Table of Contents for the Green Infrastructure Curriculum

Green Infrastructure Walk and Classroom Lessons on Climate and Sustainability

By Rosemary Millham

Introduction

Whether you are an individual, family, or class out to observe our Green Infrastructures on the SUNY New Paltz campus, we invite you to use this module as a reference and/or as curriculum support. Each green infrastructure located on campus has signage that describes the green infrastructure and its purpose. The lessons included in the module can be used prior to visiting campus, or as a follow-up instructional piece. Please feel free to contact Rosemary Millham at millhamr@newplatz.edu for further information on the curriculum and its use.

Part I - The Green Infrastructure Walk for Visitors

A. If you are a family or an individual interested in seeing what has been put in place on campus, please follow the map and visit the sites you are interested in viewing. An app for the walk is available at XXXXX. Check out the following curriculum support materials, if you like, for explanations, activities, and suggestions for sustainable practices. Also available are two documents you can download for information on green infrastructures and questions to engage youth; **"Green Infrastructure Curriculum Walk for Visitors" and "**

B. If this is a class visit, please read the module activities in Part II prior to visiting campus so that you and your students get the most out of your visit. The **"Green Infrastructure Curriculum Walk for Visitors"** can also be used and is an app at XXX. Included in the full curriculum module are the following lessons in Part II.

Part II – The Lessons

If you have time for lessons prior to, during, or after visiting campus, please review the following lessons. They may be just what you are looking for to teach about storm water and green infrastructures, as well a bit of climate change science. The lessons in the module include (along with a glossary and additional resource list):

- Lesson - Water Cycle Relay
- Lesson - Groundwater as Part of the Water Cycle
- Lesson - Ground Surfaces and Infiltration
- Lesson - Watch Your Storm Drain!!!!
- Lesson - How Rain Gardens Preserve and Improve Our Water
- Lesson - Green Infrastructure Calculator (on the web)
- Lesson - How Much Water Do You Use?
- Lesson - Water Use Matching Game
- And, Your Carbon Footprint Is?

Lesson - Water Cycle Relay
By Rosemary Millham
(Significantly modified EPA resource)

Keywords evaporation, condensation, cloud, precipitation, river, infiltration, groundwater, evapotranspiration, and hydrologic Cycle

Grade Levels 5-8

Activity Time 20-30 minutes

Setting Inside the classroom in large groups

Prerequisites Students must be familiar with, and be able to identify, the phases of water

Subjects Science

NYS Science PERFORMANCE INDICATOR 2.1
Explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.

> 2.1j Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle.

Topic The water cycle introduction/review

Objectives

1. The student groups will identify the meaning of various parts of the hydrologic cycle.
2. The student groups will be able to explain the meaning of the parts of the hydrologic cycle.
3. The student groups will demonstrate their understanding of the hydrologic cycle by identifying the correct phase.

Materials Needed
Two trays of ice cubes
Two spoons
Tape
Two sets of vocabulary words on slips of paper (found at the end of this document)
Large drawing of the hydrologic cycle
Bucket.

Personal Connection - Recycled Water If water droplets could talk to one another, they might be heard to say, "Hey, haven't I seen you somewhere before?" The drops that drip out of your faucet today, could have fallen as rain during the time of the dinosaurs, been frozen in the glaciers during the ice age or risen as steam from your great-great Grandmother's tea kettle. Water just keeps going around and around. The amount on the

Earth today is the same amount that has always been here. It is the ultimate in recycling. So next time you pour yourself a glass of water, think of where it might have been and where it might be going.

Directions:

1. Divide the class into two teams. Show them **Water Cycle (hydrologic cycle)**, pointing out the missing vocabulary words that describe the steps in the cycle indicated by arrows in the video. Explain that they will fill in these blanks with the missing words in the course of a water cycle relay race. http://www.youtube.com/watch?v=0_c0ZzZfC8c
2. Pass out a spoon and a tray of ice cubes to each group. As part of the relay, each group will place an ice cube on the spoon and pass both from the back of the line to the front of the line. Let the groups practice passing the spoon with the ice cube on it.
3. Next, give each group a set of the following nine vocabulary words written on slips of paper: **evaporation**, **condensation**, **cloud**, **precipitation**, **river**, **infiltration**, **ground water**, **evapotranspiration**, and **hydrologic cycle**. Have the groups attach a piece of tape to each slip of paper. Ask the groups to discuss the words, reviewing their meanings and where they fit in the water cycle illustration at the front of the class (sample found at the end of this document).

4. Explain that you will read a matching water cycle "riddle" (below) for each of the vocabulary words. The students must quietly decide among their group which word best fits the riddle. The last person in line tapes the slip of paper with the matching word to the bottom of the spoon and places the ice cube in the spoon. He or she then passes the entire spoon to the next person and so on down the line. The person at the head of the line walks quickly to the exhibit at the front of the room with the spoon and ice cube, places the ice cube in a bucket and tapes the word to the correct spot on the cycle, then, returns to the end of the line and the race begins again with another riddle.
5. Before beginning the race, review the rules for the relay. No one may touch the ice cube after it has been placed on the spoon until it reaches the head of the line. That means no holding it as it is transferred up the line or while carrying it to the

exhibit. If it falls off, it starts from the back of the line again. If the students are having trouble, let them start the ice cube where it fell off.

6. Invite the students to help decide how points should be awarded and record these figures on the blackboard. Ask them to decide the number of points to be given to the team that finishes first, the team that selects the correct vocabulary word, and the correct placement of the word in **the hydrologic cycle**.
7. Let the races begin! The winner is the team with the most points.

Homework As a homework assignment, send the students on a scavenger hunt. Have them look for and record water in its different forms in and around their homes.

Extensions:

a. Have the students create a mini water cycle in a plastic sandwich bag. Have them work in small groups. Ask them to place a mark on a small plastic cup one inch up from the bottom. Demonstrate how to hold the plastic bag at an angle so that one corner of the opening edge is at the top and tape a cup to the middle of the inside of the bag. Then have the groups tape their cups to the inside of their bags. Have them fill the cup with water to the line. Ask them to seal the bag carefully and securely tape the closed bag to a sunny window. What do they think will happen to the water in the cup over time? What will the inside of the bag look like? Ask them to record their observations at various time intervals for the next several days. Have them measure the amount of water inside the cup and bag at the end of the experiment. Did it change? How? Can they explain what happened if there were changes?

b. Have your students make a terrarium to view the water cycle. Have the students bring in the large size plastic soda bottles with **black bases**. The black bottom is removed and used as the base of the terrarium. The clear top quarter of each bottle is then cut off and inverted, fitting tightly into the planter base. Divide the class into pairs. Give each pair a base and clear top. Have them line the base with small pebbles and add potting soil until it is 3/4 full. Ask them to collect moss and some small plants to plant in the soil. Have them water the soil lightly and securely put on the clear top of the terrarium. Put the terrariums on a sunny windowsill and observe.

The riddles of vocabulary for the relay are located on the next page!

