculator from Grace Links.)

➤ Students will make observations of containers filled with contaminated water as a result of dish washing. Containers will be prepared by teacher ahead of time. Students record their findings in the table. (Attachment A)

-------------------

➤ Students calculate the volume of water consumed by washing a plate. Students record their individual data on a group poster.

➤ Teacher models with prepared example to complete analysis of range, mode, median, and mean of data.
In groups, students find the mean, median, mode and range of water consumption for washing a plate.

Display group data and discuss ways to conserve water for each task and elicit ideas for why conserving water could be important.

Homework Suggestions:
- List 5-10 ways to decrease personal water usage.
- Students can calculate the mean, median, mode, and range of the water consumption for washing a plate for the entire class.

Students will find the total amount of water used by the entire class for washing plates. (Use Attachment B: Data Sheet for Follow Up to Water Usage)

Discuss ways to conserve water while washing dishes.

Give students a card indicating how much water they could save while washing a plate. These cards should be made up prior to class and should be labeled with values between 0.25 and 1 liter.

In small groups, students can use the data sheet to calculate the new mean of water consumption for washing a plate and can calculate how much water would be saved by the whole class.

Class discussion about the world-wide impact if each person reduced water usage by a small amount.

**B. EXPLORE AND EXPLAIN THE PERCENTAGE OF FRESHWATER AVAILABLE FOR HUMAN USE.**

Teacher reminds students that we need fresh water for washing our hands, washing our dishes, and brushing our teeth.

Teacher introduces the question of how much of our planet's water is accessible fresh water. Explain that even though there is a lot of water on the planet, there are many factors that can make water unavailable for human consumption (salt water, glaciers, pollution...) Ask students to make a guestimate of the proportion of accessible fresh water to non-potable water on the planet.

a. Break students into small groups of three or four. Give each group a one meter long piece of cash register receipt paper.

b. Have each group put markings on the paper showing their estimates of accessible fresh water and non-potable water. Teacher should model an example.
c. (Statistics in the following exercise come from USGS Bar Graphs--Where is the Water?) Show the students a liter of water and tell them it represents all the water in the world. Ask where most of the water on earth is located (oceans). If necessary, refer to a map or globe. Pour 30 milliliters of the water into a 100 milliliter graduated cylinder. This amount represents the Earth’s freshwater, about 3 percent of the total. Put salt into the remaining 970 ml to simulate water found in oceans, unfit for human consumption.

d. Ask where most of the remaining “unsalty” water might be found. Explain that almost 80 percent of the Earth’s freshwater is frozen in ice caps and glaciers. Pour 6 ml of fresh water into a small dish and place the rest (24 ml) in an ice tray. The water in the dish (around 0.6 percent of the total) represents non-frozen freshwater.

e. Ask students where some of the rest of the water might be trapped. 4.5 ml of the water represents ground water. Fifty percent of the people in the United States get their drinking water from underground wells, but not all groundwater is reachable.

f. Using an eyedropper, remove a single drop of water (0.003 ml) from the dish and drop it into someone’s hand. This drop represents clean, fresh surface water (from lakes and streams), that is not polluted or otherwise unavailable for use. This amount is much less than 1% of the total amount of fresh water of the planet. This precious drop must be managed properly.

g. Go through the demonstration again and have students mark the other side of their register tape with the actual proportions... (30 ml will be represented by 3 cm and so forth until the small numbers can not be represented on the register tape).

D. ELABORATE THROUGH WATER FOOTPRINT RESEARCH

1. Discuss the results of the demonstration. At this point, students should conclude that a very small amount of water is available for human use. Remind the class of their earlier guesses at how much water is available to humans and compare with the actual percent available. Have students explain their reasoning for their initial estimates. Discuss whether or not there seems to be enough water available for the current population. Discuss ways that one could calculate whether there is enough water available for the current population.

2. Ask the students to estimate how much water they use in the course of a day. Encourage students to base their estimations, in part, on the calculations from washing plates earlier in the Learning Experience. Using the Water Calculator from Grace Links, students can
calculate their personal water footprint. Compare personal water footprints to the national average.

E. EXTEND BY COMPARING WATER CONSUMPTION IN THE UNITED STATES TO WATER CONSUMPTION IN THE DEVELOPING WORLD.

Students can work within their groups to research and to present the implications of their water footprint and the amount of accessible water available. Groups can research facts about water consumption of developed and developing countries. Groups can determine what percentage of the world’s population does not have access to clean drinking water. Students can compare water consumption of developing countries to that of the United States and other developed countries. Students can generate inferences that account for disparity between water consumption in developed countries and water consumption in developing countries. From there, students can use their “Watershed Journal” to complete a constructed writing piece in answering the following questions, “How does our class water footprint data compare to the national average and to the averages of developing countries? Why do 1/3 of the people on the planet not have access to clean drinking water?” This project can include a discussion and explanation about the current Millennium Development Goals (United Nations Millennium Development Goals) that the UN developed. Students and teacher can develop questions to form a research guide.
VIII. Evaluation

Formative Assessments:

- Ideas, reflections and surprises recorded in students’ “Watershed Journal”
- Calculations associated with water saving strategies

Summative Assessments:

Teacher and students can choose from different modalities:

1. Share examples of current political cartoons with students. Remind students that they are examples of satire. One needs to understand a concept before satirizing it. Challenge students to create a political cartoon based on their research of water usage and availability. Examples are available with a Google search on various water topics. A political cartoon with limited captions and text bubbles could be a very effective tool for ELL and ESOL students.

2. 1,2,3 Summarizing Activity/Jingle
   a. 1 Sentence that summarizes what students did
   b. 2 Important facts that were learned from potable water proportion activity
   c. 3 Facts that were learned from Water Footprint Research
   d. Students use their 123 Summary to create a Jingle or a Rap highlighting important aspects of availability and usage of water.

3. Create a poster to encourage conservation of water

4. Create a video of public service announcement to conserve water

5. Write a story of life of an individual in a water-poor region
ATTACHMENT A: DATA SHEET FOR DAILY WATER USE

Name:_______________________________________
Date:____________________________

Hypothesis:

Think about how much water you are going to use to wash a plate. Write the amount of water you think you will use to wash a plate.

Washing a plate will use _____________ milliliters of water.

Observations:

Write your observations of the dirty water. Use your best descriptive words in your observations.

<table>
<thead>
<tr>
<th>Type of Dirty Water</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dish Water</td>
<td></td>
</tr>
</tbody>
</table>

Measurements:

Measure the length and width of the sink. (use metric system)

Length of sink:__________

Width of sink:__________

After washing your plate, measure the depth of your water before letting it go down the drain.

<table>
<thead>
<tr>
<th>Type of Dirty Water</th>
<th>Depth of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dish Water</td>
<td></td>
</tr>
</tbody>
</table>

Calculations:

In the chart below, find the volume of the water used to wash a plate.

<table>
<thead>
<tr>
<th>Task</th>
<th>Length</th>
<th>Width</th>
<th>Depth</th>
<th>Volume = L x W x D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing a plate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ATTACHMENT B: DATA SHEET DAILY WATER USE FOLLOW UP

Name: ________________________________
Date: ________________________________

Previous Data:

Record the volume of water that you used for washing one plate: ____________________

Record the total water used by the class for washing plates: ________________________

New Data:

How much water will you save by washing the plate differently? (Get this from your notecard) _______

Determine the new amount of water you will use for each activity.

Original volume – reduced amount = new data

New Data for Washing a Plate: ____________________

If each person in the class reduced their water usage while washing a plate by the same small amount, how much water would the whole class be able to conserve?
ATTACHMENT C: UNITED NATIONS MILLENNIUM PLANNING GOALS

GOAL 7: ENSURE ENVIRONMENTAL SUSTAINABILITY

Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources

- Forests are a safety net for the poor, but they continue to disappear at an alarming rate.
- Global emissions of carbon dioxide (CO2) have increased by more than 50 per cent since 1990.
- In the 26 years since the adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer, there has been a reduction of over 98 per cent in the consumption of ozone-depleting substances.
- Afforestation and the natural expansion of forests have reduced the net loss of forest from an average of 8.3 million hectares annually in the 1990s to an average of 5.2 million hectares annually between 2000 and 2010.

Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss

- Protected ecosystems covered 14 per cent of land and coastal marine areas worldwide by 2012.

Target 7.C: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation

- The world has met the target of halving the proportion of people without access to improved sources of water, five years ahead of schedule.
- Between 1990 and 2012, 2.3 billion people gained access to improved drinking water sources.
- Over a quarter of the world’s population has gained access to improved sanitation since 1990, yet one billion people still resort to open defecation.
- The vast majority – 82 per cent – of people practicing open defecation now live in middle-income, populous countries.
- In 2012, 748 million people remained without access to an improved source of drinking water.
- Despite progress, 2.5 billion in developing countries still lack access to improved sanitation facilities.

Target 7.D: Achieve, by 2020, a significant improvement in the lives of at least 100 million slum dwellers

- The target was met well in advance of the 2020 deadline. More than 200 million of these people gained access to improved water sources, improved sanitation facilities, or durable or less crowded housing, thereby exceeding the MDG target.
- 863 million people are estimated to be living in slums in 2012 compared to 650 million in 1990 and 760 million in 2000.

United Nations Millennium Development Goals
**X. Resources for Teachers and Students**

resourcewater.org. Toolbox!

**USGS Bar Graphs--Where is the Water?** These graphs depict the percentages of available and accessible fresh water on the planet.
*Print URL:* http://water.usgs.gov/edu/earthwherewater.html

**United Nations Millennium Development Goals** The United Nations developed these goals to ensure environmental sustainability. In particular Target 7.C discusses the goals pertaining to the proportion of the population without sustainable access to safe drinking water and basic sanitation.

**Water Calculator from Grace Links** Water footprint calculator that allows for daily consumption calculations and virtual water calculations. Gracelinks.org also includes links to numerous other water footprint calculators.
*Print URL:* http://www.watercalculator.org/
UNIT TWO: DRINKING WATER AND YOU: CIVIC RESPONSIBILITY FOR THE PUBLIC GOOD

Lesson Plan Overview:

I. ESSENTIAL QUESTION
II. STUDENT UNDERSTANDINGS
III. STUDENT OBJECTIVES
IV. CROSS-CURRICULAR CONNECTIONS
V. SETTING THE STAGE AND HELPFUL VOCABULARY
VI. MATERIALS AND PREPARATION NEEDED
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE, EXTEND
VIII. EVALUATION
IX. ATTACHMENTS
   ATTACHMENT A: GUIDED IMAGERY SCRIPT
   ATTACHMENT B: PRIMARY SOURCES
   ATTACHMENT C: DEBATE RESOURCES
   ATTACHMENT D: FIRST HAND ACCOUNTS FROM BLAKE
   ATTACHMENT E: KRIMMEL PAINTINGS
   ATTACHMENT F: WATER BORNE DISEASE CHART
   ATTACHMENT G: WATER BORNE DISEASE SCORING
   ATTACHMENT H: HISTORY TIMELINE
X. RESOURCES FOR TEACHERS AND STUDENTS

I. ESSENTIAL QUESTION

What does civic responsibility mean and how is it related to water supply?
How did ideas about civic responsibility play a role in Philadelphia's first public water supply system?

II. STUDENT UNDERSTANDINGS

In many cities and communities around the world, fresh water is provided to citizens by a government entity that ensures the cleanliness, safety and steady availability of the resource. The infrastructure needed to provide fresh, clean water to people requires a significant financial and human investment in architecture, engineering, civic planning, technology, and ongoing maintenance.
III. STUDENT OBJECTIVES

**Students will** analyze the concept of civic responsibility **in order to** compare and contrast access to safe and reliable drinking water in 1800 and today.

**Students will** examine a variety of visual and written primary sources utilizing role playing, guided imagery, and debating methods **in order to** determine what led the citizens of Philadelphia to develop a safe and reliable public water system.

IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts | • Read (and view), analyze, and describe text using the primary source as evidence for analysis  
• Fiction and non-fiction texts  
• Debate |
|---|---|
| Science | • Water borne disease and health  
• History of science and medicine  
• Inquiry and theory |
| Social Studies | • Social life/Society  
• Cities in early America  
• Philadelphia history  
• Primary source investigation (methodology) |
| Math | • Population statistics |
| Art | • Visual literacy  
• Historical context |
| Careers | • Archivist, Curator, historian |
V. **SETTING THE STAGE AND HELPFUL VOCABULARY**

Today, scientists, physicians, and policy makers understand the connection between clean water and public health. Over 200 hundred years ago, that connection was not altogether clear. Although there was much speculation and debate, scientists had not come to consensus about how diseases were transmitted.

