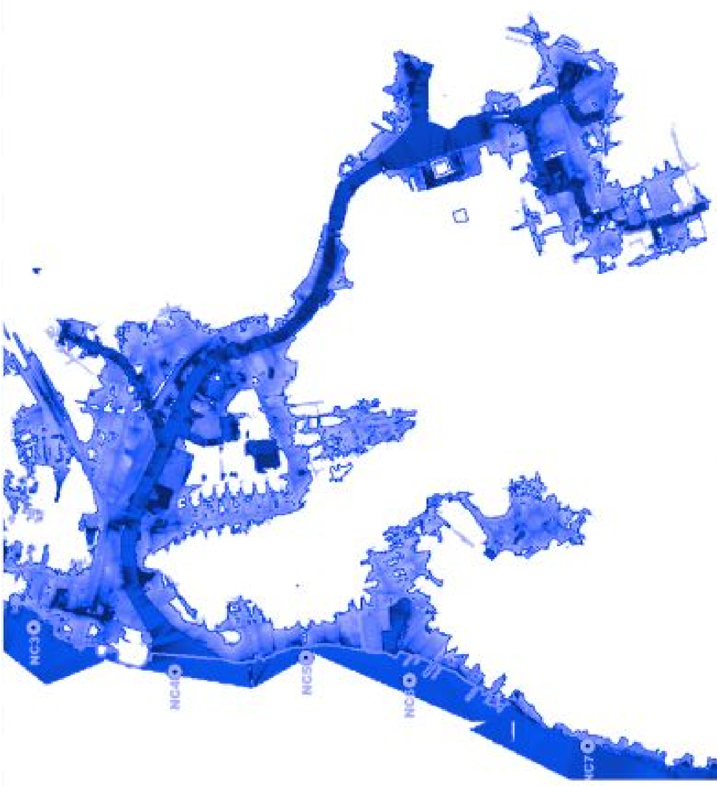
STEM
Newtown Creek
Urban Ecology Curriculum



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About this Curriculum

The Project:

The Newtown Creek has captivated people for more than 400 years, from its time as a productive tidal salt marsh to an era of intense industrialization that created the polluted waterway that we see today to its current potential to usher in a resilient future of restoration coupled with industrial revitalization. This curriculum was originally created by the Gowanus Canal Conservancy and the Urban Memory Project then adapted to its current form by the Newtown Creek Alliance for teachers to use the Newtown Creek and its watershed and sewershed as a teaching tool and learning environment. The lessons were reviewed and tested with assistance from the National Wildlife Federation Eco-Schools during the 2018 - 2019 school year in four local public schools in Greenpoint — P.S. 110, P.S. 34, P.S. 31, and M.S. 126. The lessons, maps, and worksheets are available to any teacher who wishes to engage their students with the Creek's complex and fascinating urban ecology. The Newtown Creek Watershed and surrounding area is home to dozens of upland schools in both Brooklyn and Queens. It is our hope that all schools in the watershed and sewershed will introduce their students to the urban ecology of the Newtown Creek.

Who we are:

Newtown Creek Alliance

Mission:

The Newtown Creek Alliance is a community-based organization dedicated to restoring, revealing and revitalizing Newtown Creek.

Vision:

The Newtown Creek:

The 3.8 mile long Newtown Creek was dredged and channelized during the 19th and early 20th centuries. Once a rich and productive salt marsh and Native American fishing grounds, the Creek has seen more than its fair share of environmental problems. For more than 150 years, the waters captured raw sewage and other wastes from nearby neighborhoods, industrial waste products from the businesses located along its banks, and polluted runoff from the surrounding streets.

The Creek is dotted with structures that tell the story of an industrial legacy, an integral part of the history of New York. It's banks are also home to local and migratory birds of all sorts, surprising native plants and marine life, the vestiges of the abundant wildlife that was plentiful and can be once more. Today the Creek remains an industrial waterway but the businesses that polluted it are either gone or operating in a different way, sewage still flows into it with every heavy rain. In 2010 Newtown Creek was designated a federal Superfund and investigations into the extent of its contamination are still underway. Many of your students will be grown before the Creek is fully cleaned up.

Contributors:

The bulk of this content has been adapted for use for Newtown Creek by Lisa Bloodgood, Education Coordinator for the Newtown Creek Alliance. Lisa Bloodgood and Willis Elkins from the Newtown Creek Alliance would like to thank the many individuals, organizations and funders who have generously helped us to make this curriculum. We are grateful for everyone's commitment to this project.

First and foremost thanks and appreciation goes to the Hudson River Fund, Andrea Parker, Christine Petro and the Gowanus Canal Conservancy for developing the initial curriculum that served as our template and guide in this work. We would not have been able to create this learning tool without their leadership and hard work. To learn more about their efforts in education and towards revitalizing the Gowanus Canal, visit their webpage https://gowanuscanalconservancy.org.

Thank you to Emily Fano and Sarah Ward, our partners at National Wildlife Federation Eco-Schools and all of the Sustainability Coaches, Fran Agnone, Alison Schuettinger, Fai Walker, and Tina Wong. Thank you to District 14 Superintendent Alicja Winnicki, as well as Greenpoint Eco-Schools Principals, Carmen Asselta (PS 34), Anna Cano-Amato (PS 110), Maria Ortega (MS 126), and Mary Scarlato (PS 31). We are especially grateful for the contributions of each of the teachers who workshopped these modules and collaborated with us to bring the Creek into the classroom and the classroom out to the Creek; from MS 126: Steven House and Amber Howes; from PS 110: Dana Raciunas, June Biolsi, Matthew Dicarlo, LuAnn Fortunato, Matt Jensen, Antoinette LoCascio, Michele McLee, and Allison Sweeney; from PS 34: Daniel Granito, Jeanne Marshall, and Elizabeth Wildermuth; from PS 31: Lou Ann Gallo, Lisa Derwin, Amy North, Patti Ratcliff, and Gabby Schiff.

Thank you to Shino Tanikawa and Korin Tangtrakul from the New York City Soil and Water Conservation District for all of your help, guidance and the incredible maps!

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Please credit the Gowanus Canal Conservancy, the Newtown Creek Alliance, and Greenpoint Eco-Schools when using this curriculum.

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Introduction & Methodology

Curriculum Overview

What is this curriculum about and who is it for?

This curriculum was designed by the Newtown Creek Alliance for use by middle schools and elementary schools that are located within the Newtown Creek Watershed. However, it is a flexible resource that can be used by older elementary school students and younger high school students at any school that is interested in the Newtown Creek or the Newtown Creek Watershed and the issues that surround them.

The curriculum focuses on content and skills relevant to understanding and becoming a steward of the Newtown Creek and Watershed. It includes lessons designed for both the classroom and the outdoors. We believe taking students outdoors (or "in the field" as we say) is essential to studying the Newtown Creek and in becoming active participatory learners and engaged in their community.

Curriculum Goals
What do we hope to accomplish with this curriculum?

- Build an understanding of the Newtown Creek and its Watershed as an urban ecosystem.
- Create opportunities to explore and study the Newtown Creek.
- Provide tools for students and teachers to be environmental stewards and engage in Science, Technology, Engineering and Math (STEM)
- To foster a relationship between students and their local ecosystems.

Enduring Understandings
What important ideas from this curriculum will students remember in ten years?

- Newtown Creek is part of the urban ecosystem. (The city is comprised of natural and built environments).
- You can study STEM in your community and use the environment as a classroom.
- Newtown Creek is a tidally influenced estuary that has changed over time, especially due to human industry and activity.
- We have the ability to positively change our environment through stewardship, design, and engineering.

Source: Newtown Creek Alliance

How is the Newtown Creek part of an urban ecosystem?

This is a place-based curriculum that uses the Newtown Creek as a lens to understand how urban ecosystems work. Each unit in this curriculum unpacks a layer of the Newtown Creek ecosystem, and reveals how humans impact the ecological health of our cities and waterways.

An urban ecosystem is made up of:

- Living things, including plants, animals and humans
- The natural environment, including air, water, and soil
- The built environment, including buildings, roads and sewers

The study of these city ecosystems is urban ecology.

Human impact is especially significant in the case of the Newtown Creek, which once was a pristine salt marsh that became one of the most polluted bodies of water in the United States, primarily from a long history of industrial dumping and sewage discharge. Though human actions have historically had a negative impact on the Creek, there are significant efforts underway to remediate the water and soil, with a vision for a cleaner, healthier waterway.

