Lesson Title: Swamped! Mitigating Local Runoff to Protect Our Waters

Summary: In this lesson students learn about the impact of impervious surfaces on runoff and water quality in their local community, and identify ways community members can reduce their impact. The school community is located next to the Great Swamp National Wildlife Refuge where numerous streams drain and few streams exit. Given the population density surrounding the Great Swamp, there is a potential for high volume runoff along inclusive of point and non-point source pollution. Conversely, the Great Swamp can contain and clean the water entering it. This lesson is designed to build an awareness about the Great Swamp's role in local water quality. The activities in this lesson begin by assessing how the amount of runoff changes when land-use changes. Next, students model what happens to the amount of runoff when land-use and soil types change, as well as what happens to precipitation in their community before and after land use changes. After a field trip to collect stream data around their community at locations where it enters their swamp and after it leaves their swamp, they create a data-driven project that communicates ways the community can get involved in protecting their water supply.

Background:
In thinking about the future, it is imperative that our students are prepared to address all types of issues, including those related local water quantity and quality. This project encompasses the following SENCER Ideals as they explore ways to reduce local water runoff and its subsequent impacts on our local bodies of water:

- SENCER robustly connects science and civic engagement by teaching "through" complex, contested, capacious, current, and unresolved public issues "to" basic science.
- SENCER invites students to put scientific knowledge and the scientific method to immediate use on matters of immediate interest to students.
- SENCER shows the power of science by identifying the dimensions of a public issue that can be better understood with certain mathematical and scientific ways of knowing.
- SENCER, by focusing on contested issues, encourages student engagement with "multidisciplinary trouble" and with civic questions that require attention now. By doing so, SENCER hopes to help students overcome both unfounded fears and unquestioning awe of science.

A problem-based learning model invites students to consider their local water quality, and develop a product that will encourage community members to consider their water quality too. By employing science and engineering practices of the Next Generation Science Standards (NGSS), students come to understand how water quality is related to our local land cover and land use, and create tools communicate ways we can reduce runoff and when runoff occurs, ways we can ensure good water quality when runoff occurs. They present their research and communication tool to community members as a way to spread the word that we can all assist in keeping out water clean.

Problem Statement for Students:
Chatham, like most of the rest of New Jersey, is densely populated. With the settlement of people comes changes to our natural environment. Some of these changes, if left unabated, could lead to irreversible impacts on our local ecosystem, and the ecosystem services provided by our local ecosystems, like clean air and water. Even though our community may seem built-out, development is still taking place, and with that development there is an increase in surface runoff into our local water bodies. How much does the type of surface impact the amount of water, and water quality of the runoff going into our local water bodies? What are the challenges to ensuring clean, plentiful water is available for our community as well as the communities in our area that rely on the same water supply? What are the solutions to these challenges?

Grade Level: 11 - 12

Time: approximately eight 50-minute class periods

Lesson Format/Structure: This "lesson" is a project that follows a problem-based learning model (PBL) and that includes three activities, a field trip, and project work-time.

Student Learning Objectives:

- When presented with the local water quality problem scenario, students define the problem from scientific and civic perspectives.
- Using mathematics and computational thinking, students calculate changes in runoff to ascertain how various land covers affect the quantity of runoff after a precipitation event.
- Students use a model to manipulate land covers and soil types to determine how each affect the quantity of runoff, and then apply the model outputs to determine what types of surfaces are categorized as impervious surfaces around their communities.
- Students use a model based on evidence determine the locations within their community which may have a negative impact on the water quality.
- Students carry out a field investigation following numerous watershed assessment protocols to test their understanding of how water quality in local streams can vary around a suburban community, and what role a wetland plays in a watershed.
- Students will use a form of communication to educate their community about the effects of impervious surfaces on water quality, and what they can do to enhance the quality of water coming from their yards.

NGSS Performance Expectations:

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. *[Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.]* DCI: ESS2.A: Earth Materials and Systems

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HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. *[Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]*
DCI: ESS2.C: The Roles of Water in Earth's Surface Processes

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HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. *[Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]*DCI: ESS3.A: Natural Resources

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HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* *[Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]* DCI: ESS3.C: Human Impacts on

Earth Systems * = engineering practices are a fit for this PE

NGSS Components Addressed: The following elements of NGSS are addressed in each activity of the lesson, all of which will assist learners in developing proficiency in the associated performance expectations listed above.