In 1800...
- Only 3% of the United States population lived in towns with more than 8,000 people.
- Philadelphia was the largest city in America with nearly 70,000 people (New York City was a close second with 60,000). Today, Philadelphia is a city of 1.6 million.
- Small dense alley blocks had long eclipsed William Penn's utopian plan for a Greene Country town with large airy residential blocks surrounded by wide streets and open squares. People were attracted to the city life of bustling commerce, trade and urban culture and entertainment.

**Helpful Vocabulary:**

*Accessible (adjective)*
Able to be reached

*Citizen (noun)*
An inhabitant of a particular town or city

*Civic (adjective)*
Of or relating to the duties or activities of relation to their town, city, or local area.

*Civic Responsibility (noun)*
Responsibility of a citizen

*Community (noun)*
A group of people living in the same place or having a particular characteristic in common.

*Reliable (adjective)*
Consistently good in quality or performance; able to be trusted
VI. MATERIALS AND PREPARATION NEEDED

Engage Activity: Guided Imagery
- Guided Imagery Script (Attachment A)

Explore and Explain: Circumstances and Debate Leading to Developing a Public Water System
- Fever, 1793 by Laurie Anderson or On-Line Version of Fever 1793
- Philadelphia: The Great Experiment (Go to “Watch” and “1790-1820 Fever” for webisodes relating to Yellow Fever and Public Water Supply).
- History Making Productions Fever: 1793 Teacher Materials
- History Making Productions Fever: 1793 Student Materials
- Selected Primary Source (Attachment B)
- Krimmel Paintings—Fourth of July Celebration at Centre Square from 1812 and from 1819 (Attachment E)

Elaborate: Role Play Civic Engagement
- Selected Generic Debate Resources (Attachment C)
- Selected Arguments for Debate (Attachment D)

Extensions:
- Waterborne Disease Chart (Attachment F)
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE AND EXTEND

A. ENGAGE STUDENTS WITH A GUIDED IMAGERY DESCRIPTION OF A PHILADELPHIA STREET SCENE.  
   (estimated time ~1 class period)

➤ Guided imagery is a tool by which a narrator leads participants through descriptions of a scenario for them to imagine. Guided imagery can be a useful introduction method when students are unfamiliar with a topic.

➤ The script should be read at a pace you feel is most appropriate so your students can focus on the words and descriptions.

➤ Tell your students to close their eyes if they are comfortable, or put their heads down on their desks, and focus on the words and scenes you are describing. Students should stay quiet throughout the description until you tell them to open their eyes. There will be a time for sharing thoughts, comments, and questions at the end.

➤ Read the Guided Imagery Script.  *(Attachment A)*

➤ Follow Up Discussion and Reflection (Use Watershed Journals)
   a. Encourage students to reflect through writing, drawing or talking in pairs about what they found to be strange or interesting
   b. Encourage students to compare the historical street in the script to a more familiar modern street.
   c. Elicit questions that may have developed as a result of unfamiliar vocabulary and concepts.

B. EXPLORE AND EXPLAIN THE CIRCUMSTANCES THAT LED THE CITIZENS OF PHILADELPHIA TO DEVELOP A SAFE AND RELIABLE PUBLIC WATER SYSTEM.

Utilizing the following resources will make primary source documents more accessible to your students: *(Several class periods)*

➤ Read *Fever: 1793* by Laurie Halse Anderson with your students.  [On-Line Version of Fever 1793](#)

➤ View *Philadelphia: The Great Experiment* (Go to “Watch” and “1790-1820 Fever” for webisodes relating to Yellow Fever and Public Water Supply).

➤ Use the accompanying *History Making Productions Fever: 1793 Teacher Materials* and the *History Making Productions Fever: 1793 Student Materials*  These materials make use of primary source documents and the guide will facilitate teaching and learning using these documents.
- Review Philadelphia Water Timeline and compare Philadelphia Water Timeline to a timeline of Philadelphia history and US history. Students can construct their own time line of Philadelphia history and/or US history to see how the Water Timeline fits. Look for examples of civic engagement in all. (See Attachment H for Philadelphia Water Timeline)

Students write descriptively and/or illustrate a Philadelphia scene or scenario. Review and list the problems with their creations using the texts provided. (Historical Perspective through Writing and Evidence Analysis)~1-3 class periods

- Students should write descriptively and/or illustrate a Philadelphia scene or situation from the late 18th century. Once the writing and illustrations are complete, students will examine primary sources and art work that describe Philadelphia city life at the time. (See Attachment B for primary source documents and see Attachment E for Krimmel Paintings and see Resources for additional painting resources)

Note: The readings will be difficult for students to read independently. For the primary sources that you choose to explore with your students, discuss the context and read the selections aloud while the students follow along.

Students should then compare and contrast their own description with evidence they find to highlight accuracies and differences. Students can then revise their writing or illustration based on the newly found and reviewed evidence.

- Using Krimmel’s Fourth of July Celebrations at Centre Square paintings from 1812 and 1819, students, in groups or individually, will analyze the water solution developed by Latrobe. Latrobe’s solution can be reviewed using Google Maps. See Attachment E for paintings.

  - Student discussions should initially center on what is portrayed, including the technology, style of dress, populations, actions, and even art style.
  - Elicit thoughts about how the scene and mood changed between 1812 and 1819.
  - Discussions and/or research should move onto the artist’s history, any political connections, what students question about the accuracy or truthfulness of the portrayal, and even who or what is not in the painting.
  - Consider different points of view by exploring one of the following:
    - Ask students to choose a person who is either depicted in the Krimmel paintings or someone who is not in the painting. Students can draw a picture from the viewpoint of this person looking out past the painter. What would they see?
    - Ask students to choose a person in the painting or a person outside the painting. Consider the role of the person within the Philadelphia society and share their perspective. Those potential roles include doctors, scientists, members of high society, slaves, middle class shop owners, and indentured servants. This narrative could lead to theatrical performances.
  - Teachers may prescribe their own guidelines for an effective length for the writing piece or guidelines for the illustration.
Elaboration: Students role-play civic engagement and public discourse as citizens for the collective good.

An individual or group public action writing activity; estimated time ~1 class period

- The teacher should choose, or allow students to vote on, the method for civic engagement. Examples include a debate, writing a petition, or writing a letter to the newspaper or a legislative representative. Students should choose a historically accurate water related topic (taxes, water, street use, development, architecture) on which to focus. (See Attachment C for debate resources and see Attachment D for additional primary sources to help develop arguments.)
  Note: If considering different points of view and current conditions have already led the students to discover that the people of the city had a civic responsibility to develop a water distribution system, a good topic for debate could be architecture and expense on aesthetics.

- Students should explore what defines “community” and how “collective responsibility” became a tenet of Philadelphia (among other cities) policy.

D. EXTENSIONS:

Civic Engagement:

Students research various methods of civic engagement and discussion focusing on historical examples or modern methods.

Students can poll classmate opinions on types of civic engagement and create graphs or pie charts to display results.

Students can research historical tax rates and living costs and compare them to today. Use graphs or charts to display the data.

Historical Perspective:

Visit or explore online a local American Art Collection (Philadelphia Museum of Art or Pennsylvania Academy of Fine Arts) from this time period (early 1800s) Compare and contrast the works of art. Discuss and learn about style, color, form, and presentation.

A sociological connection from the painting to historical newspaper documents about celebrations of the time, public gatherings, or public news could also link students to the world of the painting and help them understand different kind of historical documents.

Social Studies/History:

Take a trip to Old City and/or the historic section of Philadelphia and explore the neighborhoods from a "historical water" perspective.
Science:

Discuss waterborne diseases. Assign each student one of five waterborne diseases (cholera, giardiasis, shigellosis, amebiasis, and cryptosporidiosis). Students research the assigned disease and create a brief report including transmission, symptoms, prevention, treatment and when the disease was discovered.

Comparing Cities:

Find contemporary (1800) water supply/public health challenges in comparable cities like Philadelphia and New York, Chicago or Boston (Carl Smith discusses at length) and compare. This comparison could “flow” nicely into an engineering lesson on 3 different engineering solutions related to the source of water (river, aqueduct, lake).
VIII. EVALUATION

FORMATIVE ASSESSMENTS

A. Student work accompanying Fever, 1793 and/or Fever: History Making Productions
B. Written description of Philadelphia scene
C. Revisions of written description based on study of primary sources
D. Illustration of Philadelphia scene
E. Revisions of illustration based on study of primary sources
F. Participation in Civil Discourse and Engagement
G. Writings and reflections accompanying analysis of Krimmel painting.

SUMMATIVE ASSESSMENTS:

A. Students write a newspaper column announcing the new water supply system—describing the problem solved, referencing the historical texts or images.
B. The students create a radio broadcast about the new water supply system, complete with sound effects, like a “That Was the Year That Was” by Tom Lehrer.
C. Students compare media articles and accounts from the 1793 Yellow Fever Epidemic to a modern day epidemic and consider the differences in awareness, science, medicine, public services, etc.
D. Rewrite a portion of Fever, 1793 from the point of view of an African American citizen.
ATTACHMENT A: GUIDED IMAGERY RESOURCES AND SCRIPT

For more information on leading guided imagery, visit Classroom Strategies for Interactive Learning: Guided Imagery or Reading Rockets: Visual Imagery.

SCRIPT:

Imagine you are sitting by the front door of your home on Dock St. It is summer in Philadelphia, a dry summer. There has been no rain to wash away the filth and stink in the gutters yet, and you can see and smell rotting food, and human and animal waste. You can hear the dock, busy as ever, with ships arriving and sailors and dock workers yelling to unload and move wooden crates onto horse-drawn carts. You know the yelling will last until every crate has been moved, and given the heat, the horses will be moving slower than ever.

The smell, that rich, putrid, smell of litter and rich decay, draws your attention back to your street. You watch as one of the horse carts from the dock slowly makes it way past, the horse’s shoes clacking clip clop clip clop on the parts of the street that are cobbled with stone or brick. The city hasn’t completed the cobblestones everywhere yet, so there is some occasional quiet as the horse steps on dry, packed dirt instead of stone.

Around the horse cart people walking by wipe their brows due to the heat, even though it is early morning. You can feel your woolen shirt sticking to your back, and you hope the itchiness goes away eventually. Your sweat drips down your back, and you shuffle in your wooden, straight-backed chair to scratch the itch and stop the bead of sweat.

You watch the women with baskets returning from the market, where the available vegetables and flowers are already starting to wilt. The smell of meat is fresh, but without cool places to keep it in your home, you know it will have to be eaten soon to keep the maggots and flies from getting to it. In the winter a cool box is easier to manage, but the summer heat is oppressive.

The sound of chatter from your neighbor's homes, just a few feet away on both sides, starts up, and you know your neighbors have risen for the day. You hear the new baby on the first floor crying, more like wailing, and one of the six children run to it. You can hear the pounding run across the wooden slats, and even feel a little of the jostling against the wall. If the baby cries all day you may not get to run through the streets to the dock with your friend to watch the unloading and see the ships. You hope for calm.
Place of first Meeting.

Philadelphia was named as being the nearer the center of the colonies where the Commissioners would be well and cheaply accommodated. The high-roads through the whole extent, are for the most part very good, in which forty or fifty miles a day may very well be and frequently are travelled. Great part of the way may likewise be gone by water. In summer-time the passages are frequently performed in a week from Charles Town to Philadelphia and New York; and from Rhode Island to New York through the Sound in two or three days; and from New York to Philadelphia by water and land in two days, by stage-boats and wheel-carriages that set out every other day. The journey from Charles Town to Philadelphia may likewise be facilitated by boats running up Chesapeake Bay three hundred miles. But if the whole journey be performed on horseback, the most distant members, (viz. the two from New Hampshire and from South Carolina) may probably render themselves at Philadelphia in fifteen or twenty-days; the majority may be there in much less time.

Excerpted From: Reasons and Motives for the Albany Plan of the Union by Benjamin Franklin 1779 (Getting to Philadelphia)

To the Surprize of all the Inhabitants on Delaware, who live above Philadelphia, the Water about a Fortnight since, chang’d to a dark dirty Red, so thick that ‘tis said the Fish could scarce see to get out of the Way of Boats, and were frequently struck by the Oars. Those who have lived here above these forty Years, say they never saw or heard of the like before. It was accompanied with a Fresh, ‘tis true, but not very considerable when compar’d with such as come down almost every Year without such Change of Colour; and ‘tis advis’d from Places 40 Mile above the Falls, that they have had no great Rains there. Those who have caused some of the Water to settle, find a Sort of fine brown Earth at the Bottom; but it must be a prodigious Quantity to colour this vast River in such a Manner. The Conjectures of People are various concerning the Cause of it; some imagine an upper Creek, dam’d by Logs, has chang’d its Course and dug a new Bed; others, (hearing from New York, that about the same Time a Flood came down that River from the Mountains, though they had had no Rain, and overflow’d the low Lands, doing great Damage) conceive, that an Earthquake near the Head of both Rivers, has forced out a Quantity of subterraneous Water into them. These however are only Conjectures, Time may possibly make us wiser. In the Interim, we have the Satisfaction to observe, that the River clears sensibly, and we hope will soon recover its wonted purity.

