

## **From Raindrops to Resilience: A Journey Through Water's Path and Its Challenges**

### **Unit Content**

Climate change is expected to increase the frequency and intensity of rain storms in the Northeastern US. Where will all of this water go and what impact will it have on us? Understanding the water cycle is foundational to understanding the challenges of flooding in cities like Philadelphia and in developing strategies to enhance resilience. This unit delves deep into the hydrologic cycle, unraveling its complexities and exploring the pathways water traverses our city. Students will learn how climate change is causing flooding events to occur more often in Philadelphia. The narrative of the unit is consistent with a specific focus on Philadelphia, including a lesson on the combined sewage water system that is largely impacting flooding events in the city. Students will discuss how the impacts of flooding include environmental, physical health, mental health and economic challenges to communities. The unit concludes with a positive look toward the future as students develop resilience strategies to be used in addressing future flooding. This unit guides students through the nexus of water, climate change, and resilience, equipping them with the knowledge and tools to navigate the complexities.

In lesson one students will learn the process of the hydrologic cycle, the continuous circulation of water on the Earth and in the Atmospheric system. Water moves from the ground to the atmosphere and back to the ground through various processes, most importantly, evaporation, transpiration, condensation, precipitation and runoff. A basic explanation of each process along with images of the water cycle is found at [the National Oceanic and Atmospheric Administration](#) website. Evaporation of water from earth's surface, such as the ocean begins the water cycle. Evaporation changes the liquid state of water into the gaseous state, water vapor. As the water vapor rises through the atmosphere, the water vapor cools and condenses to form clouds. The water vapor remains in the atmosphere until the clouds become too heavy, causing the water vapor to turn to liquid (rain) or solid (snow) and return to Earth's surface as precipitation. Once water returns to the surface, it can either be evaporated or penetrate the surface to become groundwater, or run-off into surface water like streams, lakes, and rivers. Groundwater and surface water either travels to meet oceans, rivers and streams, or is released back to the atmosphere through transpiration, the evaporation of water from plants. A useful resource for a detailed explanation of the hydrologic cycle with links to pages specifically on each process and an explanation of an example of the hydrologic cycle can be found at [A Summary of the Hydrologic Cycle](#). [How the Hydrologic Cycle Works](#) is a 7 minute video explaining the importance and the processes of the hydrologic cycle.

In lesson two students will learn what happens when water hits the ground, beginning with an introduction to watersheds. A watershed is an area of land that channels rainfall and snowmelt to bodies of water such as streams, rivers and creeks until eventually flowing to outflow points such as the ocean, reservoirs or bays. The term watershed is interchangeable with

drainage basin, which helps to envision a watershed as a bowl where water at the high points will flow to the lowest points of the bowl and can be visualized by the [NOAA](#) explanation and diagrams. The lesson continues to explain the difference between water landing on previous and impervious surfaces. Permeable surfaces allow water to seep into the ground while impervious surfaces are solid, do not allow water to penetrate and instead force water to run off. Examples of impervious and pervious surfaces are included at [Permeable vs Impermeable](#). As water flows across Earth's surface, it collects pollutants which can be dangerous to humans. Students will learn how water flowing throughout Philadelphia on largely impervious surfaces collects pollutants that contaminate the water. A brief summary of watersheds, the collection of pollutants and the impact of impervious surfaces can be found at [What is a Watershed?](#).

In lesson three students will learn what happens to water that lands on the surface in Philadelphia. The increase in flooding in Philadelphia is two parts: first, climate change is increasing precipitation, and second the combined sewer system of Philadelphia is not equipped to handle the intense precipitation events. Climate change is impacting the water cycle largely through the warming of the atmosphere which has caused sea level rise, droughts and increased precipitation. The [United Nations](#) provides an overview of climate change, including the causes and impacts. The warmer temperatures resulting from climate change are causing more water to evaporate from the surface. Due to more water in the atmosphere there is more water returning to the surface. The [EPA](#) and [National Geographic](#) provide an explanation of how climate change is increasing precipitation and therefore increasing flooding events. After discussing the reasoning for why we are experiencing more rainfall, the students will learn where the water goes once it lands on the surface. Philadelphia has a combined sewer system which means that sewage from homes and wastewater from streets enter the same pipes to be sent to the wastewater treatment plant. The system is fine until there is too much precipitation and run-off, causing the wastewater treatment plants to be overwhelmed. As a result, wastewater spills over into the waterways untreated. The [Philadelphia Water Department](#) provides a useful explanation of Philadelphia's combined sewage system. See <https://water.phila.gov/maps/csocast/> for all of the places that combined sewer overflows occur in Philadelphia.