THE HYDROLOGIC CYCLE

Below the surface of the Earth
In between particles of dirt
That's where this water is found
Saturating everything deep underground
Groundwater

In between and all around
Through the soil without a sound
Water seeping down down down
Slowly moving underground
Infiltration/Percolation

Heat from the sun makes water rise
Up as vapor to the skies
Evaporation

Cumulus, stratus, cirrus too,
Water vapor visible in skies of blue
Cloud

Down is the direction this water falls
As crystals, drips, or even balls
Precipitation

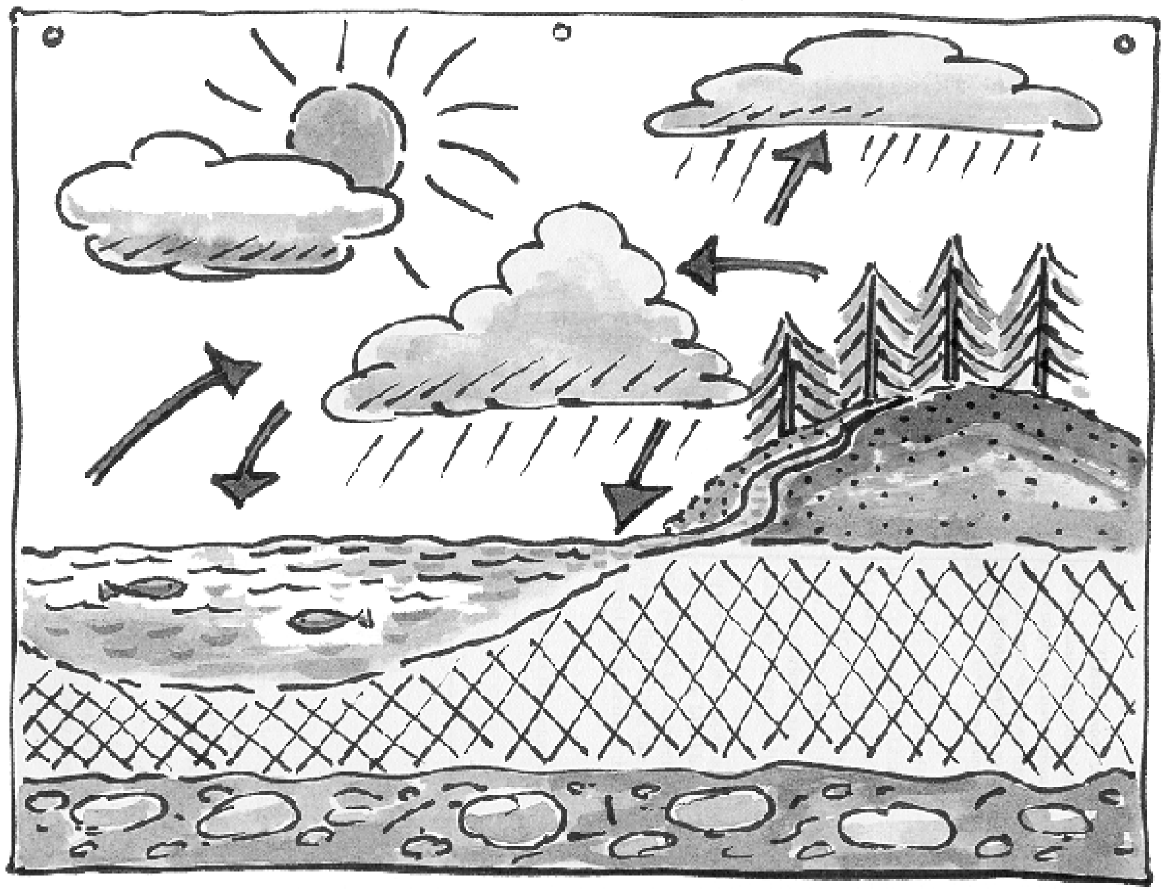
Once a gas but then it's changed
Into a liquid to be seen again
Condensation

From the pores of plants
water vapor escapes
Into the air without a trace
Evapotranspiration

I start as a trickle and then I grow
Picking up speed as down I go
Over the surface from land to the sea
Obeying the laws of gravity
River

Water going round and round
Changing form but not amount
The Hydrologic Cycle

The Hydrologic Cycle



The hydrologic cycle poster - This material has been modified and used with permission from **Shelburne Farms** by the EPA, Copyright © 1995.

Lesson - Groundwater as Part of the Water Cycle
By Rosemary Millham

Keywords groundwater, water cycle, aquifer
Grade Level 5-8
Time 30-45 minutes
Setting Classroom

State Standards
STANDARD 1 Analysis, Inquiry, and Design
Key Idea 1: S1.3 – Represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others.

STANDARD 6
Interconnectedness: Common Themes
Key Idea 2: 2.2 – Use models to study processes that cannot be studied directly.

Concepts
- Groundwater is filtered through Earth via soils and rock to supply clean water to streams and aquifers. We depend on this water resource to sustain life.
- The water cycle recharges groundwater.

Goals for the Lesson
- Students will demonstrate understanding of the effects of soils and rocks on filtering groundwater.
- Students will explain how their understandings expand their concept of the water cycle to include groundwater, aquifers, and the water table.
- Students will consider sources of contamination in the water cycle.

Materials Needed
- 2-liter clear soda bottle with the bottom cut off to make a tall funnel
- Beaker
- Ring stand and ring
- Sand, gravel, small pieces of limestone
- Fine sediments like silt to model runoff sediments
- pH strips
- Vinegar
- Coffee filter or paper towel cut into a circle to fit the small end of the soda bottle “funnel”
- Crushed leaves, moss, etc. for organic material

Activity – Teacher led with Student engagement
- Prepare all of your materials ahead of time, and mark the outside of the soda bottle “funnel” at 1 cm intervals with a permanent marker.
- In class, as a demonstration, complete the following steps and ask students questions throughout
- Place the filter at the narrow end of the funnel.
- Pack the funnel, keeping the narrow end down in the ring stand, a 3 - 4 cm layer of a sand and clay mixture topped with a 2 cm organic layer.

- Do not put in too much clay. Ask students if they can predict what would happen if you put in too much clay?
- Now, add layer of all limestone about 3 cm thick. Top this off with sand, clay, and pea-sized limestone 2-3 cm deep.
- Prepare a jar with about 500 ml of water with sediments (fine silt) in it.
- Have a student shake the jar and ask all students what this represents. It represents our streams and runoff after a heavy rain. Guide them in their thinking.
- Now ask a student to test the pH of the water in the jar. (You may want to add some vinegar or other acid to make it slightly acidic.)
- Now pour the "runoff" in the jar through the funnel of soils making sure to catch the water in a clear jar or beaker at the bottom of the funnel.
- Ask a different student to test the pH of the captured water.
- Depending on your layers of soils, and the size of limestone, you may see a small increase in pH as the water filters through. If it does not change, point out to the students that there is a greater amount of limestone in the bedrock in the Ulster County area than in the funnel's column of soils.
- Discuss the clarity of the water. How does it look? Did it change? How?
- Ask the students to compare the demonstration with a picture of the water cycle.
- Post a water cycle image that includes runoff and groundwater, without labels. Ask students to copy the diagram, and label the parts of the water cycle. If possible, follow this with one or all of the students the water cycle videos at http://www.youtube.com/watch?v=Az2xdNu0ZRk (others listed below). In their journals, ask students to draw the funnel column, labeling all of the layers, and record concepts from the water cycle that are represented in the funnel activity. These include runoff, infiltration, filtering, and change.

Additional water cycle videos can be found at:
http://www.youtube.com/watch?v=oaDkph9yQBs
http://www.youtube.com/watch?v=0_c0ZzZfC8c
http://climate.nasa.gov/climate_reel/WaterWaterEverywhere640360

Extension
Questions to ask students, and to guide them to finding answers, include:

- Other than sediments, what else can runoff pick up and carry along with the water? (Chemicals like fertilizers and pesticides, debris such as trash, leaves, stick, spills of gas, oils, other auto chemicals, and much more!)
- How do you think the materials picked up as rainwater runoff flows over the land or into the soil impact the quality of your water?

Evaluation
Check the student drawings and labels to be sure the students get it. As an additional evaluation, have the students write a half-page to a page about a concept they learned, and how the water cycle impacts their lives. Examples: 1) How does ground water change rainfall? 2) How do we depend on groundwater? 3) What can happen to groundwater to change its quality?

Lesson - Ground Surfaces and Infiltration
By Rosemary Millham (Significantly modified Colleen M. Serencsits lesson)

Keywords infiltration, water, permeability, transmit, impermeable
Grade Level 5-8
Total Time 90 minutes (or two 45-minute classes)
Setting outdoors around school, classroom

Standards

STANDARD 1 Analysis, Inquiry, and Design
Key Idea 1: S1.3 – Represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by other.

STANDARD 6
Interconnectedness: Common Themes
Key Idea 2: 2.2 – Use models to study processes that cannot be studied directly.

Goals

- Students will demonstrate the concept of permeability.
- Students will apply the concept of permeability to different types of ground materials.
- Students will apply the concept of permeability to local ground materials.