Printed in Extracts from the Gazette, 1732 by Benjamin Franklin, July 10, 1732. (Description of Discolored Delaware)
Our City, tho’ laid out with a beautiful Regularity, the Streets large, strait, and crossing each other at right Angles, had the Disgrace of suffering those Streets to remain long unpav’d, and in wet Weather the Wheels of heavy Carriages plough’d them into a Quagmire, so that it was difficult to cross them. And in dry Weather the Dust was offensive. I had liv’d near the Jersey Market, and saw with Pain the Inhabitants wading in Mud while purchasing their Provisions. A Strip of Ground down the middle of the Market was at length pav’d with Brick, so that being once in the Market they had firm Footing, but were often over Shoes in Dirt to get there. By talking and writing on the Subject, I was at length instrumental in getting the Street pav’d with Stone between the Market and the brick’d Foot-Pavement that was on each Side next the Houses. This for some time gave an easy Access to the Market, dry-shod. But the rest of the Street not being pav’d, whenever a Carriage came out of the Mud upon this Pavement, it shook off and left its Dirt upon it, and it was soon cover’d with Mire, which was not remov’d, the City as yet having no Scavengers. After some Enquiry I found a poor industrious Man, who was willing to undertake keeping the Pavement clean, by sweeping it twice a week and carrying off the Dirt from before all the Neighbours Doors, for the Sum of Sixpence per Month, to be paid by each House. I then wrote and printed a Paper, setting forth the Advantages to the Neighbourhood that might be obtain’d by this small Ex pense; the greater Ease in keeping our Houses clean, so much Dirt not being brought in by People’s Feet; the Benefit to the Shops by more Custom, as Buyers could more easily get at them, and by not having in windy Weather the Dust blown in upon their Goods, &c. &c. I sent one of these Papers to each House, and in a Day or two went round to see who would subscribe an Agreement to pay these Sixpences. It was unanimously sign’d, and for a time well executed. All the Inhabitants of the City were delighted with the Cleanliness of the Pavement that surrounded the Market, it being a Convenience to all; and this rais’d a general Desire to have all the Streets paved; and made the People more willing to submit to a Tax for that purpose.

Philadelphia has more than 3000 houses and more than 20,000 inhabitants. The city is regularly laid out, the streets are all at right angles; they are extended every year and new houses are always being built beyond the first boundary. The houses are almost all of brick, like most of those in London. Philadelphia is quite open to attack, and has only one battery on the river, to protect the city against invasion. Here and there are a few forts to protect the settlers from the Indians.
Original: An Account of the Yellow Fever Outbreak

The fever from all that I can learn is monstrous. However, yesterday a vast number of burials – I do not expect any abatement of the fever before we have rain and high winds. The day before yesterday we were witness to the shocking – a Coffin was brought to the entrance of Welsh's alley, where it stayed sometime for the mortuaries then before he was put into the Coffin, such hurry must bury many alive.

New York 14th October 1793

The mail is arrived. There are letters but none from friends. The malady in Philad. continues dreadful, one hundred and thirty-seven were buried on Sunday last by the Committee independent of many who were buried by their friends. Fifty eight were carried from Bush hill to Potter's field Thursday last.

Deaths on the 11th Oct.

T. D. Sergent Esq, Mr. Keppel, Major Franks, Jacob R. Howell, Revd. Mr. Winkhouse, Reverend Messrs Fleming & Griswold, Baldwin the druggist, Speakman the druggist, Gallagher Chima Merch, O.C. Hull apothecary, Evans of the firm of Evans & Hunts, M. M. Metsker, M. Kay surviving partner of A. Clare M. Krafe, Major Barker and his wife, Owen Jones &c.
Excerpted from: Carey, Mathew. A short account of the malignant fever, lately prevalent in Philadelphia: with a statement of the proceedings that took place on the subject in different parts of the United States. 1793.

On the 16th, the managers of Bushhill, after personal inspection of the state of affairs there, made report of its situation, which was truly deplorable. It exhibited as wretched a picture of human misery as ever existed. A profligate, abandoned set of nurses and attendants (hardly any of good character could at that time be procured,) rioted on the provisions and comforts prepared for the sick, who (Page 32) (unless at the hours when the doctors attended) were left almost entirely destitute of every assistance. The sick, the dying, and the dead were indiscriminately mingled together. The ordure and other evacuations of the sick were allowed to remain in the most offensive state imaginable. Not the smallest appearance of order or regularity existed. It was, in fact, a great human slaughter-house, where numerous victims were immolated at the altar of riot and intemperance. No wonder, then, that a general dread of the place prevailed through the city, and that a removal to it was considered as the seal of death. In consequence, there were various instances of sick persons locking their rooms, and resisting every attempt to carry them away. At length, the poor were so much afraid of being sent to Bushhill, that they would not acknowledge their illness, until it was no longer possible to conceal it; for it is to be observed, that the fear of the contagion was so prevalent, that as soon as any one was taken ill, an alarm was spread among the neighbours, and every effort was used to have the sick person hurried off to Bushhill, to avoid spreading the disorder. The cases of poor people forced in this way to that hospital, though labouringly under only common colds, and common fall fevers, were numerous and afflicting. There were not wanting instances of persons, only slightly ill, being sent to Bushhill, by their panic-struck neighbours, and embracing the first opportunity of running back to Philadelphia.

These regulations, the order and regularity introduced, and the care and tenderness with which the patients, were treated, soon established the character of the hospital; and in the course of a week or two, numbers of sick people, who had not at home proper persons to nurse them, applied to be sent to Bushhill. Indeed, in the end, so many people, who were afflicted with other disorders, procured admittance there, that it became necessary to pass a resolve, that before an order of admission should be granted, a certificate must be produced from a physician, that the patient laboured under the malignant fever; for had all the applicants been received, this hospital, provided for an extraordinary occasion, would have been filled with patients whose cases entitled them to a reception in the Pennsylvania hospital.

The number of persons received into Bushhill, from the 16th of September to this time, is about one thousand; of whom nearly five hundred are dead; there are now (Nov. 30.) in the house, about twenty sick, and fifty convalescents. Of the latter class, there have been dismissed about four hundred and thirty.

The reason why so large a proportion died of those received, is, that in a variety of cases, the early fears of that hospital had got such firm possession of the minds of some, and others were so much actuated by a foolish pride, that they would never consent to be removed till they were past recovery. And in consequence of this, there were many instances of persons dying in the cart on the road to the hospital. I speak within bounds, when I say that at least a third of the whole number of those received, did not survive their entrance into the hospital two days. Were it not for the operation of these two motives, the number of (Page 35) the dead in the city and in the hospital would have been much lessened; for many a man, whose nice feelings made him spurn at the idea of a removal to the hospital, perished in the city for want of that comfortable assistance he would have had at Bushhill*. 
The regulations adopted at Bushhill, were as follow
[s]

One of the rooms in the mansion house (which contains fourteen, besides three large entries) was allotted to the matron, and an assistant under her—eleven rooms and two entries to the sick. Those who were in a very low state were in one room— and one was appointed for the dying. The men and women were kept in distinct rooms, and attended by nurses of their own sexes. Every sick person was furnished with a bedstead, clean sheet, pillow, two or three blankets, (Page 33) porringer, plate, spoon, and clean linen, when necessary. In the mansion house were one hundred and forty bedsteads. The new frame house, built by the committee, when it was found that the old buildings were inadequate to contain the patients commodiously, is sixty feet front, and eighteen feet deep, with three rooms on the ground floor; one of which was for the head nurses of that house, the two others for the sick. Each of these two last contained seventeen bedsteads. The loft, designed for the convalescents, was calculated to contain forty.

The barn is a large, commodious stone building, divided into three apartments; one occupied by the resident doctors and apothecary; one, which contained forty bedsteads, by the men convalescents—and the other by the women convalescents, which contained fifty-seven.

At some distance from the west of the hospital, was erected a frame building to store the coffins, and deposite the dead until they were sent to a place of interment.

Besides the nurses employed in the house, there were two cooks, four labourers, and three washerwomen, constantly employed for the use of the hospital.

The sick were visited twice a day by two physicians, Dr. Deveze and Dr. Benjamin Duffield*, whose prescriptions were executed by three resident physicians and the apothecary.

One of the resident doctors was charged with the distribution of the victuals for the sick. At eleven o’clock, he gave them broth with rice, bread, boiled (Page 34) beef, veal, mutton, and chicken, with cream of rice to those whose stomachs would not bear stronger nourishment. Their second meal was at six o’clock, when they had broth, rice, boiled prunes, with cream of rice. The sick drank at their meals porter, or claret and water. Their constant drink between meals was centaury tea, and boiled lemonade.
ATTACHMENT C – DEBATE RESOURCES

Video: How to Debate (Atlanta Urban Debate)

Introductory video on how to debate. We recommend breaking the video into pieces to discuss with students.
- Recommended: 0:00-7:00

Video: Read, Discuss, Debate: Evaluating Arguments (Teaching Channel)

Watch a teacher introduce debating to her students and see the results. We recommend reading the comments below the video for further ideas.

Article: It's Up for Debate (Education World)

Includes links to five debate methods for potential use.
- Recommended: Education World's "More Resources" on debate rules, rubrics, topics, and lesson plans page

PDF Document: Welcome to Debate (Saskatchewan Elocution and Debate Association)

PDF with guidelines for debate as well as printable cards, worksheets, and speech structures.
- Recommended: Pages 4-6
In 1799, Dr. Currie gave this advice: (p. 9)

My observations however incline me to believe, that although the yellow fever is never generated in this country, it is communicated from one to another more readily and certainly when the atmosphere is replete with putrid exhalations, than when it is more pure or free from such exhalations. Prudence, therefore, dictates the propriety of removing from the city and its vicinity all putrifiable substances, and to promote coolness and ventilation during the hot season, as far as practicable...

The English traveler, James Melish, wrote: (p. 43)

It is of great importance to these works, that they are the property of the public, and not subject to individual speculation, in consequence of which the supply is liberal, and there are fountains in every street to which the whole public have access. The water can be used for watering the streets, or extinguishing fires, as often as may be necessary; while every householder, by paying a reasonable compensation can have a hydrant in any part of his premises that he pleases, even to the attic story. In short, this water is a great luxury, and is, in my opinion, of incalculable advantage to the health, as it certainly is to the convenience and comfort of the community.

Noah Webster stated the matter thus: (p. 9)

I am persuaded that the Americans may be convinced by facts, that even in our-climate, Epidemic and Pestilential Maladies may be generated by local causes. If they can be convinced of this, that sources of disease and death may be found among themselves created by their own negligence, it is a great point gained; for until they learn this, they will never attend to the means of preserving life and health. They will still wallow in filth, crowd their cities with low dirty houses and narrow streets; neglect the use of bathing and washing; and live like savages, devourirlg, in hot seasons, undue quantities of animal food at their tables, and reeling home after midnight debauches.
ATTACHMENT E: KRIMMEL, JOHN LEWIS, *FOURTH OF JULY IN CENTRE SQUARE*,
ATTACHMENT F: WATER BORNE DISEASE CHART

Name: ____________________________
Date: __________________________

Use the following website to obtain your information:
www.cdc.gov

Disease Name: ____________________________

<table>
<thead>
<tr>
<th>Organism Scientific Name</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td>How long until symptoms appear?</td>
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<tr>
<td></td>
<td>Symptoms</td>
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<td></td>
<td>Treatment</td>
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<td></td>
<td>Prevention</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Year that Disease Was Discovered</td>
</tr>
</tbody>
</table>
## ATTACHMENT G: WATER BORNE DISEASE SCORING TEMPLATE

Name: ____________________________________  
Date: ____________________

<table>
<thead>
<tr>
<th>Category</th>
<th>Score out of 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Organizer Completed</td>
<td>____</td>
</tr>
<tr>
<td>Scientific name written correctly</td>
<td>____</td>
</tr>
<tr>
<td>Cause of disease (type of disease and transmission)</td>
<td>____</td>
</tr>
<tr>
<td>Common symptoms and incubation period</td>
<td>____</td>
</tr>
<tr>
<td>Treatment</td>
<td>____</td>
</tr>
<tr>
<td>Prevention measures</td>
<td>____</td>
</tr>
<tr>
<td>Year of discovery</td>
<td>____</td>
</tr>
<tr>
<td>Picture or illustration</td>
<td>____</td>
</tr>
<tr>
<td>Spelling and grammar</td>
<td>____</td>
</tr>
</tbody>
</table>