In lesson four students will learn about the impacts of flooding. Repeated flooding impacts infrastructure, human health and the environment. Through a story about a family impacted by flooding and a sorting activity, students will learn about the environmental impacts of flooding including habitat destruction, erosion, water pollution, contaminated soil, and displacement of species. Examples of impacts to infrastructure include damage to roads and bridges from erosion, debris carried by floodwaters damaging buildings or blocking drainage systems and roads, power outages from damaged electrical systems, flooding inside buildings leading to mold growth, and weakened foundations. Impacts on physical health include, respiratory problems resulting from mold growth, waterborne disease, injuries from debris and navigating waters, exposure to chemical contaminated water, and vector-borne diseases brought

by insects drawn to moist locations. The [Federal Emergency Management Agency](#) provides examples of the impacts of flooding along with data to help conceptualize the dangers of flooding. The physical damages to the environment, infrastructure and physical human health are often represented; however, repeated flooding has significant impacts on an individual's mental health. Displacement from homes, financial loss, loss of property and additional factors all negatively affect an individual's mental health and are highlighted in [The Effects of Flooding on Mental Health](#).

In the final lesson students will learn resilience strategies that can be used to prepare for and fight against urban flooding. The [Center for Climate and Energy Solutions](#) is a resource that summarizes many of the key points in the curriculum and includes explanations of resilience strategies. A resilience strategy is a plan to enhance, withstand, adapt to and recover from disruptions or crises. Many resilience strategies to address flooding connect back to lesson two in which students learn how impervious surfaces found in cities contribute to flooding. Replacing the impervious surfaces with green infrastructure such as street trees, permeable pavement, rain gardens, and rainwater harvesting helps allow rainwater to be absorbed rather than runoff the surface and overwhelm the sewer system. By adapting resilience strategies, urban communities can be better prepared for and mitigate the impacts of flooding, protecting people, property, and the environment.

Lesson 1	
Title	What is the Hydrologic Cycle?
Grade level	Middle School Grades 5-8
Subject	Environmental Science
Objectives	Identify how water moves between different locations
Standards	4.1.5.B. Explain the basic components of the water cycle. 4.2.5.A Explain the water cycle
Vocabulary	Hydrologic Cycle Evaporation Condensation Precipitation Transpiration Aquifers Infiltration Surface Runoff
Materials	Worksheet provided in appendix labeled “ Lesson 1 Worksheet” Powerpoint provided in appendix labeled “Lesson 1 Powerpoint” Markers, crayons, or colored pencils for drawing
Resources	<p>“The National Oceanic and Atmospheric “Administration”  <a href="https://www.noaa.gov/jetstream/atmosphere/hydro#:~:text=The%20hydrologic%20cycle%20involves%20the,the%20atmosphere%20and%20back%20again.">https://www.noaa.gov/jetstream/atmosphere/hydro#:~:text=The%20hydrologic%20cycle%20involves%20the,the%20atmosphere%20and%20back%20again.</a></p> <p>“A Summary of the Hydrologic Cycle”  <a href="http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/smry.rxml#:~:text=The%20hydrologic%20cycle%20begins%20with,to%20the%20surface%20as%20precipitation.">http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/smry.rxml#:~:text=The%20hydrologic%20cycle%20begins%20with,to%20the%20surface%20as%20precipitation.</a></p> <p>“How the Hydrologic Cycle Works”  <a href="https://youtu.be/al-do-HGuIk">https://youtu.be/al-do-HGuIk</a></p>
Lesson Structure	
Lesson Launch	Respond to a prompt: Where does water come from?