Materials

For each lab group

- Paper and writing utensil
- Samples of soils and other surface materials
- Dropper
- 50 ml graduated clear-sided beaker or long tube for each sample (1 liter bottles work also)
- Source of water
- Stopwatch
- Science journals
- The attached table

Introduction and Prerequisites for Teachers and Students

- We have learned about the hydrologic cycle and the hydrologic equation. When precipitation falls on the ground, some of it infiltrates into the groundwater system, some of it sits at the surface, and some of it runs over the surface of the land as runoff. What are some of the factors that are important in predicting the path that precipitation follows? (Steepness of the land, intensity of precipitation, surface materials, types of soils, etc.)
- List ideas on board.
- The topic we will be discussing next is permeability, as the ability of soils, rock, or other material to **transmit** water.
- Demonstrate by pouring water onto the sponge and onto the rock, and asking students to describe what happens. (The water soaks into sponge, not into the rock)

Observation

- Take students outside, around the school grounds. Have students list all the types of surface material they encounter (parking lot, school, grass, bushes with mulch and without mulch, concrete, etc.), and ask them to predict whether the material is permeable or not permeable.
- Back in the classroom, list the different materials students recorded on the board.
- Query students about their predictions of permeable or impermeable, and record the consensus prediction on the board.
- Ask if students can think of any surfaces that are not included on the list. (sand, solid rock, gravel, etc.)
- Ask students to suggest ways of duplicating the local surfaces and any others on a small scale in the classroom, so that they can experiment with the permeability.

Experimentation
Students work in pairs or small groups.

Student Directions for -
Activity 1: What Is Permeable and What Is Impermeable

- Have as many samples available as possible of sand, gravel, clay, or other loose materials that can be put into a clear beaker, tube, or 1-liter soda bottle.
- Use the attached data table with four columns labeled sample, impermeable, permeable, and time.
- Put a set amount of water, such as ten drops to a few milliliters, onto each sample with the dropper. Allow three minutes for the water to disappear from the surface into the material. Decide what to label the sample, permeable or impermeable.
- Record the information on the data table.
- Now outside, if possible! Pour water onto the actual surfaces outside to see if the water infiltrates into the ground. Allow the water to sit for 3 minutes, and then decide if it is permeable or impermeable.

Teacher Directions for -
Activity 2: Additional Experimentation on Permeability of Materials

- Have samples prepared of permeable materials, with equal volumes of material (at least 50 cubic cm) in identical transparent containers.
- Ask students to gently pour 10 ml of water into each container on the top of the material.
- Have student time how long it takes the water to travel through the material to the bottom of the container (or the opening at the neck of the bottle).
- Record the time on the table.

Analysis
Have students answer the following questions on the attached handout.

1. Is there a pattern for materials that are permeable or impermeable? Explain fully.
2. Is there a pattern within the permeable materials as to how quickly the water moves through the material? Explain fully.
3. Is there a pattern to whether human-made materials around the school are permeable or impermeable? Explain fully.

4. Do these materials change the hydrologic equation? Explain carefully.
5. Describe what will happen if a slightly permeable surface is tilted. Explain fully.
6. When this school was built, how did the materials affect the infiltration of precipitation in the area, and the local water cycle and water equation? Explain fully.

Extensions

1. Estimate, by pacing for example, the area of each surface material on the school grounds.
2. Calculate the percentage of ground that is permeable.
3. Determine where the water travels that lands on top of the school.
4. Investigate historical records of lowering of local wells after the town/city underwent extensive development (if this applies).

Evaluation

Collect initial lists, charts, and analysis questions, and check for reasonable work and answers.

References

Any earth science or environmental science textbooks, such as:

- Anderson, Stanley H., Ronald E. Beiswenger, and P. Walton Purdom (1987). *Environmental Science.* 3rd edition. Ohio: Merrill Publishing Company.
- Spaulding, Nancy, and Samuel N. Namowitz (1994). *Earth Science.* Massachusetts: D.C. Heath and Company.

The data table is located on the next page.

Name ____ Date __________

	Sample Source	Impermeable Y/N	Permeable Y/N	Time needed for infiltration
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Lesson - Watch Your Storm Drain!!!!

By Rosemary Millham

Keywords Nonpoint Source Pollution, Storm Water, Storm Drain, Stream Quality
Grades 5-8
Activity Time Three 45 – 60 minute classes
Setting In class

Prerequisites Students should be able to explain the hydrologic cycle and the types of precipitation, storms, and weather

Subjects Science and Language Arts

NYS Science STANDARD 6
Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

> 2.1 Select an appropriate model to begin the search for answers or solutions to a question or problem.
> 2.2 Use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

NYS Language Arts Standard 2 – Writing
2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly

> d. Use precise language and domain-specific vocabulary to inform about or explain the topic.

Topic Environmental issues in storm water pollution

Objectives

- Students will describe what storm water is and explain the purpose of a storm drain
- Students will define the term "nonpoint source pollution" and identify examples of it
- Students will suggest reasons why people create or contribute to nonpoint source pollution - and select strategies for reducing or preventing some forms of nonpoint source pollution.
- Students will design an effective public service announcement to show how to reduce nonpoint source pollution
- Students will work cooperatively to design a system to remove the simulated "nonpoint source pollution" from the simulated river

Goals

- Analyze real-life situations to determine concerns, problems and potential solutions
- Participate in group discussions and work together to problem solve.
- Write an effective announcement to draw attention to nonpoint source pollution and how it can be reduced

Demonstration Set Up Materials

1. An aquarium (non-leaking) with clear glass sides
2. Water – should fill aquarium halfway
3. Cardboard box or box top – big enough to fit over top of aquarium
4. Green and brown food coloring (brown can be made mixing colors)
5. Two small bottles or cups each filled halfway with water
6. Three brown rolls of playdoh – logs – each 2 – 3" in length
7. 1 – Cup of a mix of soil, sand, leaves and pebbles
8. ¼ cup of vegetable oil
9. 1 – Cup food scraps and empty food packages shredded mixed together
10. 1 – Cup of yard waste - grass clippings, leaves, nuts and small sticks
11. 1 – Cup paper waste – shredded newspaper, cardboard, tissues, paper, etc.
12. One copy of list of seven scenarios (below) cut into seven slips of paper
13. A long stick for stirring the watery mix
14. Materials to create Public Service Announcements and Awareness posters
15. Materials brought from students' homes to clean up the water

Activities

A. Warm Up: This lesson should be completed after students understand the concept of what a watershed is, and can identify the Saw Mill Brook watershed.

The purpose of the warm up is to elicit existing knowledge regarding the purpose of a storm drain, where it drains, and how it might impact the watershed. The following can be used to accomplish this:

Draw or show a picture of a storm drain to the class and ask questions. Sample questions are:

- "What is this called?" (Sewer or storm drain).
- "Where would you find these [sewers/drains]?"(Along sidewalks and curbs, embedded in pavement, parking lots, bridges, etc.)
- Encourage stories from students about balls, toys, or other items that have been accidentally dropped into storm drains or sewers by anyone they know. Then ask them, "Were they able to get these items back? If not, where do you think the items went?"
- "What do you think is the purpose of a storm drain, and what does it have to do with a storm?" (i.e. flood control measure).
- "Where does water from snow or rain go after it enters a storm drain?" (In most cases, water is carried through a pipe into a nearby river, stream, lake, ocean, etc.).
- Introduce the term "storm water" to the group.
- "What other materials can enter storm drains with storm water?" List suggestions on the board. (Examples include litter, fertilizer, road salt, oil, sand, soil, leaves, twigs, animal waste, and hazardous waste dumped into drains or soil, etc.)

B. Creating a Storm Drain: Demonstrate to the class how to make a storm drain in the classroom. This will illustrate its purpose and the types of materials that can fall into a storm drain.