<table>
<tr><th>Activity</th><th>Science & Engineering Practices[1]</th><th>Disciplinary Core Ideas[2]</th><th>Crosscutting Concepts</th></tr>
<tr><td rowspan="3">Problem Introduction and Swamped! Part 1 - Catch it if you can</td><td>(9-12) Using Mathematics & Computational Thinking; Developing and Using Models</td><td>(9-12) ESS2.A: Earth Materials and Systems
ESS3.C: Human Impacts on Earth Systems</td><td>(9-12) Cause & Effect; Scale, Proportion, and Quantity</td></tr>
<tr><td colspan="3">Blended 3-D Teacher & Student Actions
Teacher: Introduces the overarching problem (see above).
Pose case scenario and lead a brainstorming session on what we know and need to know to solve the case. Assist students with determining outcomes. At the end of the activity, debrief students about the accuracy of their calculations to model the quantity of runoff.

Student: Identify data needed to ascertain the quantity of runoff when a land use practice is changed. Using this data, they perform calculations to quantify this value.</td></tr>
<tr><td colspan="3">CC Math & ELA
Mathematics -
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
ELA/Literacy -
WHST.9-12.1 Write arguments focused on discipline-specific content.</td></tr>
<tr><td rowspan="3">Swamped! Part 2 - Capturing Precipitation</td><td>(9-12) Developing & Using Models</td><td>(9-12) ESS2.C: The Roles of Water in Earth's Surface Processes</td><td>(9-12) Systems & System Models</td></tr>
<tr><td colspan="3">Blended 3-D Teacher & Student Actions
Teacher: Reviews work from the previous day and then engages students with a satellite image of their school grounds to discuss what happens to the precipitation that falls on the school grounds. Ask students how to verify their ideas, and from their previous experience they will likely mention that using models will assist them with verification. Introduce them to Micro Site Storm Model. Debrief the activity at the close of the class period.

Student: Students participate in the discussion about the flow of water on school grounds, and then run the model to test their ideas. They investigate their own ideas at the end of this activity, and reflect on applications for what they learned in the activity.</td></tr>
<tr><td colspan="3">CC Math & ELA
Mathematics –
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
ELA/Literacy –</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">WHST.9-12.1 Write arguments focused on discipline-specific content.
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.</td></tr>
<tr><td rowspan="3">Swamped!
Part 3 - My Watershed</td><td>(9-12) Developing & Using Models</td><td>(9-12) ESS2.C: The Roles of Water in Earth's Surface Processes
ESS3.A: Natural Resources</td><td>(9-12) Systems & System Models; Stability & Change</td></tr>
<tr><td colspan="3">Blended 3-D Teacher & Student Actions
Teacher: Challenge the students to trace a drop of water as it flows through their community. After they list all of the obvious ways it might flow from high to low, introduce them to Activity 3 and their topographic maps to refine their description of how a drop of water flows through their community. Afterwards, introduce them to Model MY watershed and the other data tools for in this activity, and allow them time to investigate the uses of each.

Student: Use map skills to identify key map features that will affect the flow of water through their community. Because the data tools in this activity provides them with a personal view of their watershed, they will be able to provide preliminary thoughts about what they will find in the water when they go on their field trip to various streams in their community.</td></tr>
<tr><td colspan="3">CC Math & ELA
Mathematics –
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
ELA/Literacy –
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.</td></tr>
<tr><td rowspan="3">Swamped!
Field Trip</td><td>(9-12)Analyzing & interpreting Data</td><td>(9-12) ESS3.A: Natural Resources</td><td>(9-12) Cause & Effect; Patterns; Systems & System Models</td></tr>
<tr><td colspan="3">Blended 3-D Teacher & Student Actions
Teacher: Prior to the trip, on the trip, and after the trip ask students about the purpose of the field trip. Encourage their powers of observations while at each site, and connect their observations to their experiences with the classroom activities in this project. Probe students about possible solutions to water quality issues found in their community that includes problems identified on their field trip.