Lesson 1	
	Give students a few minutes to think about a response to the prompt, discuss with neighbors, call on students to respond to the class
Background	<p>Explain that to understand where water comes from, they must understand the hydrologic cycle</p> <p>Introduce the concept of the hydrologic cycle through a short video</p> <p>Ask the students: “Why is water vital for life on earth? How do you think water moves around the planet?”</p>
Intro (pre activity)	<p>Present the key points of the water cycle through the powerpoint “Lesson 1”</p> <p>Students fill out the fill-in-the-blank worksheet in appendix page _____ throughout the powerpoint</p> <p>Engage students in a discussion about what they already know about the water cycle</p>
Activity	<p>Independent Practice</p> <p>On the back of the worksheet, students create their own illustrated diagrams of the hydrologic cycles explaining each stage in their own words</p> <p>Instructions for the activity are included on the worksheet</p>
Discussion / debrief	Review the stages of the hydrologic cycle as a class

Lesson 2	
Title	What happens when water hits the ground?
Grade level	Middle School Grades 5-8
Subject	Environmental Science
Objectives	Observe and analyze the model of a watershed Identify and describe how rainwater interacts with matter as it falls from the ground
Standards	4.2.5.C - identify physical chemical and biological factors that affect water quality  4.2.6.C - identify the natural and human made factors that affect water quality  4.2.7.A. - explain how water enters moves trough and leaves a watershed  4.5.7.C. - explain how human actions affect the health of the environment - Identify residential and industrial sources of pollution and their effects on environmental health  4.2.8.A - describe factors that affect the quality of ground and surface waters
Vocabulary	Watershed Impervious surface Pervious surface Aquifers Pollutants
Materials	Powerpoint in appendix labeled "Lesson 2" Disposable paint tray Models of homes, farms, buildings, animals Spray bottle Red food coloring Sprinkles Soy sauce Jello mix Small pieces of paper

Lesson 2	
Resources	<p>“NOAA”  <a href="https://www.fisheries.noaa.gov/new-england-mid-atlantic/habitat-conservation/what-watershed">https://www.fisheries.noaa.gov/new-england-mid-atlantic/habitat-conservation/what-watershed</a></p> <p>“Permeable vs Impermeable”  <a href="https://www.udel.edu/canr/cooperative-extension/fact-sheets/permeable-impermeable-surfaces/#:~:text=Permeable%20surfaces%20(also%20known%20as,forcing%20it%20to%20run%20off.">https://www.udel.edu/canr/cooperative-extension/fact-sheets/permeable-impermeable-surfaces/#:~:text=Permeable%20surfaces%20(also%20known%20as,forcing%20it%20to%20run%20off.</a></p> <p>“What is a Watershed”  <a href="https://oceanservice.noaa.gov/facts/watershed.html">https://oceanservice.noaa.gov/facts/watershed.html</a></p>
Lesson Structure	
Background	<p>Powerpoint titled “Lesson 2”</p> <p>What is a watershed:  Explain that a watershed is an area of land that drains rainwater or snowmelt into a river. And that runoff from fields, lawns, and pavement could carry potentially dangerous materials from our watersheds to our rivers, which is our drinking water source. Even if you live far from a river, your actions still have an impact on the water quality of the area.</p> <p>Watch 2 minute video explaining watersheds both urban and rural  <a href="https://why.pbslearningmedia.org/resource/ket09.sci.ess.water.wshed/what-is-a-watershed/">https://why.pbslearningmedia.org/resource/ket09.sci.ess.water.wshed/what-is-a-watershed/</a></p> <p>Find your watershed  <a href="https://water.phila.gov/watersheds/map/">https://water.phila.gov/watersheds/map/</a></p> <p><b>Rain acts differently when it hits different surfaces</b>  Impervious surface definition  Pervious surface definition  <b>Places water can go when it hits the ground</b>  Previous surfaces:  Not all water flows directly to the sea, however. When rain falls on dry ground, it can soak into, or infiltrate, the ground. This groundwater remains in the soil, where it will eventually seep into the nearest stream. Some water infiltrates much deeper, into underground</p>