PART I: 45 – 60 minutes

1. **Prior to the lesson**: Place the aquarium in an area where it is easy to view by all of the students. Fill the aquarium halfway with water. This water represents the river that the storm water drains into after it has rained and the storm water that has traveled from a street through a storm drain and into the river.
2. **Prior to the lesson**: Cut a rectangular hole in the center of the box or box top that is large enough for someone's hand to fit through. Place the box or box top over the top opening of the aquarium – this cover represents the storm drain opening. Leave the aquarium's sides uncovered so students can view its contents.
3. The **eight scenarios** (below) with a simulated pollution event, on the separate sheets of paper, provide realistic examples of the types of water pollution that enter storm drains in neighborhoods and communities. These scenarios should be randomly handed out to groups of 3-5 students. The simulated materials should be placed on a table and numbered appropriately for each scenario.
4. Invite two student volunteers from each group to introduce each scenario – one student should read it to the class and the other student should find the corresponding material (place the materials in the front of the room somewhere where all students can see them) and drop the "simulated pollution" into the storm drain (box opening on top of aquarium) when the reader is finished. After each scenario, ask students to draw conclusions regarding the concerns or problems that the scenario presents and have them to enter notes into their science journals, based on their conclusions (as the information may be useful to them later.) Ask students if they know someone who dumps waste into storm drains, either on purpose, or by accident. The students will be very excited, so perhaps a recorder at the board would be better than on individual paper.
5. Use the stick to stir the contents of the aquarium when the scenarios have all been completed, or as each is completed. This usually gets quite a reaction from the students. Collect the scenario cards for later use.
6. Ask students to examine the contents of the aquarium and describe how the quality of the water it contained changed during the activity. In a real-world setting, what do they think happens to these forms of water pollution? Review with them basic information about the water cycle, water movement, and a watershed.
7. Discuss the definition of "nonpoint source pollution" and explain that the forms of pollution mentioned in the scenarios are all forms of nonpoint source pollution. Explain that nonpoint source pollution originates from the individual actions of residents and can occur anywhere (we cannot point to the offender) – in small communities and neighborhoods as well as in cities and suburbs.
8. Ask students: "Does this type of pollution harm the environment? If so, how?" Explain that the water quality of almost all of New York's streams, rivers and lakes are affected in some way by nonpoint source pollution, and it does factor in to whether people can drink the water, swim in it, or fish from it. It can also be

harmful to the animals and plants that live in or near the water. It is helpful to make a list on the board of ideas.

9. Ask students: “Do you think that the people in the scenarios wanted to damage the environment? Do you think they planned to pollute the water near them?” If so, have them explain why people might want to do these things. If not, have them guess why these people did what they did regarding their individual actions.

PART II: 45- 60 minutes

1. Divide the class into small groups of 3 – 5 students and give each group one scenario (one slip of paper from the scenarios on the next page), a pencil, and a piece of blank paper. Give them 5 – 10 minutes to address the problem in the scenario by answering the following questions:

- What is the concern in this scenario?
- Can this type of pollution be reduced or prevented from happening? If so, how? Explain fully. Or, better yet, can this form of non-point source pollution be prevented from entering the water cycle in the first place? If so, how? Explain fully.

2. Have each group design a public service and awareness announcement and poster to limit the specific nonpoint source pollution they have witnessed. Each group should describe their public service and awareness announcement and poster and find a place to hang it in the school, and copy and send home to parents, or post on websites, etc.

Assessments – Rubrics should be designed for these

1. Participation in group activity and discussion.
2. Responses to questions from the teacher.
3. Public service announcement created by each group.

Extension

1. Have students "invent" a method or mechanism that would remove unwanted chemicals, solid materials, and/or floating objects from storm water. Students should bring materials to class the next period. Give students a sample of the water and give them time to test their methods.

- Pour the final product into clear jars and compare the groups
- Award a “best method” certificate for cleaning up the water
- Be sure to reiterate that the goal is not to clean up what we have messed up, but to prevent it at the source!

Storm Drain Watch - Eight Scenarios

Scenario #1: Mrs. Howard has two small trees next to the house porch. The trees attract wasps, mosquitoes, and caterpillars. She has sprayed the trees with a chemical to kill or drive away the insects. A storm occurred soon after she sprayed, and most of the chemical was washed off the leaves and onto the sidewalk and driveway. From there, the chemicals were washed with rainwater into the storm drain along the sidewalk.
Simulated Pollution: Mix 2-3 drops of green food coloring with the water in one of the bottles and add water into the opening on top of the aquarium

Scenario #2: A small stream winds through a popular golf course. During a heavy rain, the stream is filled with fast flowing water. In certain places, the sides of the stream are wearing away and tree roots are showing. During and after each rain, soil, sand, leaves, pebbles, and other natural debris, are swept away with the heavy flow of water as the shores of the stream slowly erode. Every rainfall this material is carried, by the stream, into the river that it empties into.
Simulated Pollution: Add the mix of soil, sand, leaves and pebbles into the opening on top of the aquarium.

Scenario #3: Susan enjoys helping her father change the motor oil in the family automobile. She clumsily carries the huge pan of black, thick, used motor oil to the storm drain in front of their apartment building, where she dumps it. It's gone! Eventually the oil will mix with the water of a nearby stream or river. The motor oil that she spilled onto the ground while carting the oil away will go into the soil and mix with underground water.
Simulated Pollution: Empty the vegetable oil into the opening on top of the aquarium.

Scenario #4: One snowy winter evening the Palmer family heard raccoons outside of their house. The raccoons were opening and turning over the garbage cans they left out by the curb. It was too dark and cold to go outside and chase them away! The next morning, no one in the family had time to clean up the litter that was strewn all over the street. When the snow melted most of the trash floated with the water into the storm drain.
Simulated Pollution: Add the paper waste through the opening on top of the aquarium.

Scenario #5: One of Matthew's jobs at home is to cut the lawn each week after school. When the grass catcher is full, he dumps the grass clippings into the nearby ditch or sewer, whichever one happens to be closer to the lawnmower at the time. While in the ditch or drain the clippings turn yellow and begin to rot and smell. Eventually, water from the next rain storm carries the clippings away.
Simulated Pollution: Add grass clippings through the opening on top of the aquarium.

Scenario #6: Theresa enjoys walking the family dog, Patches. When Patches needs to go to the bathroom, Theresa is careful to make Patches go on the paved road along the curb so that Patches doesn’t create a mess on the neighbors’ lawn. She doesn't worry about picking up the mess because she knows that eventually the dog’s waste will be washed with the rain into the nearby storm drain.
Simulated Pollution: Put the playdoh logs through the top of the aquarium.

Scenario #7: The Smith family enjoys stopping at a fast-food restaurant for dinner while on their way to the beach for the weekend. To save time, the family eats inside their mini-van while parked in the restaurant parking lot. In order to keep the car clean, they leave their bags of food trash on the pavement in the parking lot for the workers to pick up (there are no trashcans in the parking lot). This family may not realize that animals and wind will eventually open up the bags and spread this trash around. If it isn’t picked up, it can be carried by rainwater during the next storm into a nearby storm drain.
Simulated Pollution: Add food scraps and food wrappers at the opening of the aquarium.

Scenario #8: A maintenance worker employed by some townhouses must take on new summer duties because the landscaper is out sick. These duties include lawn care for each of the residences. It took him about three days to spread weed killer and, two days after he started, an all-day rainstorm kept him indoors. The maintenance worker failed to realize that the downpour would wash away most of the weed killer that was already applied on the lawns. In fact, the chemicals would most likely be washed from plants and pavement into the nearby storm drains.
Simulated Pollution: Mix 2-3 drops of brown food coloring with the water in one of the small bottles. Empty this brown water into the opening on top of the aquarium.

References

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http://www.haddonfieldnj.org/pdf/Non-Point-Source-Pollution.pdf
Beneath the Shell…A Teacher’s Guide to Nonpoint Source Pollution and Its Potential Impact on New Jersey Shellfish. New Jersey Department of Environmental Protection. First Printing 1991; Revised 1993; Reprinted annually from 1997 – 2002 and 2004; adapted from “Storm Drain Watch”(pgs. 46 – 48).