Student: Full participation in the field trip to collect data and make connections between data and their hypotheses about what they expected to find before water went into their wetland, and when it came out.</td></tr>
<tr><td colspan="3">CC Math & ELA
Mathematics –
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
ELA/Literacy –
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical</td></tr>
</table>

	events, scientific procedures/ experiments, or technical processes.		
Swamped! Project	(9-12) Asking Questions and Defining Problems; Engaging in Argument from Evidence; Obtaining, Evaluating, and Communicating Information	(9-12) ESS3.C: Human Impacts on Earth Systems	(9-12) Cause & Effect
	Blended 3-D Teacher & Student Actions Teacher: Introduce the problem and assist students with the identification of all the associated parts of the problem, such as the what where, when, how, etc. After completing all the activities, students should be ready to adopt a project topic that will assist in solving the problem. Walk students through the expectations of each topic and how each topic will assist in solving the problem. Student: Students form teams and select a topic from the list, and begin developing their project. Students complete their project in a stepwise fashion: topic selection, project proposal design, research, final products (presentation materials and a tool to communicate their findings).		
	CC Math & ELA *Mathematics* – MP.2 Reason abstractly and quantitatively. HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *ELA/Literacy* – RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.		

[1]Combined in lesson sequence, practices both science and engineering.
[2]Both science content and engineering design Disciplinary Core Ideas.

Assessment(s)	
Formative Assessments	
Swamped! Part 1	In this activity students calculate the difference a type of land use and soil type has on the amount of runoff. They use this data to make an informed decision about the housing density on a piece of farmland. Students are assessed on their ability to use formulas to

	make data-driven decisions and to problem solve.
Swamped! Part 2	In this activity, students use a model to determine how land use, land cover, and soil type affect the amount of precipitation that goes into runoff, infiltration, and evapotranspiration. They collect and analyze this data and apply it to a local scenario about zoning in their community. Students are assessed on their ability to apply model results to date-driven decisions and to problem solve.
Swamped! Part 3	In this activity, students trace the movement of water throughout their community using topographic maps, online data tools, and online models as a way to ascertain the dimensions of their local watershed. The online model allows them to apply what they learned in the previous lesson to their local watershed. They run the model using various water conservation methods and apply the outputs to their understanding of how water quality changes as it moves throughout the community, and what homeowners can do protect the water from contamination. Students are assessed on their ability to apply model results to data-driven decisions and to problem solve.
Swamped! Field Trip	Students were debriefed at the end of the field trip while still in the field to find out if they made connections between the data and their understanding of the dynamics of a wetland that purifies water. In addition, students reported their data analysis to their classmates who were not on the field trip.
Swamped! Project	Along, the way to completion, students are required to submit "checkpoints" which includes an overview of their final project, their research notes, and a rough draft of their powerpoint presentation and "tangible" (pamphlet, video, etc). These checkpoints will determine the strength of student progress, and allow for feedback to ensure students remain on target for a successful product when they are finished.
Summative Assessment	
Student teams are assessed on their final products - a powerpoint presentation and associated oral presentation to a community audience, and a "tangible" (pamphlet, video, etc) - using a project rubric.	

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Activity 1: Swamped! Part 1 - Catch it if you can

Activity 1 Essential Question: How do land use practices impact the quantity of runoff after a precipitation event?

Introduction:
Before starting this activity, introduce the overarching problem for this set of activities. This activity is used to explore environmental impacts of land use change, or to explore sustainable practices for land use. This activity only ties in one impact of land use change; use this limitation to raise the question about other impacts and how they can be pre-assessed before the development occurs. You may also want to tie into the discussion how Environmental Impact Statements (EIS's) are designed, and have the class create a mock-EIS for a local project.