## Lesson 2

	<p>reservoirs called <u>aquifers</u>. In other areas, where the soil contains a lot of hard clay, very little water may infiltrate. Instead, it quickly runs off to lower ground.</p> <p>Impervious surfaces: Rain and snowmelt from watersheds travel via many routes to the sea. During periods of heavy rain and snowfall, water may <u>run onto and off of impervious surfaces</u> such as parking lots, roads, buildings, and other structures because it has nowhere else to go. These surfaces act as "fast lanes" that transport the water directly into storm drains. The excess water volume can quickly overwhelm streams and rivers, causing them to overflow and possibly result in floods.</p> <p>3 minute video on impervious vs pervious surfaces and water <a href="https://youtu.be/iEVC3LYogMQ">https://youtu.be/iEVC3LYogMQ</a> Explain how the example of the San Antonio River in the video is similar to the Schuylkill and Delaware Rivers in Philadelphia</p> <p>Explain how rain gardens and porous pavement are examples of replacing impervious surfaces with pervious surfaces to help decrease water flow - rain garden and porous absorb the water so it can help decrease the amount of water running on impervious surfaces</p> <p>As water moves through the watershed it picks up pollutants Ask students what kinds of things are in our neighborhoods that can pollute water. Write the list on the board as students respond. (garbage, animal waste, gas and oil from gas stations, fertilizers, pesticides, chemicals from industrial sites)</p>
Intro (pre activity)	Explain that you are now going to create your own watershed to see how water can collect pollutants as it moves through a watershed specifically with impervious surfaces such as Philadelphia
Activity	<p>Create a model of a watershed showing how pollutants can get into our water sources.</p> <ol style="list-style-type: none"> <li>1. Separate students into small groups 2-4. Each group gets a supply bin</li> <li>2. Review where rainwater comes from (rain is precipitation that comes from clouds full of water)</li> <li>3. Call out scenarios and students have to place the corresponding "pollutants" into the tray             <ol style="list-style-type: none"> <li>a. Paint from the side of a house = red food coloring</li> <li>b. Excrement from animals = sprinkles</li> <li>c. Gas and oil from gas stations = soy sauce</li> </ol> </li> </ol>



Lesson 2

- d. Chemicals from factories = jello mix
- e. Garbage from homes = small pieces of paper
- 4. Once all the pollutants are placed in the tray have the students spray the tray with the spray bottle to model rain
- 5. Have the students discuss the following questions
  - a. What did you notice?
  - b. How did the pollutants affect the water?
  - c. Do you think the amount of rain will affect how polluted the water will be?
  - d. Where does the water collect after the rain? (the water will collect in th base of the pain tray)
  - e. What does the base of the paint tray model? (a storm drain that flows under the city)
  - f. What happens with the storm water after the rain?

Formative assessment

Students individually answer the following question to be turned in:  
How does rainwater become polluted before going into the sewer?  
Use two examples to support your response.

Lesson 3	
Title	Where does our water go?
Grade level	Middle School Grades 5-8
Subject	Environmental Science
Objectives	Explain how climate change is causing an increase in rainwater
Standards	4.2.6.C - identify the natural and human made factors that affect water quality  4.1.7.E. - identify factors that contribute to change in natural and human made systems
Vocabulary	Climate change Evaporation Precipitation Water vapor Wastewater Combined sewer system
Materials	Powerpoint in apedenix titled "Lesson 3"  Article also in appendix labeled "Lesson 3 Article" <a href="https://water.phila.gov/stormwater/#why-manage-stormwater">https://water.phila.gov/stormwater/#why-manage-stormwater</a>  Individual technology sources with access to internet Or One technology source with access to the internet  Website also in appendix labeled "Lesson 3 Website" <a href="https://water.phila.gov/maps/csocast/">https://water.phila.gov/maps/csocast/</a>  Blank paper for each student
Resources	"United Nations" <a href="https://www.un.org/en/climatechange/what-is-climate-change">https://www.un.org/en/climatechange/what-is-climate-change</a>  "EPA" <a href="https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding">https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding</a>