Lesson - Rain Gardens - How Rain Gardens Preserve and Improve Our Water
By Rosemary Millham

Keywords rain garden, storm water runoff, pollution, non-point source, conservation, paved areas, natural filter, infiltration, downspout, ecosystem, native plants, and pollinators

Grade Level 5-8 **–** activities and vocabulary can be adapted according to age level

Time Required Two or Three 1-hour sessions

Setting Outside the school and in the classroom

Subjects Science and Mathematics (If the third session is used)

Topics Water Conservation, Pollution, Natural Resources, Environmental Education

Objectives

1. Students will describe and explain the negative effects of pollution on storm water **runoff**
2. Students will investigate the negative effects of paved areas on water runoff
3. Students will explain the importance of water conservation
4. Students will describe how rain gardens can help filter our water supply and improve our environment.

Materials Needed
Journals
Pencils
Clipboards
Pictures (local, if possible) of water polluted with such things as motor oil, fertilizers, pesticides, sediment; pictures of paved areas like parking lots, streets, driveways; roof drain spouts, street drainage systems, rain gardens.
Optional: cameras

NYS Science STANDARD 6
Key Idea 4: Equilibrium is a state of stability due either to a lack of change (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

> 4.1 Describe how feedback mechanisms are used in both designed and natural systems to keep changes within desired limits.

Activities are hands on, small group, investigation, data collection, comparison, discussion, and analyzing

First Session - Students walk around the school perimeter or their neighborhood and list or draw, in their journals, all paved areas that they see. Ideally, this activity could be done after a rainstorm when students can document any standing water. They could also document any pollution they see. They should label each area and its location. Students return to classroom and compare their results.

Second Session –

- First, ask students what kind of pollution they think ends up in rainwater, followed by examples they may have missed, and pictures of pollutants that enter the water supply and drainage systems (storm water drains) near paved areas where the polluted water enters from storm water runoff.
- Then ask students if they know where that runoff water goes. Many people believe this water is filtered and treated in the sewage system and are surprised that it is not, and that it will eventually end up in our rivers, lakes and streams; often heated to a temperature too high for fish to survive.
- Next, the teacher will ask students if they know of any natural ways to filter storm water runoff. After collecting information from students, the teacher may need to explain that there are natural ways to filter storm water runoff. The usual natural method is filtration through soils where most pollutants are filtered out of the water.
- Following this, the teacher will share pictures of rain gardens (or go see the real deal if they are close by) that capture water from rooftops and hard, impermeable surfaces. The rain gardens are planted soils that can filter pollutants before they reach storm drains and pollute our streams.
- Next, the teacher briefly discusses conservation of water resources and how rain gardens can beautify and benefit the ecosystem in several ways. **BE SURE** to ask students what they know about conserving water and how rain gardens benefit the ecosystem prior to giving any explanations.

NOTE: This is a great time to conduct a water usage activity such as, "How Much Water Do You Use". This activity helps students understand just how much of an impact they have on our freshwater resources. Several such activities can be found on the web, and one is included in the modules for the SUNY New Paltz curriculum for green infrastructures.

Next: Discuss how rain gardens can be built, remembering to ask students questions to determine what they think they know before presenting the guidelines. Then, share these general guidelines (you will need to explain these concepts carefully. Note that this is an excellent math opportunity):

General Guidelines for Rain Gardens

- **Location**: at least 10 feet from a building in a slightly depressed area downhill from a gutter downspout or paved area (first check with utility companies, local municipality/school, etc. to be sure you have permission)
- **Design**: the size is usually 5-10 % of the area being drained as runoff (rainwater flows downhill), has a slope of 10-12%, a depth of 4-8 inches with a level bottom (first dig 2 feet to loosen soil), with a length about twice width. Demonstrate this for the students to model expectations.

- **Site Prep**: remove soil and test it because you may need to add sand or compost; ideally, the soil should be 50-60% sand, 20-30% topsoil without clay, and 20-30% compost. An excellent resource for soil identification can be found in the GLOBE protocol for soils at http://www.globe.gov/web/soil/overview
- **Plant Selection**: native plants adapt to local conditions very well, require less maintenance, and provide habitat for beneficial pollinators and insects including bees, butterflies, and birds. Research what plants are native to your area (a local natural nursery will know the answers).
- **Mulch**: use 2-3 inches of shredded bark mulch (not chips - they wash away) if planting flowering plants and shrubs/trees.

Third Session

Have students work in groups to design a rain garden for the school, and have them identify where the rain garden would go, and why that is a good place to have a rain garden. Be sure they follow the guidelines listed in the second session. If you are lucky enough to get approval, and have the resources, implement the rain garden on the school property! This would, of course, increase the amount of time to complete this module, but applying their understandings benefit students enormously.

Evaluation

Assessment is conducted as the teacher observations during activities, journal writings and drawings, and class participation. A rubric should be designed to evaluate competencies.

References

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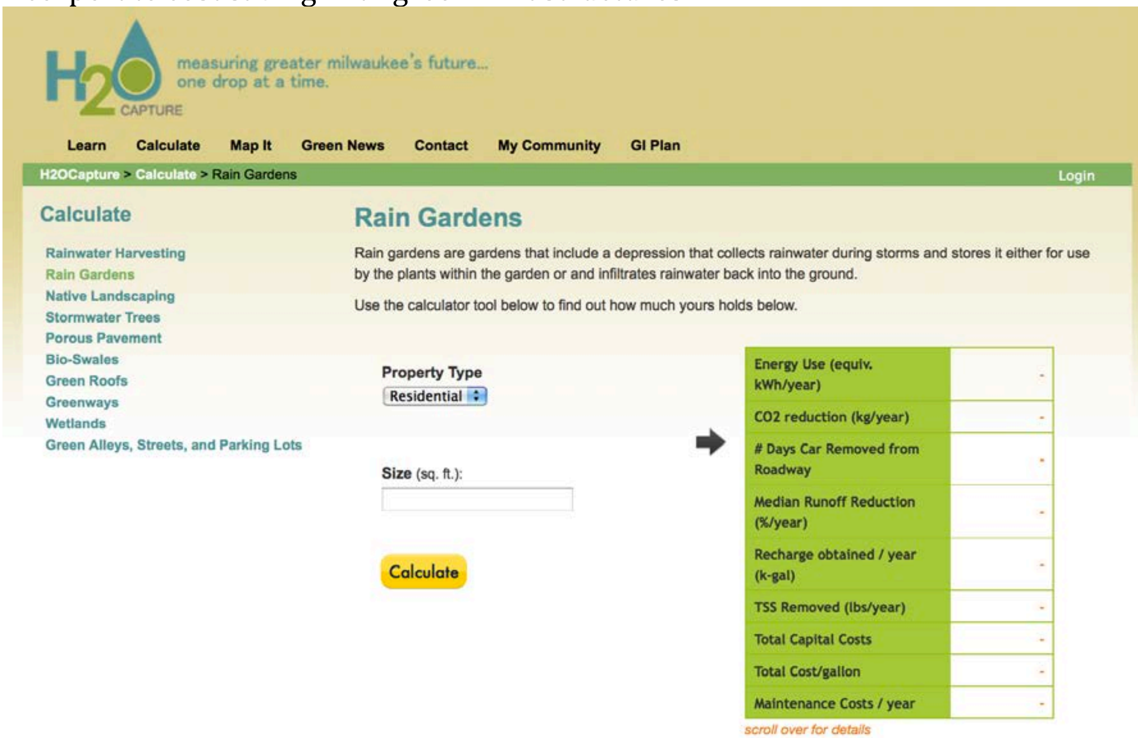
Lesson - Green Infrastructure Calculator
These activities are on the web, and assist students in calculating the benefits of various green infrastructures.

First, http://www.h2ocapture.com/Calculate/Rain-Gardens.aspx is designed to incorporate cost saving with green infrastructures.



Each of the green infrastructures listed on the left side of the page can be calculated separately to determine cost benefits to each structure. The importance of being able to connect environmental benefits to cost savings is not only important to businesses and institutions, homeowners can also benefit by employing green infrastructures.

A second web-based calculator is found at http://green.americanrivers.org/. This site is for excellerated students and looks at the overall benefits of green roof use. Here is the information for the calculators:

Estimated money saved: Based on annual cooling and heating degree days in 9 regions of the U.S. according NOAA. Actual benefits will vary based on growing media on the roof and composition/depth, plant coverage/type, building characteristics, and local climate and weather pattern variables.