The full picture of the Newtown Creek as an urban ecosystem must include analysis of how the built environment and human activity affect water and soil quality, as well as plant and animal life. It is also helpful to understand the Creek's history as a salt marsh turned industrial waterway, where it is geographically located in relation to the rest of Brooklyn, and the other water bodies it is connected to. The Newtown Creek ecosystem can be defined by the Newtown Creek Sewershed boundaries, or the upland areas surrounding the Creek that once naturally drained into it and are now solely fed by storm and sanitary sewer pipes. Today, many human activities in the upland neighborhoods impact the health and vitality of the Creek, primarily through the combined sewage overflows that empty into the Creek from sanitary and storm sewers throughout the Sewershed.

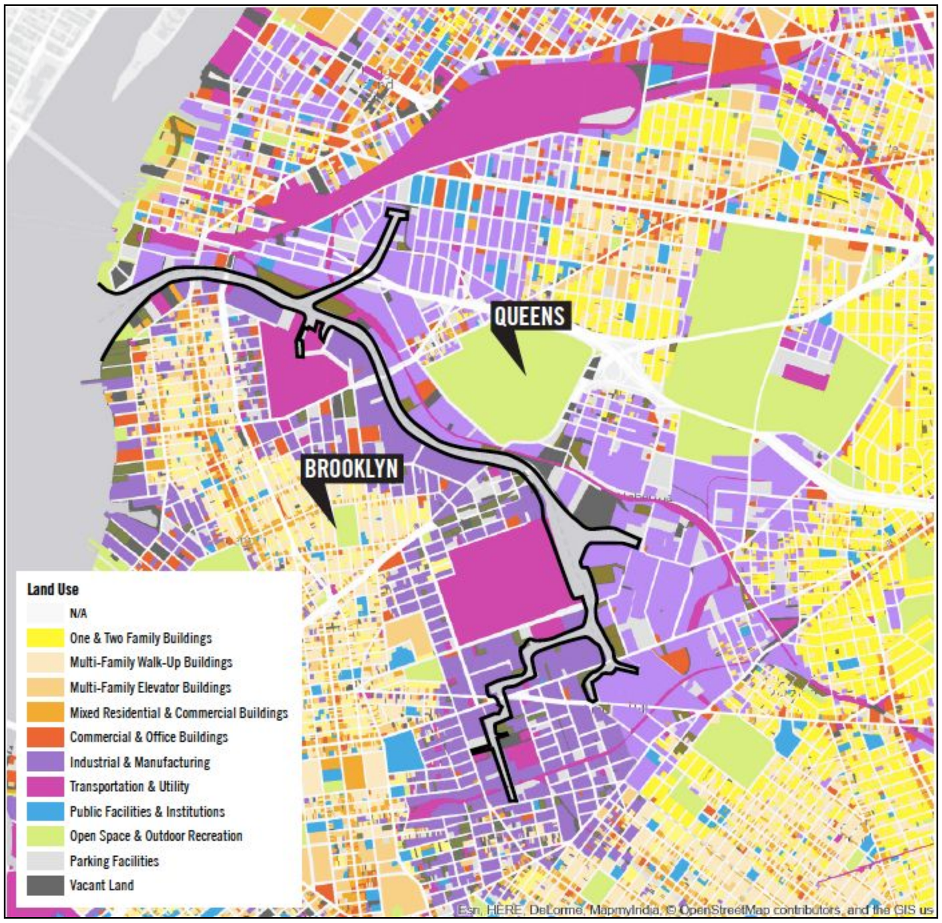
A primary strategy is to offset negative impacts of sewage overflow into the Creek is to create more "green spaces," which are areas that are planted with trees and other vegetation. Green spaces act like sponges and absorb stormwater before it overwhelms the sewage system.

The benefits green space can provide to an urban ecosystem are significant:

- Lower heat island effect and reduce energy costs
- Filter out pollutants in air and water
- Reduce noise by natural buffers
- Manage stormwater through permeable surfaces, which recharges groundwater
- Increase biodiversity and habitat
- Increase health and well-being through public and recreational space
- Provide space for food production

The lessons in this curriculum allow students to apply concepts related to ecosystems and urban ecology both indoors and outdoors, and to learn specifically how the Newtown Creek could be a much cleaner, healthier waterway and urban ecosystem by having sufficient upland green spaces.

It is our intent that teachers and students who experience the Creek through this curriculum will develop concern for its particular issues and become active stewards of our local waterway. Stewardship may involve advocating for Creek ecological health, educating others or implementing a project that addresses the Creek's environmental issues. Teachers and students can focus this concern on the issues of the Newtown Creek watershed, or apply this knowledge to understanding urban environmental issues around the world.



Map of Newtown Creek, showing today's land use

Source: Newtown Creek Alliance

Curriculum Format and Flexibility

How is the curriculum organized?

There are four units in this curriculum: Flora & Fauna, Water Quality, Watersheds & Sewersheds, and Soil Quality. Each unit includes: a Teachers Introduction with resources, two to three Lessons, a Field Lesson, and an Applied Learning Lesson.

- The Introduction to each unit is written for the teacher, in order to provide background information related to the unit; however, the introduction text could be modified for student use.
- The Lessons can be completed within one or two typical class periods and cover concepts and skills that prepare students for their time in the field. Taking time to expand the Lessons or do some of the Extension Lessons is encouraged, but not necessary.

- The Field Lessons are meant to be done outdoors, include a variety of activities, and can last from one to several hours.
- The Applied Learning Lessons help the students reflect on their field experience by analyzing the data they collected, then considering how stewardship, engineering or design would impact data results.

Overall, the units are designed to be flexible. We feel it is ideal to complete all lessons sequentially within the unit; however, you can easily pick and choose which lessons you want to use and in what order. For example, you can do the lessons without going in the field, or you can go in the field without doing the applied learning lesson. Additionally, you can pick and choose lessons from different units to create your own specialized unit.

Discussion Questions/Assessment Tools
How can teachers assess students on their knowledge?
The Lessons include a list of Discussion Questions. These questions can be used in a variety of ways. For example, you may simply use the questions in coordination with the "Procedures" to help guide the lesson. Or you may use the questions to create a handout or written assessment for the students. Each Field Lesson includes both Discussion Points and Journal Prompts, which are also very flexible and can be made into appropriate assessments.

Consider using and/or modifying the Introductions to each unit for your students. Giving students this informational text will allow for another layer of assessment as students cite the text and make comparisons between the text and the lesson activities.

The most rigorous assessments are found in the Applied Learning Lessons and within the Design Project, where students take the skills and content they have learned in the Lessons and Field Lessons and apply it to their own design ideas. Throughout the design process students have to explain, defend, and modify their own design ideas, while analyzing, critiquing and incorporating the ideas of their classmates.

Vocabulary
How is the vocabulary organized in this curriculum?
All of the vocabulary is collected and defined in the Glossary. In cases where there are multiple definitions for a word, the definition with the most relevance to this curriculum was chosen.

This curriculum provides three categories of vocabulary for each unit: Background, Extension, and Essential Vocabulary for the unit.

- *Essential vocabulary* are words and concepts students should master for the unit
- *Background vocabulary* are helpful to understand context prior to working in the unit
- *Extension vocabulary* are more advanced terminology that can be used with the lessons

There are so many ways to introduce, teach and reinforce vocabulary, that we felt it best left up to the teachers to decide what works for their students.

Journal Writing

How and why should teachers use journal writing as part of this curriculum?

Regardless of whether you spend a hour or a day in the field, conclude the experience by having the students write a journal entry. Journaling allows students time to reflect on their experiences and to think meta-cognitively.

Journal writing can include:

- Observation
- Inference
- Description
- Detail
- Site Metadata (e.g. location, time, weather conditions)
- Procedure (so someone else can do what you did)
- Personal experience
- Reflection (e.g. self to lesson, self to world, lesson to world)
- Opinions
- Feelings

Journal illustrations can include:

- Organisms
- Landscapes
- Structures
- Measurements
- Labels
- Additional written information
- Being “good at drawing” is not required!

Journal prompts can include:

- One of my goals is...
- Today I improved upon...

- One of my challenges is...
- This experience taught me…

Relate journal assignments to the Five Habits of Mind:

- Point of View – From what point of view are we looking at this topic?
- Evidence – What is the evidence used to support the major point of view, argument, or hypothesis?
- Connections – What are the connections of content within the chosen topic?
- Alternatives – What other point of view can be used to investigate this topic?
- Significance – Why is the topic under investigation important to the student and within the larger context of society?