Lesson 3	
	<p>“National Geographic”  <a href="https://education.nationalgeographic.org/resource/how-climate-change-impacts-water-access/">https://education.nationalgeographic.org/resource/how-climate-change-impacts-water-access/</a></p> <p>“Philadelphia Water Department”  <a href="https://water.phila.gov/stormwater/#why-manage-stormwater">https://water.phila.gov/stormwater/#why-manage-stormwater</a></p>
Lesson Structure	
Background	<p>Powerpoint:  <b>Climate change</b>  Climate change is affecting the water cycle in many ways. Climate change has caused the global average temperature to increase. Climate change is causing warmer global temperatures causing the ocean to expand and melting glaciers to add to the ocean’s volume, causing sea level rise. Another way climate change is affecting the water cycle is by causing more floods and droughts.</p> <p>Droughts are occurring more often due to the increase in evaporation, As surface temperature increases so does evaporation causing the soil to dry out faster, making the soil harder. As a result, rather than being absorbed by the soil, water is running off into streams and rivers.</p> <p>The increase in water evaporation also impacts precipitation. Warmer air can hold more water vapor which can lead to stronger, more intense storms which cause massive floods.</p> <p>summary : climate change is causing more intense storms and increased rainfall</p> <p><b>Review of watershed lesson</b>  What happens when water hits the ground?  What is the difference between impervious vs pervious surfaces?  How does water act differently when it hits impervious vs pervious surfaces?  What happens to water as it moves across surfaces?</p> <p><b>Transition to sewer</b>  So where does water go?</p> <p>Philadelphia has a combined sewer system which means that sewage from homes and wastewater from streets enter the same pipes to be</p>

### Lesson 3

sent to the wastewater treatment plant.

Explain that the rainwater has gone down the sewer and meets with sewage from homes that flows to a water treatment plant. The water treatment plant cleans the water and returns the water back to the large body of water (Schuylkill and Delaware Rivers).

With normal amounts of rain this system works well. However as we just learned climate change is causing stronger storms with more rainfall at once

This system is fine until there is more rain than the treatment plants can handle. When there is too much water for the wastewater treatment plants the wastewater is discharged into the waterways untreated. Since the sewer system is combined this means all the sewage and polluted water from the rainfall are now combined and overflow into our waterways such as the Delaware and Schuylkill River

#### Activity

Read the article

<https://water.phila.gov/stormwater/#why-manage-stormwater>

Using the CSO Cast map have the students answer the following questions (if students have access to laptop / tablet complete individually, if not complete as a class using the school's address)

Do one as an example (selecting the data points is difficult. You know you selected the data point when the diamond becomes a green circle and the name of the streets appears, if the "combined sewer area paragraph appears you have not selected the point)

1. Read the Combined Sewer Overflows and the key on the left of the page
2. Click both the "combined sewer overflow status" and the "rain gauge status" boxes so all sets of data points are shown on the map
3. Find your house by typing you address into the "search the map box
4. Is your house within an area of the city with combined sewers (use key, if the area is blue yes)
5. Zoom out until you see the closest data points for Combined Sewer Overflow Status to your house. Select data points and fill in the information (start closest to your house and work farther away until you have 3 data points with information)

Lesson 3	
	<ul style="list-style-type: none"> <li>a. Name of the streets:</li> <li>b. Status:</li> <li>c. Date Updated</li> </ul> <p>6. Find three closest data points for Rain Gauge Status and fill in the following information</p> <ul style="list-style-type: none"> <li>a. Rain gauge number:</li> <li>b. Status:</li> <li>c. Rainfall</li> <li>d. Date updated:</li> </ul>
Discussion / debrief	<p>Ask the students the following questions to review the information from the lesson. (discuss as a class, answer individually on paper, pair and share etc)</p> <p>What are three ways climate change is impacting the water cycle? (sea level rise, droughts, flooding)</p> <p>What impact is affecting Philadelphia the most? (flooding)</p> <p>What type of sewer system does most of Philadelphia have? (combined)</p> <p>How does the combined sewer system cause increased flooding in Philadelphia? (pipes become overwhelmed and overflow back into the water untreated, these streams and rivers can overflow their banks )</p>