Estimated stormwater runoff prevented: Based on precipitation averages in 9 regions of the U.S. according NOAA, and assuming a 60% retention rate. Actual benefits will vary based on growing media depth/moisture content, local climate and weather pattern variables, roof structure, and size/distribution of storm events.

Lesson - How Much Water do You Use?

Part I – Answer the following questions in your journal.
- How much water do you think you use every day?
- How did you figure this out?
- Does the amount of water you use matter? If so, how and why?

Part II - A survey to determine how much water you use during one day. The number of gallons for each water use is estimated based on the average use for each activity.

ACTIVITY	# of TIMES/DAY		GALLONS/DAY
Flush Toilet	________x 5 gallons	=	__________
Short Shower	________x 25 gallons	=	__________
Brushing Teeth with Water Running	________x 2 gallons	=	__________
Brushing Teeth with Water Off	________x 1 gallon	=	__________
Washing Dishes	________x 60 gallons	=	__________
Washing Clothes	________x 40 gallons	=	__________
Washing Hands	________x 1 gallon	=	__________
Pitchers/Glasses of Water at Meals	________x 1 gallon	=	__________
Other Water Use	________x _______	=	__________

GRAND TOTAL __________ Gallons

Part III
The national average is 50 gallons per person per day. Is your average more or less than the national average?

_____ More _____ Less

How do you think you can change the amount of water you use daily? Why does it matter? Explain.

Lesson - Water Use Matching Game

Grades 5-8

Again, How Much Water Do You Use?

First, show students a gallon of water. It can be in any container. Then go on to “A”.

A. Guess how many gallons of water you use, personally, every day. ________ gallons.

B. Now, draw a line matching the items on the left to the amount of water on the right.

1. Taking a shower	A. 30 gallons
2. Watering the lawn	B. 180 gallons
3. Washing the dishes	C. 4-7 gallons
4. Washing clothes	D. 1/2 gallon
5. Flushing the toilet	E. 39,090 gallons
6. Brushing teeth	F. 62,600 gallons
7. Drinking	G. 15-30 gallons
8. Needed to produce one ton of steel	H. 9.3 gallons
9. Needed to process one can of fruit or vegetables	I. 1 gallon
10. Needed to manufacture a new car including tires	J. 9-20 gallons

Check for the real answers to these questions by keeping track of your water usage at home, and researching on the Internet for answers to water usage that you would not really know, such as how much water it takes to manufacture car tires!

C. Considering that you take a shower each day, one load of wash is for your clothes each week, the water you drink (and this includes the water in juice, soda, and other drinks), brushing your teeth, flushing the toilet, and washing your dishes, how much water do you think is used, by and for you, each day?

D. Why would the water used to make steel, cars, tires, and the processing of foods have anything to do with your water usage?

How Green Infrastructures Work to Mitigate Flooding
Where Does the Water Go - Why do we Care?

By Rosemary Millham
(With modified EPA resources)

Introduction

Flooding caused by increased **precipitation** happens more often now than in the past decade. As humans build new malls, industrial centers, and housing developments, more precipitation flows over the surface of the Earth and into major streams. How does this happen? How can we protect our water resources? Why does flooding even matter to us?

This curriculum module provides some answers to these questions. It includes content and suggestions for how we can manage our land to **mitigate** the effects of flooding through **green infrastructures** and other practices. It includes interesting investigations and activities to better understand how these management suggestions work (found in the Teacher Lesson Section). Also included are lessons that help us to understand climate change and how we can live a more sustainable life to help decrease our impact on the environment. Some of the more sustainable activities will even help to reduce our carbon footprint with the hope of reducing increased temperatures and precipitation. Changing the way we live through sustainability, changes the environment for the better, every day.

Background Content

Part I: What is Storm Water Runoff - Why is it a Problem?

Storm water **runoff** occurs when precipitation from rainfall or snowmelt flows over the ground and does not **infiltrate** into the soil. **Impermeable** (**Impervious**) surfaces like driveways, parking lots, and sidewalks prevent storm water from soaking into the ground.

When storm water falls or flows onto **permeable** surfaces, like sand and other soils that allow water to go pass through (Infiltrate**)**, we call them permeable. This is a natural way for storm water to return to the water cycle without harming the environment.

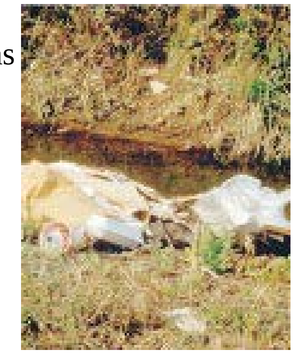
Why is storm water runoff a problem?

Storm water can pick up **debris**, chemicals, dirt, and other **pollutants**. These can flow into a **storm sewer system,** a lake, stream, river, wetland, or coastal waters. Anything that enters a storm sewer system is **discharged** into the bodies of water we use for swimming, fishing, cooking, bathing, and drinking.

The effects of pollution

Polluted storm water runoff can affect plants, fish, animals, the environment, and people in many ways.

- **Sediment** can cloud the water and make it impossible for **aquatic** plants to grow. Sediment also can destroy aquatic **habitats**.
- To many **nutrients** deposited into water can cause **algae blooms**. When algae die, they sink to the bottom and decompose in a process that removes oxygen from the water. Fish and other aquatic **organisms** cannot exist in water with low levels of oxygen.



- Bacteria and other **pathogens** can wash into swimming areas and create health hazards. This often causes beaches to be closed.
- Debris such as plastic bags, soda bottle six-pack rings, bottles, and cigarette butts - washed into bodies of water - can choke, suffocate, or disable aquatic life like ducks, fish, turtles, and birds.
- Household **hazardous** wastes such as **insecticides, pesticides,** paint, **solvents**, and used motor oil can poison aquatic life. Land animals and people can become sick from eating diseased fish and shellfish, and from drinking or cooking in polluted water.
- Polluted storm water can impact drinking water sources and can affect human health. Pollution will also increase the cost of treating drinking water to make it safe for humans to drink.

Part II: Storm Water Pollution Solutions

A. Residential

Recycle or properly dispose of household products that contain chemicals, such as insecticides, pesticides, paint, solvents, and used motor oil. **Do not pour them onto the ground or into storm drains**!!

1. **Lawn Care**

Too much fertilizer and pesticide spread on lawns and gardens will wash off during heavy rains and pollute streams. In addition, yard clippings and leaves can wash into storm drains and contribute nutrients and organic matter to streams.

How can you help?

- Do not overwater your lawn. Consider using a soaker hose instead of a sprinkler.
- Use pesticides and fertilizers with care. Do not use too much!! When they are necessary, use the chemicals only at the recommended amount. Use organic mulch and pest control methods whenever possible.
- **Compost** or **mulch** yard waste. Do not leave it in the street or sweep it into storm drains or streams.
- Cover piles of soil or mulch used in landscaping projects to prevent them from washing away.

2. **Septic Systems**

Leaking and poorly maintained septic systems release nutrients and pathogens (bacteria and viruses) that can be picked up by storm water and **discharged** into nearby bodies of water. Pathogens can cause public health problems and environmental issues.

- Inspect the family system every 3 years and pump your tank as necessary (every 3 to 5 years).
- Do not pour household chemicals or medication waste into sinks or toilets.

3. **Auto Care**

Washing the family vehicle at home can send **detergents** and other chemicals through the storm sewer system. Dumping fluids from vehicles into storm drains has the same impact as dumping the materials directly into a body of water.

- Use a commercial car wash that treats or recycles its wastewater. Or, wash the family vehicle on your lawn so the water infiltrates into the ground.
- Repair leaks and dispose of used auto fluids and batteries at approved drop-off or recycling locations.

4. **Pet Waste**

Pet waste can be a major source of bacteria and excess nutrients in local waters.