Journal assessment can be based on:

- Meaningful observations and reflections
- Touching on all points in the prompt
- Level and depth of detail
- Completeness/thoroughness of ideas

It is often helpful to:

- Have students write silently
- Have more than one prompt for students to choose from
- Include “Write anything else you want to write” at the end of each prompt
- Give written, personal feedback when assessing journals

Field Work

What should teachers keep in mind when bringing students in the field?

Field work is an exciting part of this curriculum; however in order for the field work to be safe and of the highest educational value you will need to do a fair amount of prep work. Here are a few suggestions as you plan your field day:

- **Site Pre-Visit:** Be sure to visit the field site(s) yourself before bringing your students there. Scope out where students can put their bags down, where they can sit, where you can gather and talk to the whole class, where small groups can work, and any safety questions and concerns.
- **Field Trip Forms:** Follow the Chancellor’s Regulations and have all the appropriate forms required by the DOE for a field trip.

- **Expectations:** Make sure your students know what to expect. Prep them at least a day in advance regarding the schedule, weather, lesson and classwork for their day in the field. Review what you expect of them in terms of conduct in the field. Create a field expectation contract for your students to sign.
- **The Field as a Classroom:** It is important the students understand that going into the field is NOT a field trip. They are simply having class outdoors, in a new setting. Students are expected to participate and complete their assignment just as they would in the classroom.
- **Student Preparedness:** Students should expect to get wet and dirty in the field. Be sure they wear clothes and shoes that are appropriate for the weather conditions. Even if it seems warm at school, students should have jackets, and in cooler weather hats and gloves. They should also bring a water bottle and a snack. Being hot, cold, dehydrated or hungry leads to discomfort and crankiness — which can really disrupt your day in the field!
- **Agenda**: Go over an agenda for the field day before you leave the classroom. For example, tell students how they'll be traveling to and from the site and when they will have lunch. This kind of information can allay students' concerns and make your day go more smoothly.
- **Supplies:** Pack and organize all your supplies for the field before your students show up. Use bags that are easy to transport such as backpacks and bags with wheels.
- **Clipboards:** Students need a reliable surface on which to write in the field. We highly recommend using clipboards. Binders are awkward and folders do not protect papers from flying away in the wind.
- **Volunteers:** Recruit a core group of adult volunteers to help you manage students and run small group activities in the field.

Small Groups in the Field

How can you structure field work so it goes smoothly?

In the field, you will likely need to talk to your whole class at certain times throughout the day in order to give directions. We recommend you spend limited time talking to your class as a whole and spend as much time as possible having your students work in small groups.

Group work does not always come naturally. Have your students begin to work in their small groups during the preceding lessons. To promote group cohesion and collective support, consider evaluating the group's work rather than the work of the individuals within the group.

Before heading out to the field, make sure that each group knows the assignment and what role each student will play. Every student should have an assignment, so no one wanders around disturbing other groups.

Nature is inspiring and exciting. It's okay if your students feel this excitement and make observations unrelated specifically to the assignment. It's important to support the student's curiosity and exploratory nature.

Field Expectations Contract

INSTRUCTIONS: Please read and sign this contract with your parent/guardian.

Teacher Responsibilities:

- Keep you in a safe environment in class, in the Field
- Help you develop critical thinking skills
- Support the curiosity and exploratory nature of students in the field

Student Responsibilities:

Behavior

You are expected to behave according to the following guidelines.

Respect for Self

- Be prepared for class.
- Be on time.

Respect for Others

- No foul language or shouting.
- Keep hands, feet, and objects to yourself.
- Listen when others are speaking.
- Raise your hand and wait to be called on before speaking.

Respect for Classroom Environment

- No electronic devices are permitted to be seen, heard, or used in class or in the field.
- Head coverings of a non-religious nature are not allowed.
- Keep the classroom clean.

Respect for Outdoor Environment

- Put all garbage in a garbage can. Please do not litter!
- Respect all wildlife. Please do not feed or scare animals!
- Respect the vegetation. Do not unnecessarily pick or trample plants.
- Respect the built environment. No scraping, tagging or graffiti.

Preparedness

Each day you are in the field you will be graded on having the following items with you:

- clipboard
- reading book
- water bottle
- snack
- layer (jacket or other clothing needed)
- pencil
- field bag (backpack or messenger bag – no purses or tote bags)

Clothing and Supplies

The Newtown Creek is part of our classroom. This means that some of our activities will take place outside. While this is fun, exciting, and makes school a special place, it also requires that you dress properly and care for yourself when we are outside.

Required Clothing & Supplies:

__ Water Bottle
Part of staying comfortable and safe outside is making sure you have enough water. We often do not have access to drinks, so bring your refillable bottle.

__ Old Clothes & Shoes
Don't throw away your old clothes. Keep a pair of old jeans and an old sweatshirt around to wear in the field. We do get dirty sometimes.

__ Waterproof or Water Repellent Jacket
A big part of staying warm is having an insulated, outer layer that can keep water out. If the jacket and insulation are non-cotton, so much the better.

__ Hat, Gloves, Scarf
Baseball hats protect you from the sun. Knit hats and scarves will keep you warm because you lose a lot of your body heat from your head and neck. You need gloves to do your writing when it's cold!

__ Book Bag
You need a sturdy, good-sized bag. No plastic bags, purses or handbags! The book bag needs to hold your work for the day, a book to read on the subway, your water bottle and extra layers of clothes.

Suggested Clothing & Supplies:

__ Long Underwear
We will be outside when the temperature is low. In order to stay warm, especially if it is damp outside, you should wear non-cotton or synthetic long underwear under your clothes. The less cotton the better because cotton absorbs water and can make you cold!

__ Wool or Synthetic Socks
Nothing is worse then cold feet!! Your cotton socks will make your feet cold if they get wet. It's also a great idea to bring an extra pair of socks to change into at the end of your day in the field.

__ Sunglasses & Sun Block
Even if you have dark eyes or skin you are still susceptible to the ultraviolet rays of the sun. These items will help protect you on the sunnier days, even if it is not hot out.

What it means to be In The Field...

- You must ***eat breakfast*** before school. No breakfast equals crankiness.
- You ***may not buy*** lunch (or anything else) once we have left the school building.
- You must bring a ***water bottle*** with you in the field.
- ***Do not*** wear new clothes and shoes. Wear things that can get dirty and wet.
- You must have a ***full-size*** school bag. No plastic bags or purses.
- You should use the restroom before you leave the school.
- As a class we will ***wait for the light***. Do not cross the street in front of your teacher. Stay with the group at all times!
- You must ***stay with the class*** at all times. If you leave the class group you will be considered truant and for safety purposes the principal and truancy police will be notified.
- You are to be on your ***best behavior*** while in the field. All school rules and policies apply.

Contract

We have read and agree to the above Field Expectations

Student Signature:

____Date:_________

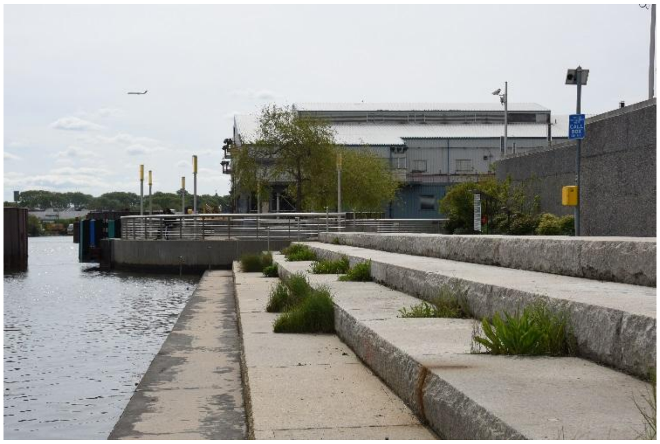
Parent/Guardian Signature:

____Date:_________

Guides to Newtown Creek Field Sites
The best places to explore for the Field Lessons in this curriculum.

Newtown Creek Nature Walk

Entrance near 88 Paidge Avenue, Brooklyn 11222



The Newtown Creek Nature Walk is maintained by the Department of Environmental Protection (DEP). It features access to Newtown Creek and is open to the public every day, sunrise to sunset, weather permitting.

Designed by environmental sculptor, George Trakas, the site contains thought-provoking features like seven stone circles that pay tribute to the area's Lenape heritage. Design elements can be explored in whole or part with the assistance of **The Newtown Creek Nature Walk Scavenger Hunt.** Also notice the **Constructed Wetland Frames** installed in the water by **The Newtown Creek Alliance (NCA)** to improve **water quality** and provide **habitat**. The Nature Walk can be utilized to provide a rich site visit for many of the units in this curriculum.