Lesson 4	
Title	What are the Impacts of Urban Flooding?
Grade level	Middle School Grades 5-8
Subject	Environmental Science
Objectives	Explain the range of impacts of flooding on communities
Standards	<p>4.5.7.C. - explain how human actions affect the health of the environment - Identify residential and industrial sources of pollution and their effects on environmental health</p> <p>4.5.7. E - describe the length and degree of exposure to pollutants may affect human health - Identify diseases / conditions that have been associated with exposure to pollutants</p>
Vocabulary	<p>Mental health</p> <p>Physical health</p> <p>Environmental health</p> <p>Infrastructure</p>
Materials	<p>Powerpoint titled "Lesson 4"</p> <p>Story PDF titled "Lesson 4 Story"</p> <p><a href="https://docs.google.com/document/d/1yNGUEkBz7Ay_HH5ZIdQxpbximFDQm-OFzqu-jXt_2CU/edit?usp=sharing">https://docs.google.com/document/d/1yNGUEkBz7Ay_HH5ZIdQxpbximFDQm-OFzqu-jXt_2CU/edit?usp=sharing</a></p> <p>List of impact statements also in appendix labeled "Lesson 4 Statements"</p> <p><a href="https://docs.google.com/document/d/1-P4wYjI34KApFze2tAPtrhVdZE6Oad1blxcPcW_fOq8/edit?usp=sharing">https://docs.google.com/document/d/1-P4wYjI34KApFze2tAPtrhVdZE6Oad1blxcPcW_fOq8/edit?usp=sharing</a></p> <p>Index cards or small pieces of paper</p> <p>Markers</p> <p>Poster board, large pieces paper or white board</p> <p>Sticky notes or tape (optional)</p>
Resources	<p>"Federal Emergency Agency Management Agency"</p> <p><a href="https://community.fema.gov/ProtectiveActions/s/article/Flood-Impact#:~:text=Floods%20can%20cause%20power%2C%20water,problems%20including%20landslides%20and%20mudslides">https://community.fema.gov/ProtectiveActions/s/article/Flood-Impact#:~:text=Floods%20can%20cause%20power%2C%20water,problems%20including%20landslides%20and%20mudslides</a></p> <p>"The Effects of Flooding on Mental Health"</p>

Lesson 4	
	<a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3461973/#:~:text=Flooding%20affects%20people%20of%20all%20ages%20and%20it%20can%20herald,problems%20with%20their%20mental%20health.">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3461973/#:~:text=Flooding%20affects%20people%20of%20all%20ages%20and%20it%20can%20herald,problems%20with%20their%20mental%20health.</a>
Lesson Structure	
Intro (pre activity)	<p>Explain that students will be learning about the impacts of floods with two activities. The first is a powerpoint that takes students through a story where a family experiences different health issues following a flood. The second activity is where students will be sorting different impacts of flooding into categories: mental health, physical health, infrastructure and environment.</p>
Background	<p>A flooding event leaves strain on a community in a variety of ways. The health of residents, the environment and the impact on infrastructure all affect the way a community is able to recover following a flood. To grasp the range of impacts a flood has on a community the students will participate in two activities.</p> <p>To begin, there is a story for the students to read. The story describes a family, two parents and two children, that live in Eastwick Philadelphia. The family experiences a flooding event and the story explains how each family member has different health effects resulting from the flood.</p> <p>The story is provided in two formats. There is a document version that can be distributed to each student to read individually or there is a powerpoint with the same story broken into slides with pictures showing the impacts described in the story. The document is labeled “Lesson 4 Story” and the powerpoint is labeled “Lesson 4” both can be found in the appendix.</p> <p>The story activity focuses on the health issues resulting from floods. Following the story activity, transition into the sorting activity where students will learn about the numerous other impacts flooding has on a community.</p>
Activity	<p>Impact Sorting</p> <ol style="list-style-type: none"> <li>1. Each student receives an index card with a statement describing an impact of urban flooding</li> <li>2. In the classroom have 4 locations for the categories</li> </ol>