Materials:

- EnviroScape Model - if available, otherwise, use the materials listed below
- 4 9"x13" trays of soil
- small houses, trees, pieces of felt which can model grass, red powdered drink mix
- spray bottle
- Activity 1 handout

- handout with data tools needed to complete the calculations

Activity Sequence

Student Prior Knowledge	(6-8) ESS2.A: Matter cycles within and among Earth's systems (6-8) ESS3.C: Human activities have altered the biosphere. Activities and technologies can be engineered to reduce people's impact on Earth
Engagement (phenomena/ engineering scenario)	To engage students, ask them what would happen to the local environment if a development was built in a neighboring open space. Use this brainstorming to guide student thinking about environmental impacts and how they are measured. If needed, use the materials to create models of different land uses, and use the spray bottle to make it rain over the models. Assist students with cause and effect and how cause and effect vary with each intensity of land use.
Gathering Data or Exploration	Introduce the case and work through the problems with the students.
Reasoning or Explanation/ Elaboration	Using the data collected from their calculations, students explain how land use can impact the quantity of runoff in a community, and elaborate on types of solutions to reduce the impact of the runoff.
Reflection or Evaluation	Students use the results of this activity to consider land use and runoff in their own community, which is a segue into the next activity. Discuss the accuracy of their calculations to model the amount of runoff for each type of land use practice.
Assessment(s) (formative & summative)	In this activity students calculate the difference a type of land use and soil type has on the amount of runoff. They use this data to make an informed decision about the housing density on a piece of farmland. Students are assessed on their ability to use formulas to make data-driven decisions and to problem solve.

Additional Notes:

- Students may be challenged initially with the equations, but the guided example was designed to assist them in their use of the equations.
- Allow students to work with partners as a way to check the results of the calculations.
- Clean-up: Discard disposable materials, and store reusable materials for later use.

Additional Resources:
None

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Activity 2: Swamped! Part 2 - Capturing Precipitation

Activity 2 Essential Question: How do land use practices affect runoff when combined with other variables such as soil type?

Introduction:
Now that they have the idea that the types of land use practices found in an area can increase or decrease the amount of stormwater runoff going into our local bodies of water, students will investigate how well the surfaces in their area retain stormwater runoff using a general model in this activity. They will use a model that will allow them to test different types of surfaces other than those in the Part 1 for their ability to retain water. Next they'll look more closely at their school and community to hypothesize what happens to water around there after a precipitation event.

Materials:

- Computers - 1 per student or student pair
- Website access: Model Microsite Runoff at https://micro.app.wikiwatershed.org/
- Activity 2 Handout

Activity Sequence

Student Prior Knowledge	(6-8) ESS2.C: Water cycles among land, ocean, and atmosphere. Water movement causes weathering and erosion, causing landscape changes.
Engagement (phenomena/ engineering scenario)	What happens to stormwater runoff when we change land use practices? Students label a satellite photo of a 1 sq km plot that includes their school yard with "I" for infiltrate and "R" for runoff. This will help them visualize the movement of water off their school grounds.
Gathering Data or Exploration	Students use the Model Microsite Runoff modeling tool to gather and graph data relative to land use practices first and then to soil type. After interpreting their data, they investigate their own question that combines the two variables (land use type, and soil type).
Reasoning or Explanation/ Elaboration	After analyzing and interpreting data to identify relationships, students construct explanations for the patterns found in the data.
Reflection or Evaluation	Students reflect on the results of their own investigation, and on their labeled satellite image to evaluate their progress in understanding the role of land use practices and soil type play in water infiltration. In addition, they complete the application for this activity which links the activity to land use planning in their community.
Assessment(s) (formative & summative)	In this activity, students use a model to determine how land use, land cover, and soil type affect the amount of precipitation that goes into runoff, infiltration, and evapotranspiration. They collect and analyze this data and apply it to a local scenario about zoning in their community. Students are assessed on their ability to apply model results to date-driven decisions and to problem solve.

Additional Notes:

- Students may have problems interpreting the satellite image of their location in the first step of this activity. Alternatively, provide a digital version of the image (projected or their course learning management system) so they can clearly define impervious and impervious surfaces.
- Assist students with constructing the bar charts, or set up an Excel table that converts the data into a chart for them.
- If needed for some learners, allow students to work with partners to complete their original investigation.

Additional Resources:
None

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Activity 3: Swamped! Part 3 - My Watershed

Activity 3 Essential Question: What is included in your watershed?

Introduction:
Now that we know what can happen to our precipitation as it strikes different surfaces, let's trace it as it flows from one place to another. What determines where it flows? This activity will help students identify their local watershed and give them information that can be used in problem solving a water protection plan for their area by running a model that includes a variety of conservation techniques.