Learning Activities

Self-guided or Invite a Guest Expert from Newtown Creek Alliance (NCA).
Pre-site visit is essential to the success of this trip.

Flora & Fauna	Water Quality	Watersheds & Sewersheds
· Identify species of flora and fauna using the **Newtown Creek Field Guide**. Many plants are labelled. · Complete the **Flora and Fauna Field Survey Handout** and **Metadata Survey.** · Complete **Observation Inference Chart** for plants with the Observe a Plant Activity. · **Collect a plant sample** for a herbarium press.	· With direct access to Newtown Creek water, you are able to **collect water samples** by tossing a bucket over the side of the railing with a rope line. · **Water Quality Testing**: pH, Temperature, Salinity, Dissolved Oxygen, Turbidity · **Journal Writing** with prompts from their field experience. · Observe the **Rain Garden** on Provost Street near Paidge Avenue.	· Map the **permeable** and **impermeable surfaces** with **Land Surface Survey** handout **and Newtown Creek Nature Walk Site Map**. · Complete the **Make it Rain Activity** using the **Observation Inference Chart**. · Have students clean the space using the **Litter Pickers Activity** as a guide.

Information

No Bathroom on site | Tables are available for eating bagged lunches or snacks.

- **Getting There:** Reserve a school bus; Buses can park on the corner of Provost Street and Paidge Avenue. Nearest address to give Bus Driver is 88 Paidge Avenue. 11222 (Time Warner Cable Office Address right next to Entrance.)
- **To Book a Trip:** No cost or booking required. *Site could be occupied by another class and is open to the general public.*
- **What To Bring:** Several adult chaperones, appropriate materials for learning activity, student journals, data collection sheets, clipboards, water bottles, appropriate clothing

Kingsland Wildflowers Green Roof

520 Kingsland Ave, Brooklyn, NY 11222 • www.kingslandwildflowers.com

The Kingsland Wildflowers is a 21,000 square foot rooftop green space that provides a corridor of native grass and flower habitat for NYC's bird and insect populations; it features all elements of a Certified Wildlife Habitat because it provides wildlife with: *food, water, cover, places to raise their young*. Designed and built by Alive Structures, the green roof is managed through a joint partnership by NYC Audubon and NCA.

Kingsland Wildflowers is also stocked with educational materials, including field guides, birding books, plant identification charts, binoculars, and more.

Learning Activities

Led by Newtown Creek Alliance Educator

Flora & Fauna

- Identify species of flora and fauna on the rooftop.
- Complete the **Observe a Plant** Activity, using the **Flora Observation Worksheet**.
- **Collect a plant sample** for a herbarium press.
- Observe interactions between native plants and wildlife, including birds, pollinators or insects.

Watersheds & Sewersheds

- Map the **permeable** and **impermeable surfaces** with **Land Surface Survey**
- Conduct the **Make it Rain Activity** using the **Observation Inference Chart**.
- Discuss the sewershed system using the DEP Wastewater Treatment Plant as a reference

Information

Tours typically last 1 hour | Bathroom on site

- **Getting There:** Walk or reserve a school bus; address: 520 Kingsland Avenue
- **To Book a Trip:** contact education@newtowncreekalliance.org to book a trip and discuss your class' specific learning objectives
- **What To Bring:** Several adult chaperones, appropriate materials for learning activity, student journals, data collection sheets, clipboards, water bottles, appropriate clothing

McCarren Park Demonstration Garden

457 Leonard Street, Brooklyn, NY 11222 (behind McCarren Pool)

The **McCarren Park Demonstration Garden**, "Demonstration" because its main purpose is to serve residents and gardeners as a learning tool. The garden features “best practices” in urban gardening, including raised bed gardens, herb, vegetables, native pollinator gardens, and even a few invasive plant species; the space also features a **rain garden**, intensive and extensive **green roofs**, and a **rainwater catchment system** for managing and collecting stormwater. Picnic tables and storage containers are perfect for bringing classes and storing lesson materials. Three of the four units can be easily taught in this space as soil, water, green infrastructure elements, and flora and fauna are all available.

Learning Activities

Led by Newtown Creek Alliance Educator

Watersheds & Sewersheds

- Investigate examples of green infrastructure; observe the rain garden and green roof.
- Map the **permeable** and **impermeable surfaces** using the **Land Surface Survey** worksheet.
- **Calculate** how much **rainwater** the rain barrels can capture during a one inch rainstorm.

Soil Quality

- **Conduct Soil Quality Tests:** collect soil samples from multiple locations and record data on **Soil Quality Data Sheet.**
- Identify **Soil Organisms**: collect soil samples for close observation.

Flora & Fauna

- Complete the **Observe a Plant** Activity, using the **Flora Observation Worksheet**.
- **Collect plant samples** for a herbarium press.
- Complete the **Observe a Plant** Activity, using the **Flora Observation Worksheet**.

Information

“Porta san” toilet | storage for Lesson Activity materials | picnic tables

Getting There: G train to Nassau Avenue; B26 or B46; L train to Lorimer Station

To Book a Trip: By appointment only. Contact your Sustainability Coach, and/or NCA.

What To Bring: See the Field Site Visit Contract for required clothing and supplies, student journals and other necessary learning activity materials and worksheets.

The Ed Shed @ North Brooklyn Boat Club

51 Ash Street Brooklyn, NY 11222   www.northbrooklynboatclub.org

The Ed Shed (at North Brooklyn Boat Club) features access to Newtown Creek, as well as a number of hands-on educational components and activities including a centerpiece aquarium, water quality monitoring, and plankton sampling and observation.

The Ed Shed is also stocked with educational materials, including field guides, microscopes, and a Sewer in the Suitcase; an on-site educator can lead students through STEM-based activities while providing an industrial and ecological history of Newtown Creek.

Learning Activities

Led by Newtown Creek Alliance Educator

Flora & Fauna

- Identify species of flora and fauna using the **Newtown Creek Field Guide**.
- Complete the **Observe a Fish** Activity. Identify and investigate the **aquatic wildlife species** of Newtown Creek, including plankton, mussels, crabs, and fish under the microscopes.
- Complete the **Observe a Plant** Activity, using the **Flora Observation Worksheet**.

Water Quality

- **Water Quality Testing**: with direct access to Newtown Creek, this is an ideal location to conduct pH, Temperature, Salinity, Dissolved Oxygen, and Turbidity tests.
- **Journal Writing** with prompts from their field experience.

Watersheds & Sewersheds

- Use the **Sewer in a Suitcase** to demonstrate how combined sewer overflows (CSOs) affect water quality.
- Map the **permeable** and **impermeable surfaces** at or near the Ed Shed using the **Land Surface Survey** worksheet.

Soil Quality

- **Conduct Soil Quality Tests:** collect soil samples from multiple locations and record data on **Soil Quality Data Sheet**
- Identify **Soil Organisms**: collect soil samples for observation under microscopes

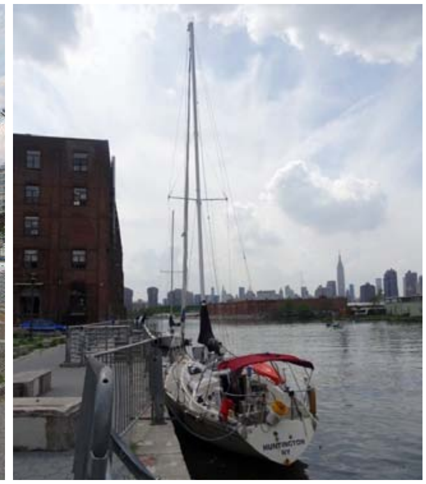
Information

Fees pending | Bathroom on site

- **Getting There:** Reserve a school bus; address: 51 Ash St., Brooklyn, NY 11222
- **To Book a Trip:** contact the Education Department at education@newtowncreekalliance.org to discuss your class' specific learning objectives
- **What To Bring:** Several adult chaperones, appropriate materials for learning activity, student journals, data collection sheets, clipboards, water bottles, appropriate clothing, hand sanitizer

Manhattan Ave Street End Park

Northern End of Manhattan Ave, beyond Ash Street, Brooklyn, NY 11222



This location, the only public park in Brooklyn near the banks of Newtown Creek, was established in 2009. The site features a grassy area, trees, benches, decorative granite stones, as well as a public launch site for canoes, kayaks, and other small boats. Educational signage about Newtown Creek's history and NYC's watershed and waterways are displayed in several locations throughout the park. This accessible public space offers students the opportunity to view visible signs of the city's infrastructure (notice all of the underground maintenance/utility holes), the Creek's present-day industry (look for barges and boat traffic), and novel ecosystems along the water's edge.