Lesson 4	
	<ul style="list-style-type: none"> <li>a. Mental health</li> <li>b. Environmental health</li> <li>c. Physical human health</li> <li>d. Infrastructure / Community</li> </ul> <ol style="list-style-type: none"> <li>3. Allow time for each student to read the card silently to themselves and decide which category the card can belong to</li> <li>4. Students will then write the statement on their index card under the corresponding categories labeled on large sheets of paper or poster board. <ul style="list-style-type: none"> <li>a. Some statements can be placed in several categories</li> </ul> </li> <li>5. After the students are seated, read through each statement in each category <ul style="list-style-type: none"> <li>a. ask the student to explain their reasoning for sorting their statement into each category to the class</li> </ul> </li> </ol>
Discussion / debrief	<p>Discuss the interconnectedness of the impacts and how they can overlap (physical damage to infrastructure leading to mental stress for residents).</p> <p>Emphasize the importance of considering all three types of impacts when assessing the consequences of flooding on urban communities.</p>
Formative assessment	<p>Homework Assignment</p> <p>Research an urban flooding event</p> <p>Each student must find an urban flooding event and respond to the following prompts</p> <p>Location of the flood</p> <p>Date of the event</p> <p>How long did the flooding last?</p> <p>Was the flood a result of an extreme weather event (hurricane?)</p> <p>What were the impacts of the flood?</p> <ul style="list-style-type: none"> <li>a. Mental health</li> <li>b. Physical health</li> <li>c. Environmental</li> <li>d. Infrastructure</li> </ul>



Lesson 5 and 6	
Title	What Resilience Strategies Can We Use to Fight Flooding?
Grade level	Middle School Grades 5-8
Subject	Environmental Science
Objectives	Critically think about solutions to mitigate the harms of flooding
Standards	4.5.8.A - explain how best management practices can be used to mitigate environmental problems
Vocabulary	Resilience Mitigation Adaptation
Materials	Powerpoint titled "Lesson 5" Index card or piece of paper Scenario list - attached
Resources	"Center for Climate and Energy Solutions" <a href="https://www.c2es.org/document/resilience-strategies-for-flash-flooding/">https://www.c2es.org/document/resilience-strategies-for-flash-flooding/</a>
Lesson Structure	
Background	Powerpoint presentation discussing:  Definition resilience and explaining its importance in addressing the impacts of urban flooding.  An overview of resilience strategies, including preparedness measures, infrastructure improvements, and community-based initiatives.
Intro (pre activity)	<ol style="list-style-type: none"> <li>1. Divide the class into small groups of 3-4 students each</li> <li>2. Provide each group with a scenario depicting a hypothetical urban flooding event and its potential impacts on a community (impacts were discussed in the last lesson) Scenario options: <ol style="list-style-type: none"> <li>a. Your neighborhood park floods repeatedly</li> <li>b. Your school has floods repeatedly</li> <li>c. Houses in the neighborhood flood repeatedly</li> <li>d. Commercial locations (stores, gas stations, pharmacy offices) flood repeatedly</li> </ol> </li> </ol>

Lesson 5 and 6	
	<ul style="list-style-type: none"> <li>e. Roads have flood repeatedly</li> </ul> <p>3. Ask each group to brainstorm resilience strategies that could help mitigate the impacts described in their scenario</p> <ul style="list-style-type: none"> <li>a. Encourage students to consider a wide range of strategies, including infrastructure upgrades, emergency preparedness plans, community education programs, and environmental conservation efforts.</li> </ul>
Activity	<p>Create a Resilience Strategy Plan</p> <ul style="list-style-type: none"> <li>1. Have each group select one or two resilience strategies from their brainstorming session to focus on.</li> <li>2. Have students to develop a detailed plan outlining how their chosen strategies will be implemented in response to the urban flooding scenario provided (this can be done creatively as an oral presentation, powerpoint presentation, poster, multimedia creation, video etc) <ul style="list-style-type: none"> <li>a. Encourage students to consider specific actions, timelines, resource allocation, and stakeholder involvement in their plans.</li> </ul> </li> </ul>
Discussion / debrief	Each group presents project

# Appendix

## **Lesson 1 Powerpoint**

<https://prcceh.upenn.edu/wp-content/uploads/Climate-Change-MS-Lesson-1.pptx>

## **Lesson 1 Worksheet**

[https://docs.google.com/document/d/16NwuENDWUOFP\\_WrqoRwHEW1LvOVtuVuQk6VJppg25e8/edit?usp=sharing](https://docs.google.com/document/d/16NwuENDWUOFP_WrqoRwHEW1LvOVtuVuQk6VJppg25e8/edit?usp=sharing)