Total: _____ out of 45 = _____%

---

Name: ____________________________________  
Date: ____________________

Water Borne Disease Rubric

<table>
<thead>
<tr>
<th>Category</th>
<th>Score out of 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Organizer Completed</td>
<td>____</td>
</tr>
<tr>
<td>Scientific name written correctly</td>
<td>____</td>
</tr>
<tr>
<td>Cause of disease (type of disease and transmission)</td>
<td>____</td>
</tr>
<tr>
<td>Common symptoms and incubation period</td>
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<tr>
<td>Treatment</td>
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<tr>
<td>Prevention measures</td>
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<tr>
<td>Year of discovery</td>
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<tr>
<td>Picture or illustration</td>
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</tr>
<tr>
<td>Spelling and grammar</td>
<td>____</td>
</tr>
</tbody>
</table>

Total: _____ out of 45 = _____%
<table>
<thead>
<tr>
<th>Timeline of Major Events in Philadelphia’s Water History</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1790s-1800s:</strong> Yellow fever epidemics cause widespread panic; residents believe contaminated water supply is the cause. Watering Committee formed in 1799 to provide clean water.</td>
</tr>
<tr>
<td><strong>1801-1820s:</strong> Centre Square distribution system transports water pumped from the Schuylkill River. New pumping station and reservoir built at “Faire Mount”, the highest point of the city.</td>
</tr>
<tr>
<td><strong>1820-1850s:</strong> Fairmount Dam and millhouse harness the hydropower of the Schuylkill River. Efficient hydraulic turbines replace traditional breast water wheels.</td>
</tr>
<tr>
<td><strong>1855:</strong> City purchases land along the Schuylkill River to protect the water supply. Land purchases continue through the 1890s, creating several thousand acres of buffer known as Fairmount Park, the world’s largest urban park.</td>
</tr>
<tr>
<td><strong>1860s:</strong> The Civil War spurs massive industrial development and the coal industry thrives. City water managers’ ability to provide reliable water supply system plays a pivotal role in Philadelphia becoming the first major industrialized U.S. city. Use of the river for waste disposal leads to crisis: Typhoid.</td>
</tr>
<tr>
<td><strong>1880s:</strong> Annual typhoid outbreaks drive up death counts; medical reports point to contaminated drinking water as the source of the epidemics.</td>
</tr>
<tr>
<td><strong>1890s:</strong> Citizens push for city government to build filtration plants to treat water supplies and stop annual typhoid outbreaks. The city weighs piping clean water to the city from distant locations, but all plans are rejected. Privatization is proposed and rejected.</td>
</tr>
<tr>
<td><strong>1902-1912:</strong> After many political and financial delays, the city builds 5 filtration plants to treat drinking water and stop epidemics. Industrial and domestic wastes continue to flow into the river, degrading water quality further.</td>
</tr>
<tr>
<td><strong>1913:</strong> The city treats its water supply with chlorine and disease rates plummet. River water quality continues to deteriorate from increasing amounts of waste.</td>
</tr>
<tr>
<td><strong>1914:</strong> The city’s master plan for sewer and sewage treatment system receives wide acclaim from water managers, but is not put into place.</td>
</tr>
<tr>
<td><strong>1950-1966:</strong> Over 30 years after conception, the city constructs three sewage treatment plants and associated sewers.</td>
</tr>
<tr>
<td><strong>1970s-Present:</strong> Increasingly stringent government regulations drive engineering advances in water and wastewater treatment. Stormwater management becomes a priority.</td>
</tr>
</tbody>
</table>
X. RESOURCES FOR TEACHERS AND STUDENTS

Resources for Teachers:
resourcewater.org, Toolbox!


Relevant sections:
- Module 3 - Other Systems Before Philadelphia’s Public Water Supply
- Module 4 - Philadelphia Builds a Public Water System at Centre Square, 1801-15

Print URL: https://canvas.instructure.com/courses/25754?invitation=cyzGNGU06O6EC1dLXl
OQdCVWrh29LRqwsKK0uIPb


Relevant sections:
- Excerpt from Chapter 1
- For select first-hand accounts, see Appendix C.


History Making Productions Fever: 1793 Teacher Materials
Print URL: http://www.historyofphilly.com/wp-content/uploads/2015/02/Microsoft-Word-TEACHER-Yellow-Fever-
Lesson_Revised_Version-2.docx.pdf

History Making Productions Fever: 1793 Student Materials

Philadelphia: The Great Experiment (Go to “Watch” and “1790-1820 Fever” for webisodes to accompany 1793 Teacher and Student Materials)
Print URL: http://www.historyofphilly.com/media/#http%3A%2F%2Fi.historyofphilly.portalbounce.com%2Fen%2Fuser-media-library.html%3Faid%3D213

Classroom Strategies for Interactive Learning: Guided Imagery
Print URL: http://teach.clarkschools.net/jbernhard/Literacy_Web/Web_Files_Literacy/Guided_imagery_Buehl.pdf

Reading Rockets: Visual Imagery
Print URL: http://www.readingrockets.org/strategies/visual_imagery

PGWI: Philadelphia Lessons in Sustainability, Time line for Water History
Print URL: http://www.pgwi.org/documents/Philalessonsinsustainability.pdf

RESOURCES FOR STUDENTS

NON-FICTION/FIRST-PERSON SOURCES


Relevant sections:
- Chapter 2 – True Blue

Relevant sections: On the webpage, click “agree” to access the sections without searching.

- Extracts from the Gazette, 1732 – description of discolored Delaware River.
- Reasons and motives for the Albany Plan of the Union – description of travel to and from Philadelphia by land and water; see “Place of First Meeting”

Print URL: http://franklinpapers.org/franklin/framedVolumes.jsp?vol=7&page=199a

Unknown. An account of the yellow fever outbreak in Philadelphia. October 11-14, 1793. [Access original document here; Access transcript here.]
Print URL: https://www.gilderlehrman.org/sites/default/files/content-images/02437.05942.web_.jpg

Carey, Mathew. A short account of the malignant fever, lately prevalent in Philadelphia: with a statement of the proceedings that took place on the subject in different parts of the United States. 1793. Web. [Access original document here; Access transcript here.]
Print URL: http://www.usgwarchives.net/pa/philadelphia/history/yellowfever1793.pdf

FICTION SOURCES

Print URL: http://www.gutenberg.org/ebooks/18508


Print URL: http://www.southamptonschools.org/webpages/ecullings/classroom.cfm?subpage=1785848

VISUAL SOURCES
Understanding the Urban Watershed
Unit Two
Learning Experience Two
Krimmel, John Lewis, *Fourth of July Celebration in Centre Square, 1819.*


Krimmel, John Lewis, *Fourth of July Celebration in Centre Square, 1812*

Print URL: http://commons.wikimedia.org/wiki/File:'Fourth_of_July_in_Center_Square'_by_John_Lewis_Krimmel.JPG


Print URL: http://www.metmuseum.org/collection/the-collection-online/search/12734

Köllner, Augustus, *Near East Park, Phila. (29th and Fairmount), 1860*

Print URL: http://www.aradergalleries.com/prints/images/901_Philade/kollner_east_park.jpg

Access: [Online collection with High-res versions here](http://teachingamericanhistory.org/convention/birch/).

Print URL: http://teachingamericanhistory.org/convention/birch/

Wild, John Caspar, *Untitled painting of the Fairmount Water Works in Philadelphia, 1834*

Print URL: http://www.the-athenaeum.org/art/full.php?ID=130254
I. ESSENTIAL QUESTIONS

Why do human beings decide to engineer a solution for water delivery?

How can an engineered system aid in the delivery of water?

What naturally occurring systems can aid in the delivery of water?

II. STUDENT UNDERSTANDINGS

Engineering advancements and human ingenuity provide solutions to the problems of accessibility to clean, fresh drinking water in both densely and non-densely populated areas.
III. STUDENT OBJECTIVES

Students will explore various water distribution methods in order to determine best practices.

Students will be able to...engineer and/or build a water distribution model using pumps, pipes, water wheels, gears, and/or gravity.

Students will be able to explain the role that gravity plays in an engineered system of distributing water throughout a city.

IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts | • Read (and view), analyze and connect scientific and historic text to personal experiences.  
|• Write reactions to material through note-taking, reflecting and informative text  
|• Research water delivery systems  
|• Present information |
|---|---|
| Science | • Engineering practices  
|• Gravity  
|• Pumps, Gears, Water Wheels (Simple and Compound Machines) |
| Social Studies | • History of Water Delivery systems  
|• Implications of Engineered Water Delivery System (or lack thereof) on civilization, community, family, individual |
| Math | • Calculations related to weight of water and to engineering a water distribution system  
|• Calculations related to map scale and to carrying water |
| Careers | • Firefighter  
|• Civil Engineer  
|• Environmental Engineer |
V. SETTING THE STAGE AND HELPFUL VOCABULARY

In the early 1800’s, Philadelphians were able to benefit from an engineered solution to their drinking water problem. These benefits were both social and economic. Engineering a system of pumps, pipes, waterwheels, gears, hydrants, and reservoirs made water delivery convenient and abundant.

Helpful Vocabulary:

Aqueduct (noun)
An artificial channel for conveying water, typically in the form of a bridge supported by tall columns across a valley.

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.

Hydrant (noun)
An upright water pipe, especially one in a street, with a nozzle to which a fire hose can be attached.

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

Steam Engine (noun)
An engine that uses the expansion or rapid condensation of steam to generate power.

Turbine (noun)
A machine for producing continuous power in which a wheel or rotor, typically fitted with vanes, is made to revolve by a fast-moving flow of water, steam, gas, air, or other fluid.

Water Tower (noun)
A tower supporting an elevated water tank, whose height creates the pressure required to distribute the water through a piped system.

Water Wheel (noun)
A large wheel driven by flowing water, used to work machinery or to raise water to a higher level.
VI. MATERIALS AND PREPARATION NEEDED

Engage Activity (Bucket Brigade)

Materials:
- 10 buckets (or containers)
- Water source (hose, sink)
- Tank for Collecting Water

Preparation: This activity is recommended as an out-of-doors activity. As students may get wet, teachers may want to notify parents in advance so dry clothes are available if necessary.

Explore and Explain: (Learning Stations)

Materials:

Station #1: Water is Heavy!
- Gallon Containers
- Scale (optional)
- Watershed Journal
- Worksheet (Attachment A)

Station #2: Mapping the Route to Water
- Map of Philadelphia
- Rulers appropriate to scale of map
- Calculators
- Worksheet (Attachment B)
- Reading Material
  - A Long Walk to Water
  - Water Wheel Lightens the Load in Developing Nations
  - Women Spend 40 Billion Hours Collecting Water

Station #3: Pump Station
- Pump with plunger
- Marbles
- Two buckets and water
- Towels and sponges for clean up
- Watershed Journal
- Pump Diagram (Attachment C)
Station #4: Engineering Systems for Moving Water
- Containers of various sizes
- Cups
- Straws
- Tubes
- Buckets
- Gears/axles
- Wood
- Hot glue gun
- Watershed Journal
- So Many Ways to Transport Water (Attachment D)
- Reading Material--
  - How Stuff Works-Water Towers
  - How Stuff Works-Aqueducts
  - USGS Wells
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE AND EXTEND

A. ENGAGE STUDENTS WITH A BUCKET BRIGADE. (1 CLASS PERIOD)

- Take students outside.
- Form a bucket brigade with the goal of filling a tank or putting out a mock fire.
- Lead students fill their buckets from a water source (hose or sink) and then buckets are passed down the line. Do not wait for one bucket to get to the end of the line before sending the next one.
- Students at the end of the line bring the buckets back to the beginning.
- Students can use their Watershed Journal to record their observations and reactions to the bucket brigade. They can write about the pros and cons of using this method of water delivery.

Share the following information with students: Bucket Brigades were originally used to put out fires directly. Later, Bucket Brigades were used to fill a reservoir so that a pump could then spray water on a fire. Benjamin Franklin started the first fire company in Philadelphia in 1736. For more information, visit FWW Water Course: Philadelphia: Colonial Settlement to U.S. Capital, 1682-1801 and Philadelphia Fire Fighting History Timeline

B. LEARNING STATIONS TO EXPLORE AND EXPLAIN WATER DISTRIBUTION SYSTEMS. (3-6 CLASS PERIODS-INCLUDES ELABORATION TIME)

(Note: These learning stations can also be conducted as whole class activities. We encourage you to organize the learning stations or whole class activities so that the students can work on the Reading, Writing and Reflection “Elaboration” Assignments between explorations. All worksheets can be found in the Attachments.

Station #1: Water is Heavy

Fill several “gallon jug” containers with water and place them in a designated area. Students will answer questions and solve math problems about these gallons.