Learning Activities

Self-guided or Invite a Guest Expert from Newtown Creek Alliance (NCA)

Flora & Fauna

- Identify species of flora and fauna using the **Newtown Creek Field Guide**. Look for birds on land and water!
- Complete the **Observe a Plant** Activity, using the **Flora Observation Worksheet**.
- **Applied Learning:** How can the addition of native plant species benefit wildlife that live in or near the park?

Water Quality

- **Water Quality Testing**: conduct Temperature, pH, Salinity, Dissolved Oxygen, and Turbidity tests; toss a bucket attached to a rope line over the railing to collect water samples.
- Use the NYC watersheds and waterways signs for **journal prompts** and reflections about Newtown Creek.
- **Applied Learning:** How can the Creek's water quality be improved by the addition of plants?

Watersheds & Sewersheds

- Map the **permeable** and **impermeable surfaces** using the **Land Surface Survey** worksheet.
- Have students practice stewardship using the **Litter Pickers Activity** as a guide.
- **Applied Learning:** What engineering or design solutions could increase the absorption of rainwater at this site?

Soil Quality

- **Conduct Soil Quality Tests:** collect soil samples from multiple locations and record data on Soil Quality Data Sheet
- Discuss **built vs. natural environment** and the role of industry over time.
- **Applied Learning**: How can soil health in this area be improved by the addition of plants?

Information

No Bathroom on site | Benches are available for eating bagged lunches or snacks.

- **Getting There:** Reserve a school bus; buses can park at the end of Manhattan Ave to the left of the park there is a parking space.
- **To Book a Trip:** No cost or booking required. *Site could be occupied by another class and is open to the general public.*
- **What To Bring:** Several adult chaperones, appropriate materials for learning activity, student journals, data collection sheets, clipboards, water bottles, appropriate clothing, hand sanitizer

Living Dock

459 North Henry Street, Brooklyn, NY 11222

The Living Dock is a 200 square foot floating structure designed to promote marine life and provide important habitat. The Dock provides a protected place for marsh grasses to grow, shellfish to live, and marine animals to hide and feed. The dock can host visitors to provide a first hand look at the habitat and numerous species that have been returning to Newtown Creek.

The site features access to Newtown Creek, a number of hands-on educational components and activities including water quality testing, and fish and other marine life observation, flora and fauna observation opportunities. The Living Dock is also stocked with educational materials, including field guides, microscopes, and a Sewer in the Suitcase; an on-site educator will lead students through STEM-based activities while providing an industrial and ecological history of Newtown Creek.

Learning Activities

Led by Newtown Creek Alliance Educator

Flora & Fauna

- Identify and investigate the **aquatic wildlife species** of Newtown Creek, including fish, mussels, oysters, crabs and plankton under microscopes
- Wildlife Survey and **Observe a Fish** activities.

Water Quality

- With direct access to Newtown Creek water, the Living Dock is an ideal location to conduct **water quality tests.**
- Use the **Sewer in a Suitcase** to demonstrate how combined sewer overflows (CSOs) affect water quality
- Newtown Creek Ecological and Industrial History

Watersheds & Sewersheds

- Permeable and impermeable surfaces are on site.
- A demonstration of how runoff gets into the Creek is available.

Information

Workshops must be a minimum of one hour | price for workshop pending | No bathroom on site

- **Getting There:** Reserve a school bus; address: 459 North Henry Street, Brooklyn, NY 11222
- **To Book a Trip:** contact education@newtowncreekalliance.org to discuss your class's specific learning objectives
- **What To Bring:** See the Field Site Visit Contract for required clothing and supplies, student journals and other necessary learning activity materials and worksheets, hand sanitizer.

Flora & Fauna

In this Unit:

This Unit has been modified by permission by the Newtown Creek Alliance from the original with assistance from the National Wildlife Federation's Greenpoint Eco-Schools Program. The original module was developed by the Gowanus Canal Conservancy.

Unit Overview

Essential Questions:

- How do native plants and animals contribute to the overall health of the Creek's ecosystem?
- How can examining or observing the plant and animal life in the Creek teach us about the health of the Creek?
- How does biodiversity support the overall health of the environment and what are humans role in protecting that diversity in and around the Creek?
- How can we develop proposals to create conditions that will encourage more native plants and animals to grow and thrive in and around the Creek?

Lessons & Objectives:

Teachers Introduction

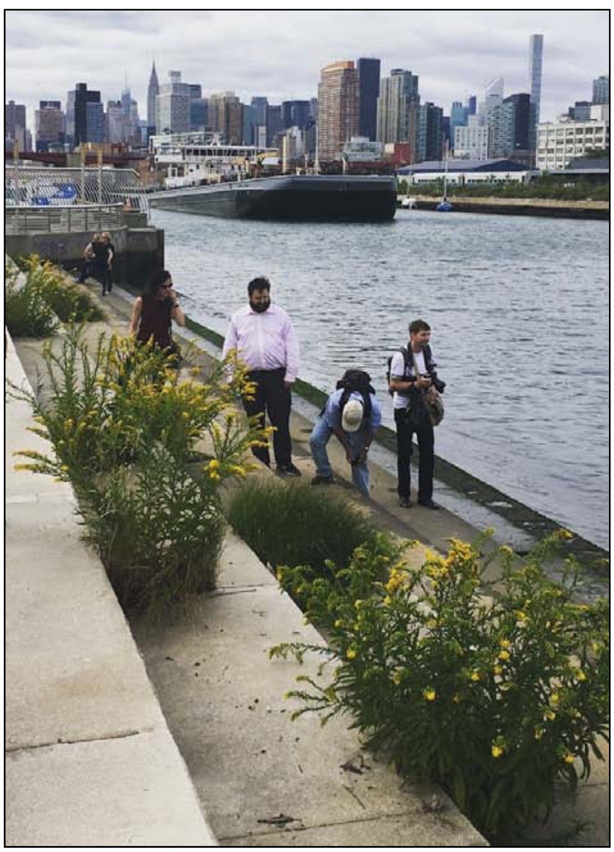
What are Flora and Fauna?

Flora and **fauna** are terms that mean plants and animals, respectively. They refer broadly to the diverse species that exist in a given **ecosystem**.

Once humans began to move goods around the world, animal and plant species came with them. Before this, ecosystems evolved in physical isolation from one another. When an **organism** is introduced to a new ecosystem, one of several things can happen: the new organism can be out-competed for resources by the **native** species and die out; it can co-exist with the native species; or it can out-compete the natives and become **invasive**. Invasive species of flora and fauna are a global problem, threatening ecosystem **biodiversity** and competing with native species for water, nutrients and space.

There are various ways to categorize flora and fauna, which are often debated by ecologists. The terms "native," "invasive," "exotic", and "**introduced**" all connote particular values and goals depending on whether the goal is to restore, conserve or let an ecosystem manage itself without human intervention.

The categories used in this unit are chosen to illustrate what type of role or function particular species play in an ecosystem.



Native species (indigenous) are organisms that existed in a local ecosystem before globalization and are integrated into the ecosystem.

Introduced species are organisms that come to a new area from another place as a result of human activity.

Invasive species are introduced species that create an imbalance in the ecosystem by outcompeting native species.

Seaside Goldenrod (*Solidago sempervirens)* growing on the steps of the Nature Walk. (Source: Newtown Creek Alliance)

Why Teach It?

Many people assume that due to Newtown Creek's toxicity and **industrial** uses it is devoid of plant and animal life. As we will see, this notion is incorrect and local environmental improvements continue to allow for increased biodiversity. This unit explores some of the plant and animal species in the Creek today as well as historical species that are no longer found in the current Creek ecosystem. Each species has an impact on the health and vitality of the waterway. For some species their contribution is clearly positive or negative, but for others the story is more complicated. For instance, invasive plants can provide ecosystem services such as shore stabilization, oxygen transpiration, shading or **habitat**.

Students will gain practice closely observing the characteristics of specific plant and animal species, practice identifying the species with field guides, and have the opportunity to explore the roles these species play or played historically in the Creek urban ecosystem. It is important that we understand which species of flora and fauna we want to encourage to flourish in the Creek.