Materials:

- tissue paper
- topographic Quads for their area
- tape
- colored pencils
- Computers - 1 per student or student pair
- Model My Watershed: https://app.wikiwatershed.org/
- USGS StreamStats: https://streamstatsags.cr.usgs.gov/streamstats/
- USGS National Map – Hydrology: https://viewer.nationalmap.gov/viewer/nhd.html?p=nhd

Activity Sequence

Student Prior Knowledge	(6-8) ESS2.C: Water cycles among land, ocean, and atmosphere. Water movement causes weathering and erosion, causing landscape changes. (6-8) ESS3.A: Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable.
Engagement (phenomena/ engineering scenario)	Using a topographic map, trace a drop of water from your yard to the lowest point in the area. Describe the surfaces the drop of water comes in contact with as it travels. The topographic map portion of this activity serves two purposes: 1) introduces students to 2-dimensional representations of their area, and 2) orients them to the area that will be included in their upcoming field trip. Although there are plenty of digital mapping tools available, a paper map provides students with a surface on which they can easily manipulate by drawing on it if it is laminated, or by overlaying it with tissue paper and outlining areas of interest.
Gathering Data or Exploration	In the second part of this activity, students run a model and gather data from Model My Watershed which includes all the land uses that occur in their watershed at the various HUC levels (8, 10, 12). The results will provide them with runoff data and water quality data. Next, they run the model again, but with applying a variety of conservation techniques within the HUC-10 level. The other data tools in this activity allows students to isolate the drainage basins for the minor streams in their watershed to a level that they can identify the specific origins of any pollutants found in their local bodies of water.
Reasoning or Explanation/ Elaboration	Students use the model outputs to describe the movement of water through their community, and to list any sources of impairments that may affect the quality of their water. In their elaboration they should discuss the use of conservation practices designed to retain the water within their yards as a way to reduce runoff.
Reflection or Evaluation	Student reflections are similar to above, although they should be relevant to their watersheds, and should include the effect of some of the conservation practices they modeled.
Assessment(s) (formative & summative)	In this activity, students trace the movement of water throughout their community using topographic maps, online data tools, and online models as a

	way to ascertain the dimensions of their local watershed. The online model allows them to apply what they learned in the previous lesson to their local watershed. They run the model using various water conservation methods and apply the outputs to their understanding of how water quality changes as it moves throughout the community, and what homeowners can do protect the water from contamination. Students are assessed on their ability to apply model results to data-driven decisions and to problem solve.

Additional Notes:
- This activity can be done without using a topographic map; however, topographic maps assist in developing spatial skills in a way that online mapping tools cannot.
- Check all links before beginning this activity.
- Allow students to work in pairs, or at least near each other since some students catch on quicker when using maps and online data tools. Modify the lesson as needed for those students who may need modification.
- Store materials for future use.

Additional Resources:
None

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Activity 4: Swamped! Part 4 - Field Trip

Activity 4 Essential Question: What's in our water?

Introduction:
The field trip connects students to the results of the activities they have been working on, the overarching problem for this project, and their backyards. While on the trip, they collect chemical, visual, and biological data at three sites where water flows into their local wetland, and from one location where water flows out of this wetland. The apply their understanding of wetlands to the analysis of the data, and begin to brainstorm ways to prevent water pollution in the local streams. It is likely that not all students attend the field trip, and therefore debriefing the trip experience and data at the end of the trip, and then again (led by those who went on the trip) with those not attending will ensure that all students are engaged in trip experience in some way. Invite the Director of Water Quality Programs from the local watershed association to class to introduce the field trip and the activities that will take place on the trip.

Materials:
- clip boards
- waders
- sunscreen and bug spray
- Data sheets: visual assessment, macroinvertebrates, water chemistry
- Visual assessment supplies: tape measure, marker flags, weighted rubber ducky, thermometer
- Water chemistry: chemical test kits (nitrates, phosphates, pH, DO) , turbidity column/meter, thermometer
- Macroinvertebrates: collecting supplies (nets, trays, spoons, eyedroppers), identification keys
- camera
- Note: Review equipment list before going into the field, and where possible, duplicate the supplies

Activity Sequence

Student Prior Knowledge	(6-8) ESS3.A: Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable.