- Students will predict the weight of a gallon of water. If scales are available, students can weigh the gallon to determine accuracy. (Remind students to weigh empty gallon container first!) If a scale is not available, students can calculate the weight using the information that one cup of water weighs 8 ounces.
- Assign students the task of carrying water for five minutes.
- Fill out the accompanying worksheet to determine the weight of water that must be moved daily for each person.
Station #2: Mapping the Route to Water

(To help students get started, mark the location of your school on the map. FWW can provide a map of watersheds that includes area schools. Students may need help figuring out how to use the scale of the map. Group students accordingly so that they can help each other.)

Students will follow a series of guided questions to help them figure out the distance to a local water source and how that distance will affect the distribution of water.

Station #3: Pump Station

(Note: For instructions on how to set up the pumps, visit Pump Directions from FWW Toolbox. Watch the video link. If you already have a pump that just needs to be assembled, the video will provide those directions as well. The piston (plunger) has been re-engineered so you can skip steps regarding the plunger. Try the pump before you ask your students to try it. Have 2-3 students learn how to use the pump so they can be resources while you are busy with other stations.)

- Assign the task of getting water from a low elevation to a higher elevation using the pump. Provide a photograph (Attachment C) of the finished pump.
- Designate a student to be pump engineer who can demonstrate where the marbles go, how the pump works, and who can do a bit of trouble shooting.
- Have students fill out accompanying worksheet. (Attachment C)

Station #4: Engineered Systems for Moving Water

Using materials (both found and supplied), students will design and test water delivery systems.

- Students can design and test a water wheel with cups, plates, and an axle. They can test different variables such as cup size, water flow, and waterfall height to develop an effective system. For the water wheels to demonstrate an engineered system for moving water, the axles will need to be attached to a piston that pumps or moves water. If the water wheels are not attached to some form of piston, be careful that the students are not led to believe that water falling through the water wheel equates to a water distribution system.
- Students can use found objects to create a Rube Goldberg type contraption to move water with the aid of gravity.
- Students can test the role of gravity by engineering a gravity fed irrigation system.
C. ELABORATE ON THE LEARNING STATIONS (READ, WRITE, AND REFLECT)

Elaboration for All Stations:

- Have students view Fairmount Water Works Film.
- Take a trip to Philadelphia’s Fairmount Water Works to view the historically significant site which was engineered to distribute water in a rapidly developing city.

(Note: Students should work on the following reading, writing and reflection assignments between learning stations.)

Elaboration for Station #1 Water is Heavy (Writing and Reflection)

- Students can use their “Watershed Journal” to record observations and thoughts about how they carried the gallon of water. They can also make suggestions about better ways to carry water and how to move water without having to carry it.

- Students can review their Water Use Data to determine how much water they need in a day. (They can also use the 87 gallon statistic.) Will their solution from the worksheet be able to provide that amount of water in a day?

Elaboration for Station #2: Mapping the Route to Water (Reading, Reflecting, Writing)

Read material related to Water Access in Developing Nations. Suggestions include:

- Park, Linda Sue A Long Walk to Water Clarion Books 2010
- Water Wheel Lightens the Load in Developing Nations
- Women Spend 40 Billion Hours Collecting Water
- Use their “Watershed Journal” to reflect on reading material and to relate the reading material to the mathematical calculations concerning water portage. Compare and contrast usage and water delivery in developing nations to usage and water delivery in Philadelphia.

Elaboration for Station #3: Pump Station (Reflection and Writing)

Have students discuss the following in their small group:

- Why would we want to move water from a low elevation to a high elevation?
- What force are you working against to pump water uphill?
- What are some sources of energy that could be used to operate a pump once your arm gets tired?
- Record discussion points in “Watershed Journal”
Elaboration for Station #4: Engineered Systems for Moving Water (Reading, Writing and Reflection)

Students can research different types of water delivery systems such as wells, hydrants, water wheels, water towers, pumps, gravity fed systems and aqueducts. They can determine whether these types of water delivery systems are used in Philadelphia. Students and teacher can work together to develop questions for a research guide sheet.

Suggested Reading Material:
How Stuff Works-Water Towers
How Stuff Works-Aqueducts
USGS Wells

D. Extend Beyond the Learning Stations

1) Invite a firefighter to visit to talk about careers, fighting fires, hydrants, and the use of water.

2) Invite a water department engineer to talk about careers, water delivery systems and the use of water.

3) Allow students to engage in a larger project regarding water delivery systems. This larger project could include videos, tri-fold displays, models, essays, and computerized slide shows.

4) Students can research water distribution systems in modern times in both developed and developing countries. Students can also research water distribution systems in ancient times and those that are planned for the future. Ancient, modern, and futuristic systems can be compared and contrasted.
VIII. EVALUATION OF THE LEARNING EXPERIENCE

Formative:

- Accurate completion of worksheets related to learning stations
- Entries in students’ Watershed Journal
- Engineered solutions to water delivery
- Research Projects

Summative Assessments:

- Summarize the engineering challenges associated with distributing water in a city. Illustrate or describe solutions that were developed to meet these challenges.
ATTACHMENT A: STATION #1: WATER IS HEAVY

Name: _______________________________ Date: ________________

STATION #1: WATER IS HEAVY!

1) Try carrying a gallon of water for 5 minutes.

2) How much do you think one gallon of water weighs in pounds? __________

3) Calculate the actual weight (in pounds) of one gallon of water.

Helpful Hints:
One Gallon = 16 Cups of Water
One Cup of Water = 8 ounces
One Pound = 16 ounces

The average quantity of water people in Philadelphia consume in one day is 87 gallons!
(Drinking, cleaning, showers, dishwashing, laundry, etc.)

4) Calculate the weight of 87 gallons of water.

5) If you did not have a sink or a faucet in your home or in your neighborhood, where would you go to get your water? How would you get that water to your home?

______________________________________________________________________________

______________________________________________________________________________
ATTACHMENT B: STATION #2: MAPPING THE ROUTE TO WATER

STATION #2:
MAPPING THE ROUTE TO WATER
HOW FAR WILL YOU GO TO GET WATER?

1) Find your school on the map. Find the scale on the map. Record the scale here: __________

Use a ruler to measure the distance from the school to the nearest water source (stream or river). Record that distance here: __________

Use the map scale to determine how far it would be to your nearest water source (stream or river).

Example: My map has a scale of 2 inches = 1 mile. I measured the distance on the map between my school and the river to be 5 inches. 2 inches = 5 inches ? miles = 5/2 = 1 mile

? miles 2 ½ miles to the river

Set up your own proportion to figure out how far it is to the nearest water source. Solve.

2) How long would it take you to walk to the water source if you walked at a rate of 2 miles per hour?

Example: I have to walk 2 ½ miles to the river. I walk at a rate of 2 miles per hour.

2 miles 2.5 miles ? hours = 2.5/2 = 1.25
1 hour ? hours It will take 1 ¼ hours to walk to the river

Set up a proportion to figure out how long it would take you to walk to a water source.

3) Now you have to walk back, so double your answer to number 2! (Consider also that you are walking up hill on the way back and that you are carrying a gallon of water—Phew!)

Understanding the Urban Watershed

Unit Two
Learning Experience Three
4) If you need 87 gallons of water, how much time will it take to carry 87 gallons from the water source back to the school? You can carry 3 gallons (24 pounds) per trip. Remember that you need to go get water AND bring it back.

Example:
It takes me 2 ½ hours to make a trip to the river and back. Since I can carry 3 gallons at a time, I need to make 29 trips. (87/3)

29 * 2.5 = 72.5
It will take me 72.5 hours to carry 87 gallons. I don’t have enough hours in a day!

Carrying water isn’t working. There are not enough hours in a day to carry 87 gallons from the water source back to the school. What are some solutions to this problem?

Your Turn:
ATTACHMENT C: PUMP DIAGRAM

STATION #3: CAN YOU GET THIS PUMP TO WORK?

Your job is to get water from a low spot to a high spot and to work against gravity! Use the materials provided to build a pump. Consult the photograph and/or the pump engineer if you get stuck.

Write a sequence of directions that someone else could follow to build the pump. Include directions and trouble-shooting.
ATTACHMENT D: SO MANY WAYS TO TRANSPORT WATER

STATION #4: SO MANY WAYS TO TRANSPORT WATER

Water is heavy! People all over the world have met the challenge of moving water in different ways. Engineers have the job of helping people with that challenge. This station is your chance to engineer your own water delivery model and to learn more about water delivery systems all over the world.

1) Use the materials provided (and find some of your own) to construct a water delivery model. Some possibilities include: a hand-powered pump, a pump powered by a water wheel, and/or a gravity-fed system.

2) Do some research. Find out what types of water delivery systems are used in Philadelphia. Research different types of water delivery systems such as wells, hydrants, water wheels, water towers, pumps, gravity fed systems and aqueducts. Determine whether these types of water delivery systems are used in Philadelphia. Teachers and students can work together to develop questions to form a research guide sheet.
X. RESOURCES FOR TEACHERS AND STUDENTS

Resourcewater.org toolbox!

For Students and Teachers:
Books:
Park, Linda Sue  _A Long Walk to Water_. Clarion Books 2010

Internet Reading:
_Water Wheel Lightens the Load in Developing Nations_ This article describes an alternative to carrying water on one’s head in areas where water must be carried.
_Print URL:_ http://www.gizmag.com/wello-waterwheel-water-transport/30325/

_Women Spend 40 Billion Hours Collecting Water_ This article describes some of the issues associated with having to carry water.
_Print URL:_ http://www.ipsnews.net/2012/08/women-spend-40-billion-hours-collecting-water/

_Philadelphia Fire Fighting History Timeline_ This website features the history of fire fighting in Philadelphia
_Print URL:_ http://www.phila.gov/fire/about/about_hist_timeline.html

_How Stuff Works-Water Towers_ Article describes how water towers work.
_Print URL:_ http://people.howstuffworks.com/water.htm

_How Stuff Works-Aqueducts_ Article explains aqueducts and compares modern aqueducts in L.A> to ancient Roman Aqueducts
_Print URL:_ http://science.howstuffworks.com/environmental/green-science/la-ancient-rome.htm

_USGS Wells_ Article explains wells and how they are dug or drilled.
_Print URL:_ http://water.usgs.gov/edu/earthgwwells.html

Video:
_Fairmount Water Works Film_ This movie explains the history and engineering behind the Fairmount Waterworks.
_Print URL:_ https://vimeo.com/95017596

For Teachers:

Internet Reading:

_FWW Water Course: Philadelphia: Colonial Settlement to U.S. Capital, 1682-1801_ Visit this site for more information on fire brigades and the history of Philadelphia.

UNIT TWO: DRINKING WATER AND YOU
LEARNING EXPERIENCE 4: PUBLIC DRINKING WATER TREATMENT PROCESS EXPLAINED

Lesson Plan Overview
I. ESSENTIAL QUESTIONS  
II. STUDENT UNDERSTANDINGS  
III. STUDENT OBJECTIVES  
IV. CROSS-CURRICULAR CONNECTIONS  
V. SETTING THE STAGE AND HELPFUL VOCABULARY  
VI. MATERIALS AND PREPARATION NEEDED  
VII. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE, EXTEND  
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X. RESOURCES FOR TEACHERS AND STUDENTS

I. ESSENTIAL QUESTIONS

What is the difference between source water and tap water?

What is the point of drinking water treatment?

What are the components of water before it is treated that might be of concern to PWD and the public?

II. STUDENT UNDERSTANDINGS

In most places in the world today, even water from a relatively clean natural source probably needs to be treated before it can be consumed. Local drinking water treatment facilities, such as those operated by the Philadelphia Water Department, are designed and engineered for this task. This treatment can include a series of processes involving sedimentation, filtration and the addition of chemical compounds designed to destroy harmful organisms and to ensure the quality and taste of the water. Treatment of water for drinking can vary widely and is dependent upon available resources and local water quality.
III. STUDENT OBJECTIVES

Students will build a model of a water filtration system in order to “clean” a water sample.

Students will evaluate the design of their water filtration system in order to evaluate the design/effectiveness of their water filtration system.

Students will describe the basic steps of our local drinking water treatment process.

IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts             | • Read (and view), analyze, and connect scientific text to personal experiences  
|                                  | • Write reactions to material through taking notes, reflecting, and informative text,  
|                                  | • Research drinking water treatment process  
|                                  | • Present Information  
| Science                         | • Drinking Water Treatment Process  
|                                  | • Filtration  
|                                  | • Sedimentation  
|                                  | • Flocculation  
|                                  | • Disinfection  
|                                  | • Engineer a filtration system  
| Social Studies                   | • Geographic Implications for Drinking Water Treatment  
|                                  | • Compare source water for drinking water treatment systems  
|                                  | • History of Industrialization along the Delaware River  
| Math                            | • Volume Measurements  
|                                  | • Calculations associated with filtration and % loss  
| Career Connections              | • PWD Plant and Lab Positions— (examples engineer, chemist, biologist, plant manager)  

V. Setting the Stage and Helpful Vocabulary

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 creating a reliable and safe water supply system. 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. Many water utilities, including the Philadelphia Water Department, use the multi-step process for cleaning source water as follows: Sedimentation, Coagulation, Flocculation, Filtration and Disinfection. It is an important responsibility to provide and distribute potable (drinkable) water. Additionally, the regulatory agencies that are involved in keeping tap water safe to drink are the Environmental Protection Agency and the state’s Department of Environmental Protection or Environmental Quality. These agencies, along with the Safe Drinking Water Act, require drinking water utilities to monitor about 100 parameters (coliform bacteria, disinfectant and disinfectant by-products, lead, turbidity, etc.) on a consistent basis. A lot happens before you turn on the faucet!