Snowy Egrets (*Egretta thula*), Great Egrets (*Ardea alba*), Laughing Gulls (*Leucophaeus atricilla*), and a Tern (*Gelochelidon nilotica*) in Jamaica Bay. (Source: NRDC Photo by Don Riepe)

Newtown Creek Flora & Fauna Background

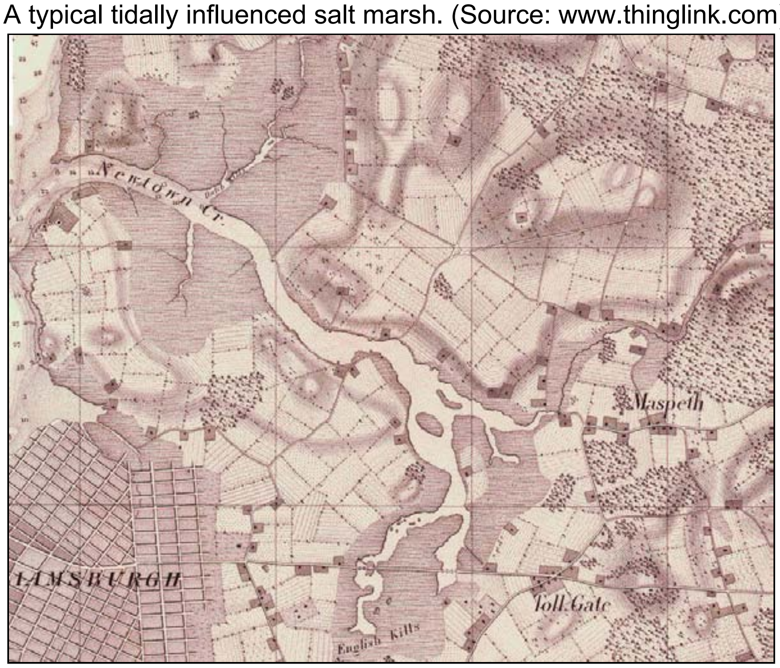
Newtown Creek is part of the Hudson Estuary, flowing west for 3.8 miles between Queens and Brooklyn and connecting to the East River. The Creek features small branches known as: Dutch Kills, Maspeth Creek, Whale Creek, the East Branch, and English Kills. It is a tidally influenced estuary with a total surface area of 140 acres. In the early days its shores presented a beautiful sight. The Creek's natural sources were fresh water streams which flowed between wooded elevations and further along lowlands until they mingled with the salt water of the East River, which is actually a Tidal Strait. When the **tides** of these waters rose, the inundation of the sea water would cause the streams to overflow into the surrounding marshes. The Creek abounded with fish and shellfish as well as birds and various mammals that used them as a food source. The Creek would have also been a favorite stop over spot for migratory birds as well. As we will see, this landscape was dramatically altered in the 19th and 20th centuries, with valuable marshland and streams lost in the process.

Newtown Creek has **brackish** water, or a mix of fresh water, from precipitation collected on land into streams, and salt water from the Atlantic Ocean. Brackish water has the ability to support a diversity of plant and animal species. Nutrients coming in from the tides stimulates plant growth in the marsh ecosystem and carries out organic material that feeds fish and other organisms. On the bottom of marshes is **peat**, which is decomposing plant matter that is often several feet thick, waterlogged, root- filled and very spongy.

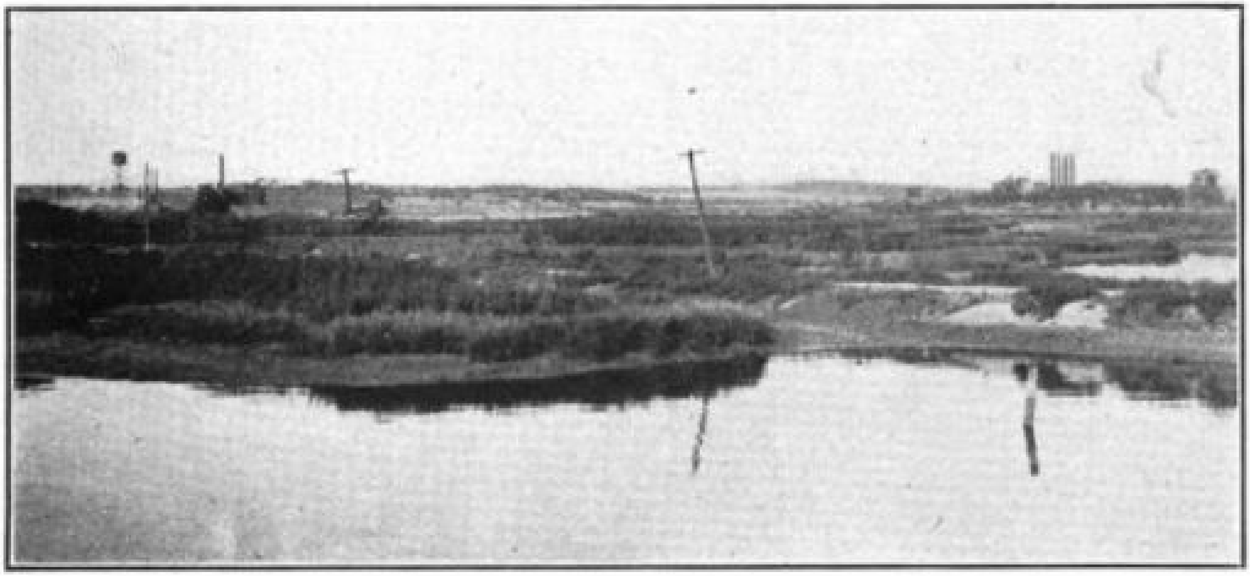
Salt marshes are among the most productive ecosystems on Earth, benefitting the wider ecosystem through the food web. Few animals eat **salt marsh** plants, but after the plants die they become colonized by bacteria, fungi and protozoans, making a rich food source called **detritus**. Detritus is an initial step in many food webs that ultimately feeds many other important (commercially and environmentally important) species. First, worms, crabs and other invertebrates eat the detritus on the marsh bottom. At high tide, mummichogs, silversides and other small fish swim across the flooded marsh surface to feed on the detritus and invertebrates. At low tide, the small fish retreat into deeper creeks. Larger fish such as winter flounder and striped bass venture into the creeks and feed on the small fish. In turn, the larger fish swim out of the marsh, which connects the salt marshes food web with that of the Hudson River, the New York Harbor and the coastal waters beyond. Through the food-web and the export of nutrients, salt marshes play a major role in sustaining larger coastal ecosystems.

Salt marshes also serve as nurseries for the young of many organisms such as winter flounder (*Pleuronectes americanus*), tautog (*Tautoga onitis*), sea bass (*Centropristis striata*), alewife (*Alosa pseudoharengus*), menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), mullet (*Mugil cephalus*), sand lance (*Ammodytes americanus*), and striped bass (*Morone saxatilis*). Other common fishes found in tidal salt marshes include Atlantic silversides (*Menidia menidia*) and mummichog (*Fundulus heteroclitus*). Many fish species reside in salt marshes for most of their life cycle, including mummichog and striped killifish (*Fundulus majalis*). Common birds of the tidal marsh include osprey (*Pandion haliaetus*), herons, egrets, rails, swans, ducks, and marsh sparrows.

A typical tidally influenced salt marsh. (Source: www.thinglink.com)



Newtown Creek and the surrounding land - 1844 (Source: https://publiclab.org/)



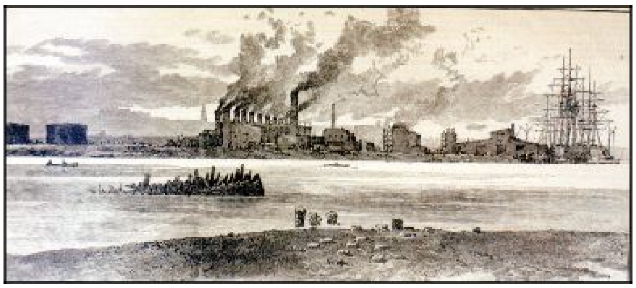
Shoreline for sale in early 1900's. Native grasses and soft shorelines are still present. (Source: The Newtown Creek industrial district of New York City. By the Merchants' Association of New York. Industrial Bureau, 1921, courtesy Google Books)

Rapidly declining water quality from industrial pollution, sewage and the introduction and growth of invasive species caused many native species to disappear during the heavy industrial period in the Creek's history. Approximately 85% of former wetlands and salt marshes in the New York/New Jersey harbor **estuary** were lost over the course of New York City's development beginning in the 1700s. By the mid-twentieth century, the Creek was completely channelized and 100% of the former wetlands and salt marshes were gone.