- When walking your pet, remember to pick up the waste and dispose of it properly. Flushing pet waste is the best disposal method. Leaving pet waste on the ground increases public health risks by allowing harmful bacteria and nutrients to wash into the storm drain and into local bodies of water.

Education is essential to changing people's behavior. Signs and markers near storm drains warn residents that pollutants entering the drains will be carried untreated into a local bodies of water.

B. Residential and Commercial

1. **Permeable Pavement—**Green Infrastructure - Traditional concrete and asphalt do not allow water to soak into the ground. Instead, these surfaces rely on storm drains to divert water. Permeable pavement allows rain and snowmelt to soak through, decreasing storm water runoff.

2. **Rain Barrels—**Green Infrastructure - You can collect rainwater from rooftops in mosquito-proof containers. The water can be used to water lawn or garden areas.

3. **Rain Gardens and Grassy Swales—**Green Infrastructure - Specially designed areas that are planted with **native plants** can provide natural

places for rainwater to soak into the ground. Rain from rooftop areas or paved areas can be diverted into the rain gardens and swales instead of into storm drains.

4. **Vegetated Filter Strips**—Green Infrastructure - Filter strips are areas of native grasses and other plants along roadways or streams. They trap the pollutants storm water picks up as it flows across driveways and streets.

5. **Commercial** soil, oil, and debris that collect in parking lots and paved areas can be washed into the storm sewer system. They eventually enter local bodies of water.

- Sweep up litter and debris from sidewalks, driveways, and parking lots; especially around storm drains.
- Cover grease storage areas and dumpsters and keep them clean to avoid leaks.
- Report any chemical spill to the local hazardous waste cleanup team. They will know the best way to keep spills from harming the environment.

6. **Construction erosion** can cause large amounts of sediment and debris to be carried into the storm water system. Construction vehicles can leak fuel, oil, and other harmful fluids that can be picked up by storm water and deposited into local bodies of water.

- **Divert** storm water away from disturbed or exposed areas of the construction site.
- Install **silt fences**, vehicle mud removal areas, **vegetative cover (**Green Infrastructure), and other sediment and erosion controls. Continue these controls, especially after rainstorms.
- Prevent soil erosion by disturbing areas as little as possible during construction projects. Also, seed and mulch bare areas as soon as possible.

7. **Agriculture** can cause a lack of vegetation on stream banks that can lead to erosion. **Overgrazed** pastures can also contribute large amounts of sediment to be deposited in local bodies of water. Too much fertilizer and pesticide use can poison animals and cause destructive algae blooms. Livestock (such as cows) that stand in streams can contaminate waterways with bacteria, making them unsafe for human contact.

- Keep livestock away from stream banks and provide a water source away from local bodies of water.
- Store and apply manure away from local bodies of water and follow a **nutrient management** plan.
- **Vegetate riparian** (Green Infrastructure) areas along waterways.
- **Rotate** animal grazing to prevent soil erosion in fields.
- Apply fertilizers and pesticides according to label instructions to save money and minimize pollution.

8. **Forestry** that is not well managed, such as logging operations, can result in erosion and sediment deposits.

- Conduct **pre-harvest** planning to prevent erosion.
- Use logging methods and equipment that disturb the soil the least.
- Plan and design **skid trails**, yard areas, and truck access roads to reduce the number of stream crossings and to avoid disturbing the forest floor.
- Construct stream crossings to reduce erosion and physical changes to streams.
- Replant new trees quickly on cleared areas (Green Infrastructure).

9. **Automotive Facilities**

- Uncovered fueling stations allow spills to be washed into storm drains. Cars waiting to be repaired can leak fuel, oil, and other harmful fluids that can be picked up by storm water.
- Clean up spills immediately and properly dispose of cleanup materials.
- Provide cover over all fueling stations and design a method to prevent spills from spreading.
- Maintain vehicles to prevent oil, gas, and other leaks from being washed into local bodies of water.
- Install and maintain oil/water separators.

Note: The content portion of this document is modified from the EPA storm water website for the preservation of fresh clean water and best practices for storm water management.

References

www.epa.gov/npdes/stormwater
www.epa.gov/nps

Algae bloom - An algae bloom is the visible appearance of millions of tiny plant-like organisms in the water. These tiny algae, or phytoplankton are present all year. The recipe for blooms is abundant sunlight, nutrients, and the right water conditions.

Aquifer - An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted**.** Typically, water is extracted from a well system into pipes and into homes and businesses.

Aquatic- Aquatic(s) means relating to water; living in or near water or taking place in water. Aquatic animals and plants live in water, for example.

Compost - Compost is organic matter that has been decomposed and recycled as a fertilizer and added to soils.

Debris - Debris is rubble, wreckage, ruins, litter, and discarded garbage, refuse, trash, and scattered remains of something destroyed or discarded.

Detergent - A cleaning agent that increases the ability of water to penetrate fabric and break down greases and dirt.

Discharge – Discharge is the volume of fluid flowing along a pipe or a channel during a specific amount of time.

Divert - Cause (someone or something) to change course or turn from one direction to another.

Erosion - The process of erosion moves bits of rock or soil from one place to another. Most erosion is performed by water, wind, or ice (usually in the form of a glacier).

Groundwater - Groundwater is water located beneath the Earth's surface in pore spaces in soils, and in the fractures of rock formations.

Habitat - An ecological or environmental area that is inhabited by a particular species of animal, plant, or other type of organism.

Hazardous – Dangerous.

Impermeable – Does not allow fluids to pass through.

Impervious - Not allowing anything (including fluids) to pass through.

Infiltrate - The process by which water on the surface of the ground enters the soil or other permeable material. For example, if the soil is permeable, rainwater will infiltrate the soil and move downward into the Earth.

Insecticide - Insecticides (also called pesticides) are chemicals used to control insects by killing them or preventing them from engaging in behaviors that are undesirable or destructive.

Mitigate - Make less severe, serious, or painful.

Mulch - Mulch is a layer of material applied to the surface of an area of soil. Its purpose is any or all of the following; to conserve moisture, to improve the fertility and health of the soil, to reduce weed growth, and to enhance the visual appeal of the area

Native plants - Native plant is a term to describe plants that originate in an area (indigenous). In fact, these plants were there long before humans. Those plants that are not native (not indigenous) can be harmful to native plants and even become invasive (taking over the ecosystem of the native plants).

Nonpoint Source Pollution - Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, particulate matter, and other pollutants, comes from many different sources that are often difficult to determine such as farmlands from far away from major streams, and trash, garbage, and other debris.

Nutrients - A nutrient is a chemical that an organism needs to live and grow, or a substance used in an organism's metabolism that must be taken in from its environment. Some nutrients are produced naturally within the environments, and some are added to the environment by humans (spreading manures or compost on soli).

Organisms – All living things; bacteria, plants, and animals.

Overgrazed – Pasture or grassland grasses that have been grazed too much without allowing time for the grasses to recover (grow more).

Particulate matter – Particulates are tiny particles of solid or liquid matter. Many are natural, such as dust, ash from volcanoes, and sea salt. Others are produced by human activity such as burning fossil fuels.

Pathogen - Anything that causes disease, especially a virus, bacterium, or other microorganism.

Permeable – Permeable means to allow materials, especially fluids, to pass through.

Pesticides - Pesticides are substances meant for preventing, destroying, or mitigating pests. Pests include insects, deer, birds, rodents, etc. that can harm gardens and other environments.

Pollutant - A pollutant is a substance or energy introduced into the environment that has undesired effects, or has harmful affects on the usefulness of a resource. Pollutants include, but are not limited to, trash, chemicals, debris, lead, mercury, carbon dioxide, particulate matter, and tropospheric ozone.

Precipitation – Any form of water that drops from the atmosphere to the land – including rain, snow, hail, sleet, and freezing rain.

Pre-harvest – Crops at a stage when they are not yet ready to pick (harvest).

Rain Barrel – A water collection system that collects water during precipitation events, usually a large barrel placed at the end of a gutter downspout.

Rain Garden - A rain garden is a depression (about 6-12 inches deep) that collects stormwater runoff from a roof, driveway, or yard, and redirects the water to a place where the water can infiltrate into the ground.