Helpful Vocabulary:

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.

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).

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

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.
VI. MATERIALS AND PREPARATION NEEDED

Engage: Student Designed Filter:
Each group of 3-4 students will need the following:
- Instructor mixes “Dirty” water sample. Mix soil, oil, food coloring, leaves and water in a large beaker. Note: If food coloring is used, students will not be able to filter out the food coloring which can lead to a connection to the issues surrounding dye factories and to connections explaining why filtering alone is not sufficient.
- Plastic spoon/spatula
- Funnels
- Sand and gravel
- Screens
- 100 mL, 250 mL beakers
- Graduated cylinder (Note: the graduated cylinder gives the most accurate volume reading)
- Cotton balls or stuffing
- Coffee filter paper
- Data Sheet (*Attachment A*)

Explore/Explain: Directed Filter
Each group of 3-4 will need the following:
- Instructor mixes “Dirty” water sample. Mix soil, oil, food coloring, leaves and water in a large beaker. Note: If food coloring is used, students will not be able to filter out the food coloring which will lead to a connection to the issues surrounding dye factories and to connections explaining why filtering alone is not sufficient.
- Plastic spoon/spatula
- Funnels
- Sand and gravel
- Screens
- 100 mL, 250 mL beakers
- Graduated cylinder (Note: the graduated cylinder gives the most accurate volume reading)
- Directions and Data Sheet (*Attachments B and C*)

Elaborate: Virtual and/or Real Tour of Drinking Water Treatment Plant
- Cut out cards describing Filtration Process (*Attachment E*)
- Articles about Dye in the River (*Attachment D*)

Extension: Comparing Drinking Water Treatment Systems
- Articles about different municipalities (*Attachment F*)
- Guinea Worm- TFK article (*Attachment G*)
VII. THE LEARNING EXPERIENCE—ENGAGE, EXPLORE, EXPLAIN, ELABORATE, EXTEND

A. ENGAGE STUDENTS WITH AN ENGINEERING PROJECT (1-2 CLASS PERIODS)
Teacher introduces the dirty water sample to the students and elicits ideas to “treat” or to “purify” the water. Elicit which pollutants may be easy to filter and which may be more difficult. Teacher provides supplies and challenges students to engineer a filtration system that will clean the water. While students are working, allow some water to sit without being filtered so students can compared freshly mixed dirty water to filtered water to water that has been allowed to sit without filtration. Make observations of the water that was allowed to sit without filtration. Did some material settle to the bottom? Why? How could a settling basin be advantageous to a drinking water treatment system? Compare filtration systems to each other. Compare filtration systems to a natural riparian buffer infiltration model. Students can record results on data sheet for the student prepared filter. (Attachment A)

B. EXPLORE AND EXPLAIN THE SCREENING AND FILTRATION STEPS IN THE CONVENTIONAL DRINKING WATER TREATMENT PROCESS. (SEE ATTACHMENTS B AND C FOR STUDENT DIRECTIONS AND DATA SHEET. -1 CLASS PERIOD)

a. Explain that the following filtration procedure will closely resemble a model of PWD’s filtration system.

b. Students will work in teams and make a filter using a funnel containing sand and gravel. Add a half spoonful of gravel to the funnel and then top it off with 2 or 3 spoonfuls of damp sand. Level the top of the sand so that the sand is compacted. There should be some space at the top of the funnel. Leave approximately ¼ inch between the top of the sand and the top of the funnel. Set the funnel aside.

c. Mix the “dirty water” sample in the large beaker and then pour out 100 mL into the small, 100 mL beaker. Ask the students to pause and observe the settling that occurs due to gravity. Note that some things are denser than water and therefore sink while some things are less dense than water and therefore float.

d. Using a screen to cover the top of the larger glass beaker, carefully pour the dirty water through the screen and into the empty beaker. Record the volume and note any changes to the water. Pour the water into a graduated cylinder to get a more precise measure. Set aside the screen. Rinse the 100 mL beaker for re-use.

e. Pour the dirty water sample through the sand filter and collect the filtrate in the clean 100 mL beaker. Note the volume and any change in the water. If a more accurate measurement is desired, transfer the filtered water to the graduated cylinder.

f. Optional: Filter the water through the sand a second, or even third, time and record results.

Discuss how the water changed after filtration and have a general discussion about the Water Department’s conventional drinking water treatment process and the importance of screening and understanding the Urban Watershed.
filtration. All data can be recorded on the attached sheet. Calculate percent water lost during filtration. Is the extra effort to filter worth the loss of water? (*Attachment C*)

C. **ELABORATE through a VIRTUAL and A REAL TOUR of A DRINKING WATER TREATMENT PLANT**

*Real Tour—1/2 day. Virtual Tour—one class period*

a. Recall that the food dye was not removed by the settling basin or filtration. In the early days of drinking water treatment in Philadelphia, treatment was limited to settling and filtration. This limited treatment allowed contaminants and pathogens into the drinking water and people got sick as a result. In fact, there were a number of factories next to the river that released various dyes into the water so “colored” water was a real problem and not just a model of a problem. Use pictures and letters found on pages 33 and 34 of *Philly h20: A Sad History of Frankford Creek* to depict the issue from 1938. These pages can also be found in *Attachment D*.

With students, view and discuss *Drinking Water Treatment and Testing Power Point Presentation* (Download to view notes.) This presentation addresses the “Essential Questions” and it includes the vocabulary.

b. Schedule a field trip to a Philadelphia Water Department Drinking Water Treatment Plant.

D. **EXTEND by COMPARING THE TREATMENT OF PHILADELPHIA’S DRINKING WATER TO THE TREATMENT OF DRINKING WATER IN OTHER PLACES. TO OTHER MUNICIPALITIES**

1. Compare the Philadelphia Water Department Drinking Water Treatment process to other treatment processes. Consider differences in geography and differences in treating ground vs. surface water. (See *Attachment F* for descriptions of the drinking water treatment process in Wilmington, Reading and Delaware.)

2. Compare the Philadelphia Water Department Drinking Water Treatment process to treatment (or lack thereof) in developing countries: *(1 class period)*

- Play a *TFK: Guinea Worm—A Smart Solution* in which residents of a village in Zambia were interviewed about the effect that a new well had on the quality of life for the residents.

- Use *Time for Kids*. February 27, 2015 (Edition 5-6). “*A Healthier World—Efforts to Wipe Out a Disease that Comes From Dirty Water are Working*” (*Attachment G*)

- Encourage students to look at front cover of magazine and make observations and inferences about photography. Students can read, “A Smart Solution”. Article profiles work to eradicate Guinea Worm
1) Silent read of article individually.
2) Teacher reads the article out loud to the class.

- Compare/contrast Zambia to Philadelphia...What is our local source of water? Can we drink directly from it? Why not? Compare/Contrast the filter that is used to stop the Guinea Worm to the PWD's filtration system.

**VIII. EVALUATION**

**Formative Assessments:**

a. Students can record reflections, ideas, and surprises in their *Watershed Journal.*

b. Compare and contrast filtered and unfiltered water

c. Check for understanding through matching terms—match terms with pictures and definitions.

d. In their *Watershed Journal,* students can write a journal entry that summarizes how the filtration process works. Include illustrations.

e. Photocopy the steps of the PWD drinking water treatment process. *(Attachment E)* Cut the steps out and put them on cards. Have students put the cards in order with or without the name or description of the step.

**Summative Assessments:** (Teachers and students can choose modality)

a. Read Joanna Cole’s, *The Magic School Bus at the Waterworks.* Challenge students to revise the story to reflect the water treatment process in the city of Philadelphia.

b. Summarize how the filtration process works. Include illustrations.

c. Deconstruct and reconstruct the Drinking Water Treatment Poster. Draw and/or explain what each step accomplishes.

d. Each small group can describe one step of the PWD drinking water treatment process and then the groups can assemble the steps in order with the entire class.

e. Essay Prompt: Why are we filtering the water? What do we hope to achieve by filtering the water?
ATTACHMENT A: DATA SHEET FOR STUDENT PREPARED FILTER

Name:_______________________________________________
Date:_______________

Public Drinking Water Treatment Process Explained

Water Filtration Data Sheet: Student Prepared Filter

Original observation of sample:

Filter design (what materials were used and in what order):

Observation of water after filtered:
ATTACHMENT B: FILTRATION AND SCREENING DIRECTIONS FOR STUDENTS

Each group of 3-4 students will need the following:

- “Dirty” water sample
- Plastic spoon/spatula
- Funnels
- Sand and gravel
- Screens
- 100 mL, 250 mL beakers
- Graduated cylinder (Note: the graduated cylinder gives the most accurate volume reading)
- Data sheet (See Attachment C)

Explore the Screening and Filtration Steps in the Conventional Drinking Water Treatment Process.

1) Work with your team to make a filter using a funnel containing sand and gravel. Add ½ spoonful of gravel to the funnel and then top it off with 2 or 3 spoonfuls of damp sand. Level the top of the sand so that the sand is compacted. Leave approximately ¼ inch between the top of the sand and the top of the funnel. Set the funnel aside.

2) Mix the “dirty water” sample in the large beaker and then pour out 100 mL into the small, 100 mL beaker. Observe what happens to the water over two to three minutes. Do some particles sink to the bottom? Do some particles float to the surface?

3) Using a screen to cover the top of the larger glass beaker, carefully pour the dirty water through the screen and into the empty beaker. Pour the water from the beaker into the graduated cylinder to get a more precise measure. Record the volume and note any changes to the water on the data sheet. Set aside the screen. Rinse the 100 mL beaker for re-use.

4) Take your funnel filter and pour the dirty water sample through the sand filter and collect the filtrate in the clean 100 mL beaker. If you want a more accurate measurement, transfer your filtered water to the graduated cylinder for a more accurate measurement. Note the volume and any change in the water on the data sheet.

5) Filter the water through the sand a second, and even third, time and record your results.

Things to think about:
How did the water change after filtration?
Why is screening important?
Why is filtration important?
Could you make your screen or your filter even more effective? How?
# ATTACHMENT C: Data Sheet for Directed Water Filtration

Name:_______________________________________________  
Date:_______________

## Public Drinking Water Treatment Process Explained

Water Filtration Data Sheet

Starting volume of water:__________________________

Observation of original sample (clarity, particulates, etc.):

<table>
<thead>
<tr>
<th>Sample</th>
<th>Volume</th>
<th>Percent Loss of Volume</th>
<th>Observation of water sample (clarity, particulates, comparison to original)</th>
</tr>
</thead>
<tbody>
<tr>
<td>After Screening</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After Sand Filtration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional Filtration</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To determine the percent loss of volume, use the following equation:

\[
\frac{\text{Starting Volume} - \text{Ending Volume}}{\text{Starting Volume}} \times 100 = \text{Percent Loss of Volume}
\]
ATTACHMENT D: FRANKFORD CREEK PURPLE AND PERFUMED

Frankford Creek
“Purple and Perfumed”
Philadelphia Evening Bulletin,
July 15, 1938
SOURCE: Temple University Libraries/Urban Archives
Philadelphia Bulletin Collection
See the next page for the text of the letters that accompanied these pictures which, being black and white, don’t show the creek’s true colors.
Frankford Creek “purple and perfumed”
Philadelphia Evening Bulletin, July 15, 1938
SOURCE: Temple University Libraries/Urban Archives
Philadelphia Bulletin Collection
ATTACHMENT E: STEPS OF THE DRINKING WATER TREATMENT PROCESS

1. The River
   Philadelphia's tap water comes from the Delaware and Schuylkill Rivers.

2. Gravity Settling
   River water is pumped to reservoirs to allow sediment to settle.

3. Disinfection
   Sodium Hypochlorite is added to kill disease-causing organisms.

4. Coagulation & Flocculation
   Chemicals are added to make fine suspended particles clump together. Gentle mixing of the water encourages this process. The clumps of particles are called "floc."

5. Gravity Settling
   The newly formed "floc" settles by gravity and is removed from the bottom of the settling tanks.

6. Disinfection
   Sodium Hypochlorite is added a second time to kill any remaining disease-causing organisms.

7. Filtration
   Water flows through filters which remove even microscopic particles.

8. Final Treatment
   Fluoride is added to help prevent tooth decay. Zinc Orthophosphatate is added to minimize pipe corrosion and Ammonia is added to keep the disinfectant in the water and reduce the chlorine taste and odor.