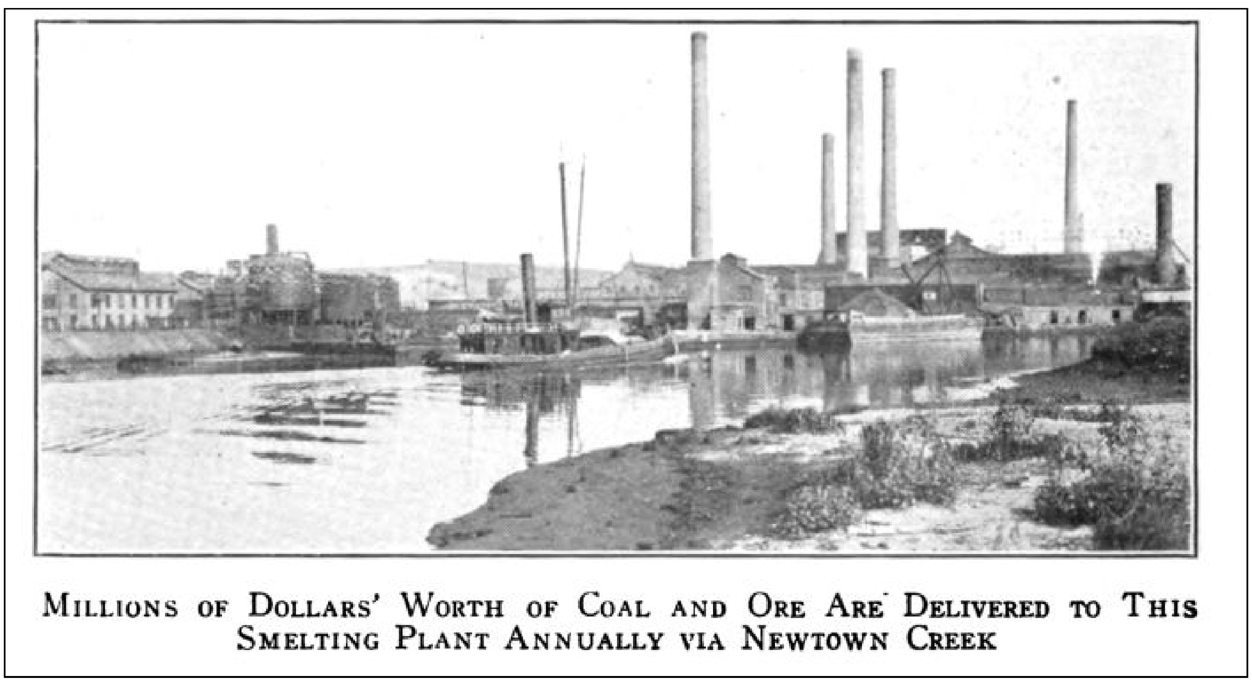
The Creek has been used by humans for hundreds of years starting with Native Americans who lived near the headwaters of the Creek, and used the whole ecosystem for food. Dutch explorers first surveyed the Creek early in the 1600's. Following skirmishes with European settlers and disease, the local Mespat tribe was eventually driven out of the area. The Dutch and English used the Creek for agriculture and industrial commerce, making it one of the oldest continuous industrial area in the nation. The country's first kerosene refinery (1854) and first modern oil refinery (1867) helped throw fuel on the fire of the fledgling industrial revolution and drastically change the nature of the Creek.

By the end of the 19th century, Rockefeller's Standard Oil, had bought up and operated over 50 distilleries on both sides of Newtown Creek. Newtown Creek was also home to such businesses as sugar refineries, hide tanning plants, animal renderers, canneries and copper smelting plants. By the 1920s and 30s, the Creek was a major shipping hub and was further widened, deepened and bulkheaded to accommodate bigger barges.

The Creek is now a highly altered environment. Since most of the ground in the footprint of the historic salt marsh has been removed from normal tidal action, it can no longer support the historic salt marsh species. There are, however, many species that are native to the region in the Creek, both planned and spontaneous, that have found small pockets where they survive and even thrive. As we plan gardens and streetscapes around the Creek, there are many opportunities to use plants native to the region that will thrive in the area's current conditions.



(left) General View of Oil Refineries 1800's (Source: http://www.astorialic.org/) (right) The Head of Dutch Kills. (Source: The Newtown Creek industrial district of New York City. By the Merchants' Association of New York. Industrial Bureau, 1939)



Fossil Fuel industry activities on the banks of the Newtown Creek. (Source: The Newtown Creek industrial district of New York City. By the Merchants' Association of New York. Industrial Bureau, 1921)

The Creek still teems with both animal and plant life despite its history of neglect and before any major cleanup has taken place. Consider the presence of the Great Blue Heron (*Ardea herodias*) that frequent the Creek — they wouldn't be there unless there were fish in the water to eat! Fish that are observed in the Creek today include Mummichog (F*undulus heteroclitus*), Atlantic silversides (*Menidia menidia*) and invertebrates including Blue Crab (*Callinectes sapidus)* and Horseshoe Crab (*Limulus polyphemus*). These aquatic vertebrates and invertebrates are hardy species that are able to withstand the extremely polluted conditions in the Creek. Oysters (*Crassostrea virginica*), once a keystone species in NY Harbor are returning to the Mouth of the Creek and there are as many as 200,000 ribbed mussels (Geukensia *demissa*) found throughout various niches and corners of the Creek. Both of these species are valuable filter feeders that actually help clean the water by removing bacteria.

With the exception of a few hardy species, there are obvious constraints to achieving a truly healthy ecosystem with a diversity of flora and fauna in the Creek today. Poor water quality, including low levels of dissolved oxygen, create stressful conditions for any type of aquatic life. Suspended **sediment** in the surface and subsurface waters prevents light from reaching the bottom of the Creek, or the **benthic** zone, which in turn prevents photosynthesis necessary for the any plants that would otherwise provide oxygen, food and habitat for aquatic animals. Sediment **contaminated** with PCBs, PAHs, heavy metals and other carcinogens also prevents most plants and animals from living in the Creek's benthic layer. Oil, pharmaceuticals, and other surface water contaminants can be highly toxic to aquatic birds, fish and insects.

On the Creek's modern **shoreline**, you will still find most of the land surrounding the waterway kept in place by bulkheads. **Bulkheads** are vertical shoreline walls that prevent erosion and act as a hard edge between water and land. These walls can be made with concrete, metal or lumber. These materials and their rigid and flat surfaces do not support habitat for the terrestrial plants that would have once populated the soft shoreline of the salt marsh.

(left) Native Ribbed Mussels (Geukensia *demissa)* clustered in the cracks in old wooden pilings. (right) A migratory monarch butterfly (*Danaus plexippus*) is attracted to native Seaside Goldenrod (*Solidago* *sempervirens*). (Source: Newtown Creek Alliance)

(left) Late season Mugwort (*Artemisia vulgaris)* dominates a shoreline in English Kills. (right) Multiple Tree of Heaven (*Ailanthus altissima*) create a narrow canopy in Whale Creek. (Source: Newtown Creek Alliance)

The plants that grow on the Creek's shores are mostly spontaneous **vegetation** dominated by invasives — such as Mugwort (*Artemisia vulgaris*) and Tree of Heaven (*Ailanthus altissima*) which outcompete other plants. However, in some spots along the creek, spontaneous vegetation includes native plants, like Seaside Goldenrod (*Solidago sempervirens*), Black Locust (*Robinia pseudoacacia*), and Black Cherry (*Prunus serotina*).

This Leopard Slug (*Limax maximus*), a European invertebrate is a surprising find during restoration work.

Cormorants (Phalacrocorax auritus) perched on a boom in Maspeth Creek, egrets (*Ardea spp.*) in the mudflats behind them. A massive combined sewer outfall in the background.

The fruit of the Black Cherry tree (*Prunus serotina*), indigenous to New York, begins to ripen in early August.