## **Lesson 2 Powerpoint**

<https://prcceh.upenn.edu/wp-content/uploads/Climate-Change-MS-Lesson-2-.pptx>

## **Lesson 3 Powerpoint**

<https://prcceh.upenn.edu/wp-content/uploads/Climate-Change-MS-Lesson-3.pptx>

## **Lesson 3 Article**

<https://water.phila.gov/stormwater/#why-manage-stormwater>

## **Lesson 3 Website**

<https://water.phila.gov/maps/csocast/>

## **Lesson 4 Powerpoint**

<https://prcceh.upenn.edu/wp-content/uploads/MS-Lesson-4.pptx>

## **Lesson 4 Story**

[https://docs.google.com/document/d/1yNGUEkBz7Ay\\_HH5ZIdOxpbximFDQm-OFzqu-jXt\\_2CU/edit?usp=sharing](https://docs.google.com/document/d/1yNGUEkBz7Ay_HH5ZIdOxpbximFDQm-OFzqu-jXt_2CU/edit?usp=sharing)

## **Lesson 4 Statements**

[https://docs.google.com/document/d/1-P4wYjI34KApFze2tAPtrhVdZE6Oad1blxcPcW\\_fOq8/edit?usp=sharing](https://docs.google.com/document/d/1-P4wYjI34KApFze2tAPtrhVdZE6Oad1blxcPcW_fOq8/edit?usp=sharing)

## **Lesson 5 Powerpoint**

<https://prcceh.upenn.edu/wp-content/uploads/Climate-Change-MS-Lesson-5.pptx>

# Resources

Links to resources appear in order of reference in the Unite Content.

“The National Oceanic and Atmospheric “Administration”

<https://www.noaa.gov/jetstream/atmosphere/hydro#:~:text=The%20hydrologic%20cycle%20involves%20the,the%20atmosphere%20and%20back%20again.>

“A Summary of the Hydrologic Cycle”

[http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/hyd/smry.rxml#:~:text=The%20hydrologic%20cycle%20begins%20with,to%20the%20surface%20as%20precipitation.](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/smry.rxml#:~:text=The%20hydrologic%20cycle%20begins%20with,to%20the%20surface%20as%20precipitation.)

“How the Hydrologic Cycle Works”

<https://youtu.be/al-do-HGuIk>

“NOAA”

<https://www.fisheries.noaa.gov/new-england-mid-atlantic/habitat-conservation/what-watershed>

“Permeable vs Impermeable”

[https://www.udel.edu/canr/cooperative-extension/fact-sheets/permeable-impermeable-surfaces/#:~:text=Permeable%20surfaces%20\(also%20known%20as,forcing%20it%20to%20run%20off.](https://www.udel.edu/canr/cooperative-extension/fact-sheets/permeable-impermeable-surfaces/#:~:text=Permeable%20surfaces%20(also%20known%20as,forcing%20it%20to%20run%20off.)

“What is a Watershed”

<https://oceanservice.noaa.gov/facts/watershed.html>

“United Nations”

<https://www.un.org/en/climatechange/what-is-climate-change>

“EPA”

<https://www.epa.gov/climate-indicators/climate-change-indicators-river-flooding>

“National Geographic”

<https://education.nationalgeographic.org/resource/how-climate-change-impacts-water-access/>

“Philadelphia Water Department”

<https://water.phila.gov/stormwater/#why-manage-stormwater>

“Federal Emergency Agency Management Agency”

<https://community.fema.gov/ProtectiveActions/s/article/Flood-Impact#:~:text=Floods%20can%20cause%20power%20C%20water,problems%20including%20landslides%20and%20mudslides>

“The Effects of Flooding on Mental Health”

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3461973/#:~:text=Flooding%20affects%20people%20of%20all%20ages%20and%20it%20can%20herald,problems%20with%20their%20mental%20health.>

“Center for Climate and Energy Solutions”

<https://www.c2es.org/document/resilience-strategies-for-flash-flooding/>