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The average Philadelphia uses 87 gallons of water per day

- Showers 20 gal
- Wash 17 gal
- Tub 22 gal
- Toilets 13 gal
- Dishes 8 gal

250,000,000 gallons of water Philadelphia treats and delivers everyday.
ATTACHMENT F: DRINKING WATER TREATMENT IN WILMINGTON, READING AND CAMDEN

(From Understanding the Urban Watershed: A Regional Guide for the Classroom pp. 24-26)
FWW Regional Guide to Understanding the Urban Watershed (Toolbox)

Drinking Water Treatment: Wilmington, DE

Like many colonial settlements in America, Wilmington first relied on wells for supply fresh water. The city's first effort to create a municipal drinking water supply system from springs was initiated in 1804 by a the Wilmington Spring Water Company who was chartered to tap a spring at high ground and convey it through wooden pipes to cisterns where subscribers pumped it by hand. This was around the same time that Wilmington’s upstream neighbor, Philadelphia initiated its first public water supply system using the Schuylkill River as its source water, which was conveyed in wooden pipes to a pumping station at Centre Square (where City Hall stands today) and delivered to subscribers in their homes and businesses or to public pumps on the street for free.

In less than a decade, the city acquired the Spring Water Company to meet the challenges of an increasing demand and diminishing water table. This marked the beginning of nearly a century of public debates about how to create a system for reliable, safe and affordable drinking water. In 1820 a plan to build an economical and reliable infrastructure like Philadelphia’s in which surface water from a river was pumped to a high reservoir was debated.

The milling industry had already been harnessing the power of the Brandywine Creek for more than a century. Large merchant grist mills lined both sides of the Brandywine Creek upstream.

At the height of mill operations, two raceways were located on each side of the river. It seemed prudent to adapt this infrastructure for the new water system. The borough bought John Cummings’ mill just below Market Street Bridge on the south side of the Brandywine Creek was chosen as a site for the first pumping station.

Two reservoirs were constructed at the site of present day Rodney Square. Water was then conveyed by gravity down Market Street in an iron “main” until it reached Water Street along the Christina River. Piped connections from the “main” to homes and public cisterns in every part of town were completed.

As in many 19th century industrialized cities, the growing population in Wilmington made necessary an ongoing series of improvements in efficiency and capacity to the drinking water system. Overtime, the town introduced more sophisticated methods for water conveyance and storage to meet public demand to keep up with political pressures politics, public health concerns and an overly thirsty populace, which seemed to grow exponentially during the 19th century's industrial age. At the same time, consumers of water took for granted a seemingly abundant and endless public supply. Take note that this story is repeated in many 19th century industrialized American cities, not just Wilmington. Increasing storage, installing larger capacity pipes and tunnels and more efficient pumps with greater capacity was only half the equation; upstream pollution of the water supply was also posing ever-increasing challenges.

In Wilmington, relatively flat areas or parts of the landscape that serve a large geographical region depend on water towers or standpipes to deal with water pressure. The township also uses “purpose built” reservoirs and dammed stream valleys or water impoundments for drinking water supply.

The introduction of a water filtration system did not occur until 1892. Raw (unfiltered) water arrives at the Brandywine Pumping Station from the Brandywine Creek and is either be pumped to the Porter Reservoir to be filtered or taken through the filtration process to remove industrial pollution and sewage on site and distributed to consumers directly.
Drinking Water Treatment: Reading, PA

Like many colonial settlements in America, the citizens of Reading first relied on groundwater for supply fresh water either from wells or from springs. Reading’s first public water supply came from a spring near 11th and Court Streets in 1821. As the City developed, so did the challenges of keeping up with an increasing demand and diminishing water table for a clean, reliable supply of water. Like Wilmington, the City of Reading adapted the 18th century water-powered technology of the milling for its 19th century for water supply system. In 1865, Reading purchased a dam and gristmill on Antietam Creek as the beginning of its new public water infrastructure. (Antietam Lake was officially taken offline in 1974). To protect the water supply, land surrounding the reservoir or impoundment was purchased. This was nearly a half-century after Reading’s more populous downstream neighbor, Philadelphia, initiated its first public water supply system using the Schuylkill River as its source water, which was conveyed in wooden pipes to a pumping station at Centre Square (where City Hall stands today) and delivered to subscribers in their homes and businesses or to public pumps on the street for free.

The growing population in Reading made necessary an ongoing series of improvements in efficiency and capacity to the drinking water system. From 1926 to 1933 a new water supply system was completed which required the construction of Maiden Creek Dam that backed up water from ten streams to create the man-made Lake Ontalaunee. Fifty properties were flooded to form the lake, which holds nearly 4 billions gallons. It is 1,000 acres and spans from 7 to 28 feet deep. It serves about fewer than 100,000 customers in the City of Reading and about 8 adjacent townships. When first completed, Lake Ontalaunee was considered the largest man-made lake in Pennsylvania. Water is treated in a nearby filtration plant before being delivered to consumers.

Drinking Water Treatment: Camden, NJ

Camden’s first successful water works used the Delaware River to supply drinking water. The Camden Water Works Company, a private company, was incorporated on April 2, 1845 and was familiarly known as the “Henry Allen Company”. An iron pipe drew water from the Delaware River. The original plant was located on a lot 30 by 90 feet at what was then the foot of Cooper Street (later the center of the Esterbrook Pen Works), and was purchased from William D. Cooper for $400. The supply of water was turned into the mains on November 1, 1846.

In 1854 by a supplement to its charter the company was authorized to increase its capital stock and to hold lands outside the city limits, and it build a plant at Pavonia, which continued to supply water to the city until 1870, when under an act of the Legislature Camden purchased all of its rights and appurtenances for the sum of $200,000. The plant was described as a two-story high brownstone structure with a mansard roof 30 x 40 feet and housed 2 steam-powered pumps. The supply pipe extended into the river and conveyed water to a forebay located under the pumps in the basement of the engine house. This water was screened and filtered before being pumped to a standpipe 5 feet in diameter, 120 feet high. Water flowed from the standpipe, which was above the level of a reservoir basin that held up to 8 million gallons and was situated 47 feet higher than the city of Camden. This water supply served Camden “rate-payers” as well as the Fire Department.

By the late 19th century, human and industrial waste dumped into the Delaware River from both sides of the river and deadly outbreaks of typhoid, a water-borne illness led Camden to seek a cleaner, more reliable source for its drinking water supply than the polluted water of the Delaware. Unlike its “river” neighbor Philadelphia which constructed filtration plants as a solution, Camden turned to its unadulterated groundwater for a new water supply.

Today Camden still supplies its citizens with water from groundwater relying on an extensive series of artesian wells (in what is called a wellfield) and individual ones as well (pun intended). After being pumped to the surface, this water is processed at the treatment facility and conveyed to the consumer through an extensive 145-mile pipe system using water mains ranging from 16 inches to 36 inches. The water infrastructure also includes a series of pumps and elevated tanks to maintain water pressure throughout the system.

Currently the water system in the City of Camden is owned and managed as a public/private partnership.
Attachment G: TFK Guinea Worm Article
A Smart Solution

Time for Kids February 27, 2015 Edition 5-6 “A Healthier World-Efforts to Wipe Out a Disease that Comes from Dirty Water are Working”

Thirsty? No problem. Here in the United States, filling your glass is as easy as a trip to the kitchen sink. But in many parts of the world, clean, safe drinking water is out of reach.

“There are 748 million people worldwide who don’t have safe water to drink,” says Sarina Prabasi of WaterAid America, which helps people get clean water. “That’s about one in 10 people.” Each year, millions of people become sick after drinking dirty water.

But there is good news: One waterborne illness, Guinea-worm disease, is close to being wiped out. Thirty years ago, about 3.5 million people in 21 countries in Asia and Africa had the disease. Today, there are only 126 cases left in the world, in four countries (see map).

Former U.S. president Jimmy Carter and his team at the Carter Center, in Atlanta, Georgia, have led the effort to wipe out the disease. In two to three years, Carter told TFK, "the whole world will be free of Guinea worm forever.”

Taking Action
A person contracts Guinea worm by drinking from a pond containing water fleas that carry the disease. About a year later, the disease appears. It takes weeks to recover. For a child, that means weeks away from school. For a farmer, it means weeks away from the field.

Carter's team began working to defeat Guinea worm in 1986. They knew a simple way to protect against the disease. Filter water through a piece of cloth, and the water becomes Guinea-worm-free. But convincing people to take this step was a challenge.

Many did not believe that the water they were so grateful to have was making them sick. "We had to show through a magnifying glass the little creatures swimming around in the water that had the Guinea-worm eggs in them,” says Carter.

Health workers also taught people not to get in the water while they had Guinea worm, since doing so can spread the disease. Fewer people got sick each year. "We're very close now,” says Dr. Donald R. Hopkins, vice president for health programs at the Carter Center. "But it’s not over until we get to zero.”

Countdown to Zero, a new exhibit at the American Museum of Natural History, in New York City, tells about efforts to wipe out six diseases, including Guinea worm. According to curator Mark Siddall, the lesson is clear: "All humans on the planet live in a big global community, and we have a shared responsibility to take care of each other.”
X. Resources for Teachers and Students

Resourcewater.org Toolbox!

Philly h2o: A Sad History of Frankford Creek: Photographs and Letters from 1938 concerning the devastation caused by dye factories on the “Frankford Creek”
Print URL: http://www.phillyh2o.org/backpages/PDFs_Misc/FrankfordCreek_SadHistory.pdf

Drinking Water Treatment and Testing Power Point Presentation Conventional Drinking Water Treatment in Philadelphia Power Point Presentation (Download to view notes)
Print URL: https://drive.google.com/file/d/0B6SRqlkAM5liU0x1MG1MVkctTFk/view

Understanding the Urban Watershed: A Regional Guide for the Classroom pp. 24-26 FWW Regional Guide to Understanding the Urban Watershed (Toolbox)

Time for Kids, February 27, 2015 (Edition 5-6). “A Healthier World—Efforts to Wipe Out a Disease that Comes From Dirty Water are Working” (Attachment G)

TFK: Guinea Worm-A Smart Solution Short video to accompany TFK article
Print URL:
I. ESSENTIAL QUESTIONS

What kind of test would you like your water to take before you drink it?
What kinds of tests are required by law for your water to take before you drink it?

II. STUDENT UNDERSTANDINGS

Water that has been treated by local municipalities, such as the Philadelphia Water Department, is required by law to be continuously monitored using a variety of tests. These tests ensure the safety and taste of the water being distributed.

III. STUDENT OBJECTIVES

Students will use chemical tests in order to determine which solution is tap water.

Students will discover the real life application of chemistry for water testing.
IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts       | • Read (and view), analyze, and connect scientific text to personal experiences  
|                            | • Write reactions to material through note taking and reflection  
|                            | • Research water quality reports  
| Science                    | • Chemical tests  
|                            | • pH  
|                            | • Hypothesis Testing  
|                            | • Turbidity  
| Social Studies             | • Compare water quality in different regions  
| Math                       | • Interpret data in water quality reports  
| Careers                    | Chemists, quality control engineers, technical writers  

IV. SETTING THE STAGE AND HELPFUL VOCABULARY

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 strips (like those that you can 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.

**pH**

In chemistry, pH 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.

**Turbidity**

In chemistry, turbidity is a measure of how clear the liquid is.
V. MATERIALS AND PREPARATION NEEDED

Materials:
- 5-in-1 test strips with color key
- 4 samples of liquids in plastic cups marked respectively
- 4 containers for each group of students
- Tap water
- Vinegar
- Household bleach
- Sodium Hydroxide
- Pencils
- Safety goggles or glasses
- Gloves
- Testing the Waters Data Sheet (Attachment A)

Preparation:
Create the following solution in the four mason jars (or beakers) before the lesson and label the samples as #1, #2, #3, and #4.

a) #1 – drinking water from tap

b) #2 – acidic solution using tap water diluted with vinegar (950 mL water and 50 mL vinegar)

c) #3 – high chlorine solution using tap water diluted with household bleach (990 mL water and 10 mL bleach)

d) #4 – hardness/alkalinity solution using tap water with sodium hydroxide (980 mL water and 20 mL of sodium hydroxide)
VI. THE LEARNING EXPERIENCE: ENGAGE, EXPLORE, EXPLAIN, ELABORATE, EXTEND

A. ENGAGE STUDENTS WITH A MYSTERY (20 MINUTES)
Teacher introduces 4 mystery clear containers and explains that one of the containers contains drinking water. The other mason jars are all contaminated. How can we figure out which solution is drinking water and which ones are contaminated without tasting? How do you think the Water Department tests the drinking water to determine whether it is safe to drink? Remind students that contaminants don’t always have smells or tastes that we can detect but that they can make us sick. Elicit the idea of chemical testing.