Riparian - A riparian zone or riparian area is a place where dry land and a stream meet. This is usually along the banks of the stream.

Runoff - Runoff refers surface runoff, the flow of water, from rain, snowmelt, or other sources, over the land. Some runoff is natural, but human structures such as roads, sidewalks, and parking lots increase runoff.

Sediment - Sediment is any particulate (tiny particles) matter that can be transported by fluid flow (usually water) and is eventually deposited as a layer of solid particles on the bed or bottom of a stream or lake or ocean. Sediments include loose particles of sand, silt, and clay.

Septic Systems – Many homes have a septic tank. This tank is a key component of a septic system, a small-scale sewage treatment system.

Silt fence – A special screen with very tiny holes that is used by construction and landscaping businesses to reduce the amount of small soil particles from washing into streams.

Skid trails – The paths left in the soil by the wheels of logging equipment and the logs dragged through the forest to trucks.

Solvents - Solvents are substances that dissolve other substances, or cause them to be spread out.

Storm drain - Storm drains are pipe systems (conduit systems) designed specifically to get rid of liquid run-off caused by precipitation and melting snow; they prevent rainstorms from flooding roads and the surrounding area.

Storm sewer system - The storm sewer system collects rain and melting snow, called runoff, in drains and pipes alongside roadways and sidewalks.

Storm water – an abnormal amount of surface water due to a heavy rain or snowstorm

Stream quality - Water quality can be thought of as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. Scientists measure and analyze characteristics of the water such as temperature, dissolved mineral content, and the number of bacteria. Selected characteristics are then compared to standards and guidelines to decide if the water is suitable for use.

Swale (grassy) - A grassed swale is a graded and engineered landscape feature appearing as a linear, shallow, open channel with a shape that allows runoff to be captured in a specific area.

Transmit – To allow movement of something through.

Transpiration - Transpiration is the process where water, in liquid form in plants, is converted to vapor and released into the atmosphere.

Vegetated – Covered with vegetation (plant life).

Vegetative cover – A method to determine how much vegetation exists in a certain place (i.e. a rainforest is densely vegetated while a desert is not).

Water Table - The water table is the surface where the water pressure head is equal to the atmospheric pressure (where gauge pressure = 0). A simpler definition would be, "the water table is the place where groundwater is at its highest point in elevation". Some groundwater is very far below the surface. We see the water table when the groundwater surface, its highest point in elevation, is exposed at the surface as a stream, pond, or lake.

Green Infrastructure Curriculum Walk
By Rosemary Millham

Introduction – This document is a short descriptive supplement for our **green infrastructure** visitors. It is also designed as an introduction or culminating activity for a teacher's curricula when teaching about flooding, the environment, or sustainability issues.

A second document is available which is a more comprehensive module incorporating various lessons for teaching about flooding, green infrastructures, the water cycle, sustainability, and climate change. Each lesson in the module has dedicated pages to make duplication easy. Each lesson is a stand-alone, not requiring other lessons to support it. Please go to XXXXX to access this document.

Green Infrastructure Curriculum Walk for Visitors

Keywords – infiltrate, runoff, environment, green infrastructures, rain garden, swale, porous, permeable, bioretention, impervious (glossary attached)

Activity Time – Approximately 10 minutes per stop

Introduction, Setting, and Background – The SUNY New Paltz has developed a plan to reduce and manage flooding from the Saw Mill Brook. Flooding is caused when there is more rainfall or snowmelt than a stream can hold in its banks. Some types of land surfaces do not allow water to sink into the ground (**infiltrate**) causing the water to **runoff** over the land. If there is too much runoff, and the stream is overflowing, more flooding can occur causing more damage to the **environment**.

The Saw Mill Brook flows through the village of New Paltz and the SUNY campus. At the Peace Park, near the Village Hall, the brook was buried long ago. The water still runs through, but it is underground at the Peace Park. The new plan will "daylight" the brook in the park, allowing that part of the brook to be exposed to the Sun for the first time in many years. This is called "stream daylighting".

The SUNY New Paltz plan also includes several ways to reduce the amount of runoff that ends up in the brook during severe storm events. These plans help to preserve the quality of our water resources. They will also preserve animal and plant habitats and human property. Interestingly, the plan uses "green infrastructures" to manage flooding - most of which you will visit today.

Each green infrastructure site on campus and in the village has a sign explaining the structure, and how the green infrastructure works to reduce runoff to reduce flooding. The green infrastructures in place include:

- Rain gardens
- Vegetated swales
- Parking lots with porous pavement (permeable)
- Bioretention areas
- Rain harvesting (capturing rain and directing it to safe places)

In addition to the green infrastructures, university faculty and students will monitor water quality through the departments of geology and biology.

Future SUNY New Paltz plans include creating additional rain gardens, and drainage work at Hasbrouck Park. A stormwater plan is also in the works for the northern part of campus. Still more plans are at work to create rainwater harvesting from roofs so rainfall will be directed from roofs to underground cisterns. This water can be used to water lawns, plants, and trees, and reduce flooding due to runoff.

Prerequisites – An understanding of precipitation, streams, and the vocabulary listed above. In addition, there are several lessons and content in the Section II module following this short green infrastructure curriculum walk. These lessons are designed for teaching concepts involved in flooding including rain gardens,

Subjects – Earth Science, Geology, Biology, Environmental Science

Objectives

The primary objectives for the short curriculum walk include:

1. Awareness of green infrastructures and how they work to mitigate flooding
2. How simple landscaping practices enhance private and public properties while serving to mitigate flooding

Materials – Please bring a notebook/journal or other method for writing observations prior to viewing a green infrastructure, and for writing the information after reading the signage (plaque).

Walk Activities – As you or your group/family take the green infrastructure walk, you will find signs at each location that describe the green infrastructure and its purpose. The challenge here is to think about what they are and how they work before you read the information provided. This gives you a sense of thinking about what you are observing before you know. Formulating your own ideas/hypotheses ahead of time, followed by the information, helps you wrap your mind around what you observe and the concepts behind your observations before the information is presented.

Here are some questions and activities you can use to help guide observations:

1. Illustrate the green infrastructure before hypothesizing what it is and what is its purpose
2. Hypothesize what you think the green infrastructure's purpose is, and provide reasoning for this hypothesis
3. Next, read the information provided on the plaque and check the description against your hypothesis
4. Answer the following:
   - How is your hypothesis similar to the information provided?
   - How is your hypothesis different from the information provided?
   - Do you think this green infrastructure will do what it is supposed to do? Why or why not?

- Is a green infrastructure something that should be created at home, or at a business? Explain.
- After viewing the green infrastructures, describe why you think the green infrastructures are important?

Thank you for joining us for the green infrastructures walk. We hope that you have enjoyed the walk and that it has been educational!

Glossary to Assist on the Walk

Impervious (impermeable) **–** to not allow passing through, such as rainwater not passing through roofing materials or concrete pavement

Infiltrate - to pass into or through, such as water seeping through soil

Runoff - the draining away of water (and substances carried in it) from the surface of an area of land, a building or structure, etc.

Environment - The surroundings or conditions in which a person, animal, or plant lives/exists.

Green infrastructures – (Also called gray infrastructures) refers to traditional practices for stormwater management and wastewater treatment, such as pipes and sewers. Green infrastructure alone refers to sustainable pollution reducing practices that also provide other ecosystem services.

Rain garden - is a planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed.

Swale - A swale is a depression created in the ground that carries rainwater and runoff, due to gravity, away from a building and property. A swale collects the rainwater and runoff water by being the lowest point in a given area and then it is directed down slope to wherever you want the water to go.

Porous – having empty spaces between particles through which liquid can pass

Permeable – is to allow water and other liquids to pass through

Bioretention - area or rain garden is a shallow planted depression designed to retain or detain stormwater before it is infiltrated or discharged downstream. While the terms “rain garden” and “bioretention basin” may be used interchangeably, they can be considered along a continuum of size, where the term “rain garden” is typically used to describe a planted depression on a homeowner’s property. Bioretention basins serve the same purpose, but a technical term typically describing larger projects in community areas as well as non-residential areas.