Engagement (phenomena/ engineering scenario)	What do you think we'll find around the community in regards to water quality? Why? Show students a map of the locations for field work, and remind them of the data they collected and viewed in the previous activities. Prepare students for field work before the day of the trip by walking them through the protocols, and what to expect when they are in the field in regards to comfort, and level of work.
Gathering Data or Exploration	Students are divided into teams for the day to collect data. Depending on the number of students, there may be duplication of datasets. That is okay so long as everyone is involved in some way.
Reasoning or Explanation/ Elaboration	Circulate among the small data collection teams, and prod them about the implications of what they are finding relative to water quality.
Reflection or Evaluation	Take time at the end of the trip, and again the next day for those students who did not attend the trip to debrief the data collected.
Assessment(s) (formative & summative)	Students were debriefed at the end of the field trip while still in the field to find out if they made connections between the data and their understanding of the dynamics of a wetland that purifies water. In addition, students reported their data analysis to their classmates who were not on the field trip.

Additional Notes:

- A field trip has many tasks which makes it less of a challenge to identify the appropriate tasks for some students.
- It is imperative that field safety be part of the pre-trip conversation. Warn students about bugs, poison ivy, slipping in the water and on wet surfaces, etc.
- Clean and store equipment for future use

Additional Resources:
None

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Activity 5: Swamped! Part 5 - Project

Activity 5 Essential Question: What are the solutions to the challenges of protecting our water quality?

Introduction:
The problem was introduced at the front-end of the project, and at this point students are working in teams on their solutions. First they choose a topic from the list, or develop their own, and then create a proposal for how they are going to approach their topic in the allotted amount of time before their presentations. All topics include data of some kind, and peer-reviewed research, both of which will support their arguments for the viability of their solutions. For more detail on the specifics of this project, visit the Great Swamp Watershed Association website (https://www.greatswamp.org/) for detailed steps for this project (Watershed Friendly Living), and all of the handouts and rubrics. Be sure to create "hard" checkpoints (specific dates) to ensure students are on target to complete their project by the due date. Provide students with rubrics so they know what is expected of them.

Materials:

- Computer access
- Access to field trip data
- Additional materials may be required as defined by the topics selected by the students
- Watershed Friendly Living Rubrics and Organizers developed by Karen DeTrolio for the Great Swamp Watershed Association

Activity Sequence

Student Prior Knowledge	(6-8) ESS3.C: Human activities have altered the biosphere, sometimes damaging it. Activities and technologies can be engineered to reduce people's impacts on Earth.
Engagement (phenomena/ engineering scenario)	Ask students for ideas on what they can do to ensure good water quality in their local watershed. Next, ask them what homeowners can do. Share the topics with the students, and allow student-teams select a topic. Ideally, only one team should adopt each topic since there are plenty of topics to from which to choose.
Gathering Data or Exploration	Circulate through all of the teams to discuss their data and assist them with acquiring the data where necessary. It is then up to the students to determine the best way to analyze and present their data, which will be to an audience on the due date for the project.
Reasoning or Explanation/ Elaboration	Students use their data and their research to explain why their solution is warranted, and how it will be effective in keeping our water clean.
Reflection or Evaluation	Students reflect on their final product and provide ideas on how they could improve it.
Assessment(s) (formative & summative)	Formative: Along, the way to completion, students are required to submit "checkpoints" which includes an overview of their final project, their research notes, and a rough draft of their powerpoint presentation and "tangible" (pamphlet, video, etc). These checkpoints will determine the strength of student progress, and allow for feedback to ensure students remain on target for a successful product when they are finished. Summative: Student teams are assessed on their final products - a powerpoint presentation and associated oral presentation to a community audience, and a "tangible" (pamphlet, video, etc) - using a project rubric.

Additional Notes:

- Students self-select groups which will assist learners needing extra assistance to complete their projects
- Be sure to check in with the groups on a daily basis asking them to explain their thinking as a way to ensure they are making positive progress.

Additional Resources:

Depends on the topics students chose, there may be additional resources needed.