B. EXPLORE AND EXPLAIN – HOW DOES THE WATER DEPARTMENT TEST THE WATER? (1-2 CLASS PERIODS (INCLUDING RESEARCH))
1) Remind students not to taste. As the students are working with chemicals, provide directions for “wafting” smells by waving their hands over the solution so the air “wafts” in the direction of their noses. Remind students to wear safety glasses and gloves.

2) Allow students to work in groups or in pairs. Each student group will have samples of the four unknown solutions and testing strips.

3) Listed on the students’ data sheets (Attachment A) are the data values for normal drinking water. Students will test each solution using the test strips and record the data values on the sheet. Once all the solutions have been tested, students will make a determination as to which unknown solution (1, 2, 3, or 4) is normal drinking water by matching the known values with the values they received by testing.

4) Review results of chemical testing. Students can discuss or research how water could become too acidic, too alkaline or too chlorinated. Suggested reading includes:

USGS Water School pH

Free Drinking Water: Water Education: Hard (Alkaline) Water

EPA FAQ: What can cause tap water to smell like bleach?

C. ELABORATE (1-2 CLASS PERIODS)
• View and Discuss Drinking Water Treatment and Testing Power Point Presentation (Slide 17 to end) Download to view notes
• Review the annual report of water quality for Philadelphia. Water reports generally come with informative articles about contaminants such as lead, pharmaceuticals, pathogens as well as articles about how the water is treated and protecting the source. Find the tables in the Philadelphia Water Department Quality Report and note tests of
substances that would be familiar—lead, copper, e-coli, etc. Use the tables to note the measurements of the familiar contaminants and compare and contrast those measurements to a report from another municipality. Or compare and contrast the Philadelphia Water Quality Report over time.

- Philadelphia Water Quality Report
- Camden, NJ Annual Water Quality Report
- Wilmington, DE Annual Water Quality Report
- Reading, PA Annual Water Quality Report

**VIII. Evaluation**

- Choose something about which to write a quality report... Pick something that is not water related, but that is collective so it can lead to a good discussion. For example, everyone could bring in a pair of sneakers and quality could be determined by tests related to color, durability, odor, etc...

- “Watershed Journal”—Reflect on what was learned and what students are still wondering about.

- Accurate completion of chart and data analysis
**ATTACHMENT A: DRINKING WATER MYSTERY DATA SHEET**

Name:__________________________________________
Date:_____________________

Testing the Waters

The Philadelphia Water Department tests tap water throughout the City to make certain it is safe. Experiments are conducted to ensure that the physical and chemical properties of our drinking water are safe and meet all local, state, and federal regulations.

Test the Chemistry! Some of the most important tests are pH, alkalinity, and chlorine. The 4 samples in front of you are mystery solutions. Be the scientist and use the water quality strips to test each sample and record the results. Using the information provided about the parameters of typical tap water, make your best guess as to which one is the tap water.

<table>
<thead>
<tr>
<th>Typical Values of Tap Water</th>
<th>pH</th>
<th>Alkalinity</th>
<th>Chlorine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 6.8 - 7.0</td>
<td>80 – 120 mg/L</td>
<td>0 – 1 mg/L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mystery Solution</th>
<th>pH</th>
<th>Alkalinity</th>
<th>Chlorine</th>
<th>Do you think this is tap water?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
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<tr>
<td>C</td>
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</tr>
<tr>
<td>D</td>
<td></td>
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</tr>
</tbody>
</table>
X. RESOURCES FOR TEACHERS AND STUDENTS

Resourcewater.org Toolbox!

Philadelphia Water Department’s Annual Water Quality Report The annual water quality report, which is required by law to publish, talks about the myriad of parameters that are required to determine if water is safe to drink.

Drinking Water Treatment and Testing Power Point Presentation Slide 17-end discuss Water Testing Procedures (Download to view notes)
Print URL: https://drive.google.com/file/d/0B6SRqlkAM5iU0xlMG1MVkctTFk/view

These annual water quality report reports could be used for comparison purposes:
Camden, NJ Annual Water Quality Report
Print URL: https://www.unitedwater.com/camden/water.aspx

Wilmington, DE Annual Water Quality Report
Print URL: http://www.wilmingtonde.gov/visitors/waterreports

Reading, PA Annual Water Quality Report
Print URL: http://www.readingareawater.com/rawa-annual-water-quality-reports

Information about chemical testing:

USGS Water School pH
Print URL: https://water.usgs.gov/edu/ph.html

Free Drinking Water: Water Education: Hard (Alkaline) Water

EPA FAQ: What can cause tap water to smell like bleach?
Print URL: http://safewater.supportportal.com/link/portal/23002/23015/Article/21515/What-can-cause-tap-water-to-smell-like-bleach
I. ESSENTIAL QUESTIONS

Bottled or tap?  
Can you tell the difference?  
Can you evaluate the difference?

II. STUDENT UNDERSTANDINGS

Tap water and bottled water are regulated by different agencies – the EPA (tap) and the Food and Drug Administration (Bottle)  
The choice of tap or bottled can be a matter of personal preference that can be influenced by taste and convenience, but other considerations such as cost and value as well as environmental impact play a part too.

III. STUDENT OBJECTIVES

Students will evaluate differences between bottled water and tap water in regards to taste, cost, convenience and environmental impact.

Students will write a persuasive piece in order to convince others to choose bottled or tap water.
IV. CROSS-CURRICULAR CONNECTIONS

| English Language Arts | • Read (and view), analyze, and connect scientific text to personal experiences  
|                       | • Write reactions to material through note taking, reflection, editorializing  
|                       | • Persuasive Writing  
| Science               | • Hypothesis Testing  
|                       | • Data Gathering  
|                       | • Analyzing Statistics  
|                       | • Drawing Conclusions  
|                       | • Engaging in Argument  
| Social Studies        | • Implications and economics of bottled and tap water  
| Math                  | • Calculate and communicate statistics related to comparing preferences between tap and bottled water  
|                       | • Calculate consumer costs of tap and bottled water  
| Careers               | Chemists, quality control engineers, Environmentalists Regulators from FDA, EPA  

V. SETTING THE STAGE AND HELPFUL VOCABULARY

It was not too long ago when the main source of drinking water in our homes was the tap of our sinks. 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, being healthier, and being more convenient than tap water. The following information comes from a compilation of the resources listed in the resource section.

Safety:
The FDA oversees the safety of bottled water while the EPA regulates the safety of tap water. These agencies use similar standards for ensuring safety. In some instances, standards for bottled water are different from those of tap water. Because lead can leach from pipes, the EPA has set an action level of 15 parts per billion in tap water. In bottled water factories, where lead pipes are not used, the lead limit is set at 5 ppb. Bottled water often does not have fluoride added or the fluoride is removed. The EPA mandates that water utilities provide annual quality reports to customers. However, the EPA does not regulate private wells.
Cost:
Bottled water can cost about $0.08 per 500 ml bought in bulk or as much as $2.50 for a name brand purchased out of a vending machine. Tap water, on the other hand, costs the consumer only tenths of a cent per liter.

Recycling
While some plastic water bottles are recycled, many plastic water bottles end up in landfills. Plastic water bottles take hundreds of years to decompose. When plastic bottles are recycled, much of the plastic waste is shipped overseas for recycling, creating additional greenhouses gases associated with transportation.

Oil
Virgin petroleum is used to make PET and some estimates put the required amount of oil to exceed 17 million barrels of oil for plastic bottle production in the US alone. In addition to the use of fossil fuels required to make plastic bottles, the manufacture of PET results in three tons of carbon dioxide emissions.

Water
For every bottle of water that is produced, the Pacific Institute has estimated that twice as much water is required for the production process. This statistic means that for every liter of water that is sold, three liters of water are used.

Transportation
The logistical requirements of water production, distribution and storage also factor into the environmental impact. Additional energy is required to automate the water bottle filling process, to transport it by truck, train, ship or plane, to cool it at home or in grocery stores, and to recover, recycle or trash the water bottles.

Helpful Vocabulary:

BPA (noun)
Industrial chemical used in polycarbonate types of hard plastic bottles. Questions about safety are associated with this chemical.

Economics: (noun)
The branch of knowledge concerned with production, consumption and transfer of wealth.

Environmental Sustainability: (noun)
A state in which the demands placed on the environment can be met without reducing its capacity to allow all people to live well, now and in the future.

EPA (noun)
Environmental Protection Agency--Oversees safety of tap water.

FDA (noun)
Understanding the Urban Watershed

Unit Two
Learning Experience Six

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Food and Drug Administration: Oversees safety of bottled water

**Profit (noun)**
Financial gain, especially the difference between the amount earned and the amount spent in buying, operating, or producing something.

### VI. Materials and Preparation Needed

- 2 “Blind Coded Cups” for each student
- Tap and Bottled Water
- Paper, Pencil

**Preparation:** Out of sight of students, fill one colored (or coded) cup with bottled water and fill the other colored (or coded) cup with tap water.

- Articles and video discussing bottled water vs. tap water. (See Resource Section for suggestions)
- Cost of single water bottle, small case, large case, gallon, 5 gallon...

### VII. The Learning Experience: Engage, Explore, Explain, Elaborate, Extend

**A. Engage Students by Challenging Their Assumptions.**
Teacher introduces students to two cups of water. Explain that one cup of water comes from the tap and one comes from a bottle. Ask the students if they think that they will be able to differentiate between the two using smell and taste. Ask the students to predict which water will smell and/or taste better. Collect statistics on the predictions. Statistics can be graphed, interpreted, and analyzed.

**B. Explore and Explain – Test the Hypothesis**
Have the students conduct a smell/taste test to compare and contrast the smell and taste of the two cups of water. How do the predictions compare with the results of the taste/smell test? Discuss any surprises and implications. Discuss ways to calculate and then calculate the consumer cost of bottled water. Students can calculate how much bottled water they drink over the course of a day. Students can make calculations using the unit cost of bottles when purchased individually and by the case. Students can...
calculate daily, weekly, monthly, and annual consumer cost of bottled water. Allow students to develop a guide to help with the calculations.

C. **ELABORATE—SHOULD WE BUY BOTTLED WATER?**

Should we buy bottled water? Who should have access to bottled water? Discuss environmental and economic impact of tap vs. bottled water. What are the benefits and draw backs from each? Who gains financially from the choices we make? Discuss alternatives to bottled water. Use articles and videos from different sources and perspectives. Note the source for each article. Discuss possible bias. Some suggestions include:

- Mayo-Clinic: *Is tap water as safe as bottled water?*
- CDC: *Commercially Bottled Water*
- International Bottled Water Association: *Bottled Water vs. Tap Water*
- NY Times: *According to GAO: Fewer Regulations for Bottled Water Than Tap*
- Slate: *You are Paying 300 Times More for Bottled Water than Tap Water*
- ABC News: *Bottled Water vs. Tap: Can you tell the difference?*
- Pacific Institute: *Bottled Water and Energy Fact Sheet*

D. **EXTEND**

- Research the beginnings of the bottled water industry
- Research and evaluate types of re-usable water bottles—stainless, plastic, glass?
- Investigate the proliferation of plastic water bottles that end up as trash in our waterways and the harmful consequences

**VIII. EVALUATION AND POTENTIAL SUMMATIVE ASSESSMENTS**

Students can write a persuasive piece that argues whether or not Philadelphians should buy bottled water. This piece can take the form of a persuasive essay, an editorial, an Op-Ed piece, or a letter to the editor. The writing should include information about PWD’s water quality testing, cost, convenience and environmental impact. Finished pieces can be published in the school newspaper.
IX. RESOURCES FOR TEACHERS AND STUDENTS

**Mayo-Clinic: Is tap water as safe as bottled water?** Brief discussion of FDA and EPA regulations

**CDC: Commercially Bottled Water** Discusses FDA regulations of Bottled Water with some depth.
*Print URL:* http://www.cdc.gov/healthywater/drinking/bottled/

**International Bottled Water Association: Bottled Water vs. Tap Water** Provides perspective from Bottled Water Association
*Print URL:* http://www.bottledwater.org/health/bottled-water-vs-tap-water

**NY Times: According to GAO: Fewer Regulations for Bottled Water Than Tap** Article argues that the EPA is a more effective regulating body than the FDA.

**Slate: You are Paying 300 Times More for Bottled Water than Tap Water** Economics of bottled water.
*Print URL:* http://www.slate.com/blogs/business_insider/2013/07/12/cost_of_bottled_water_vs_tap_water_the_difference_will_shock_you.html

**Pacific Institute: Bottled Water and Energy Fact Sheet**
*Print URL:* http://pacinst.org/publication/bottled-water-and-energy-a-fact-sheet/