Invasives, and native plants fight for space, light, water and nutrients on the edges of commercial and industrial properties or on public street ends that abut the Creek. Since local soil is mostly **landfill**, it often lacks the characteristics plants need to thrive (see Soil Quality Unit). There are several places along the Creek that are seeing **restoration** efforts by City agencies, including the Nature Walk at the Newtown Creek Waste Water Treatment Plant, Manhattan Ave. street end Park. Community groups, like the Newtown Creek Alliance, initiated and maintain several sites and, on a few private properties, workers grow vegetables or have planted break areas; aside from these few, the Creek's shorelines are mostly unmanaged and struggle in the harsh, human-made environment.

Improvements to Creek Flora & Fauna

Though Newtown Creek and the surrounding neighborhood is dominated by unmanaged vegetation, there are efforts underway to encourage native plants, street trees and **pollinators** to return to the neighborhood, while still respecting the current industrial land use.

Some projects are forged by volunteers and others by government agencies, such as NYC Department of Environmental Protection (DEP) and NYC Parks, and others by private firms and commercial businesses. Often, all of these entities work together to improve the health and environment of Newtown Creek. Included here are a handful of featured projects that have focused on the goal of restoring or increasing native species and other beneficial flora and fauna species of the Creek and its marine and terrestrial ecosystems.

Plank Road midsummer; Maspeth, Queens. (Source: Newtown Creek Alliance)

Plank Road (58th Road in Maspeth, Queens) is a revitalized street end with known historic and ecological significance on Newtown Creek. With support from the NY-NJ Harbor & Estuary Program, the New England Interstate Water Pollution Control Commission (NEIWPCC) and New York State Department of Conservation (DEC), the

Newtown Creek Alliance is working to transform Plank Road from an overgrown, muddy and littered street-end to a clean and rejuvenated public shoreline.Situated in a dense industrial area, Plank Road now offers an inviting landscape for local employees and the general public seeking respite. During our restoration project the Alliance worked with a number of city agencies including: Transportation, Sanitation and Environmental Protection. The Alliance received a generous donation of materials, labor and equipment from neighboring US Concrete to help landscape the site. The site features a path from street to the water, a native pollinator garden, mulched pathways and signage signifying the historic significance of the area.

White Pine (*Pinus strobus*), Honey Locust (*Gleditsia triacanthos*), and (not pictured) Mulberry (*Morus spp.*) trees grow where the old Penny Bridge crossing once stood.

Meeker Ave In 2017, NCA began work to clean-up and re-introduce native plantings at the Penny Bridge site in Greenpoint. Situated at the end of Meeker Avenue, this once was the location of the Meeker Avenue Bridge (or Penny Bridge) which was demolished in 1939 when the replacement, now known as the Kosciuszko Bridge, was built a block away to the east. The upland area between the street and shoreline comprises nearly 1/2 acres of city owned land which has been largely neglected for many decades, overgrown with weeds and used as a dumping ground. Newtown Creek Alliance is working with various city agencies and volunteers to transform the overlook into a valuable green space for local workers and nearby residents.

The center, open sections of the living dock are planted with native grasses (*Spartina alterniflora)* and can be extracted to reveal the marine animals that make the substrate their home. Raccoons (*Procyon lotor*) and Canadian Geese (*Branta canadensis*) frequent the dock as do students, researchers and group tours.

The **Living Dock** is a 200 square foot floating structure designed to promote marine life. The Dock provides a clean place for marsh grasses to live, shellfish to grow and small marine animals to hide and feed. Marine plant life and bivalves like mussels, oysters and clams can help filter the water of excessive nutrients and bacteria; yet many of these crucial species have limited places to grow. To offer clean habitats for native species we have incorporated various salt marsh plant species and substrates. Ropes and stone provide more protection for killifish and shrimp while other materials, like oyster and clam shells, encourage barnacles, mussels and slipper snails.

Metal frames filled with sand and native salt marsh Grasses (*Spartina alterniflora,* & *S. patens*) are thriving at the Nature Walk on Whale Creek.

Intertidal Wetland Frames Working with the environmental science department at LaGuardia community college and trained volunteers from the North Brooklyn Boat Club, Newtown Creek Alliance has reintroduced salt marsh grasses that once covered much of area surrounding Newtown Creek. Native plant species not seen on the Creek in the past 50 to 100 years are now back and thriving. The establishment of plants within the pilot frames, has successfully demonstrated the viability of reintroducing salt marsh grasses, an effort now being pursued by city and state agencies.

Tickseed (*Coreopsis spp.*) and other native perennials in full bloom on the Kingsland Wildflowers Green Roof, the Newtown Creek Wastewater Treatment Plant and the Manhattan skyline can be seen in the background.

Kingsland Wildflowers Newtown Creek Alliance has partnered with NYC Audubon, Broadway Stages and Alive Structures to build out a 20,000 sq foot green roof at 520 Kingsland Avenue in Greenpoint. The project features native wildflowers and grasses that will not only soak up rainwater but provide habitat to pollinator and bird populations. Additionally, the roof serves as outdoor classroom for local schools and the general public.

Vocabulary

Note: Some of this vocabulary is referenced in other parts of this curriculum. All vocabulary and definitions appear in the glossary of the curriculum.

Background Vocabulary:

creek
conservation
contaminate
ecosystem
estuary
food chain
habitat
invertebrate
omnivore
organism
pollutants
pollinator
species
tide
toxin
vertebrate

Essential Vocabulary:

adaptation
algae
benthic layer
biodiversity
biological indicator
brackish
decomposer
extinct
fauna
field guide
flora
industrial
introduced
introduced non-aggressive
invasive
landfill (urban fill)
native
niche
producer
propagate
remediation
restoration
salt marsh
sediment
shoreline
vegetation

Lesson I - Biodiversity

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

BIodiversity is an integral piece of a healthy and robust environment. Understanding the roles different plants and animals play in the tapestry of life allows students to make connections to their own place in the natural world. In this lesson, students will explore a resource about biodiversity and then partake in an activity or discussion designed to clarify and deepen their thinking. The students will understand the importance of biodiversity in our lives and its impact on our local waterway, Newtown Creek.

Learning Objectives

- Students will listen to and build on classmates ideas and comments
- Students will define biodiversity
- Students will describe how humans benefit from biodiversity
- Students will discuss ways to increase biodiversity in the Newtown Creek area

Time

45-60 minutes for each lesson

Vocabulary

See Flora & Fauna Introduction for a list of vocabulary words from which to choose

Tips for Teachers

- Consider using and/or modifying portions of the Flora & Fauna Introduction as a text for your students.
- Choose from one of the articles below or find another resource of your choosing about biodiversity.
- This activity is designed to clarify and deepen our thinking about content in the resource students explore, and it is meant to build on each other's thinking about the concept of biodiversity.

Materials

- Article, book or text excerpt about biodiversity
- Journals or writing notebook
- Newtown Creek Flora and Fauna slideshow
- Pens and pencils
- Chart paper
- Marker

Procedure

This activity has been adapted from the protocol "Save the Last word for Me" by Patricia Averette http://schoolreforminitiative.org/doc/save_last_word.pdf

1. Students get into small groups.
2. Class will collectively review shared resource (read aloud text, view presentation or video, etc), each student will identify what s/he considers to be the most significant idea addressed in the article, and write a word or sentence or thought about that idea.
3. When the class is ready, a student from each small group volunteers to identify the idea that s/he found to be most significant and reads it out loud to the class. This student (the presenter) says nothing about why s/he chose that particular passage.
4. The teacher records student idea on chart paper or board in a list.
5. After thinking for a moment, the other students in the small groups each have 1 minute to respond to the idea — expressing within the group what it makes them think about, what questions it raises for them, etc.
6. The same pattern is followed until all students have volunteered their ideas to be shared with the class (as time allows).
7. The class has an open dialogue about the activity and discusses the issues of biodiversity using the Discussion Questions below.
8. Class discussion then focuses on ideas for increasing the biodiversity in the neighborhood and around the Newtown Creek. Take into consideration the what already lives and thrives in Creek. (Reference Newtown Creek Flora/Fauna presentation, Newtown Creek Alliance birds and marine wildlife posters, etc.)

Discussion Questions

These questions are optional and are helpful guides. Please develop your own questions that may help guide the conversation as needed based on resource materials used.

1. What is biodiversity?
2. What are some of the benefits of an ecosystem that has a lot of biological diversity?

3. How do humans benefit from and rely on biodiversity?
4. What are some of the main causes of the loss of biodiversity today?
5. Over the past 400 years, what do you think has contributed to the loss of biodiversity in the Newtown Creek area?
6. How could we improve biodiversity in Newtown Creek and in the surrounding areas? Think about both small-scale and large-scale improvements.

Extension Lesson - Change Over Time in Newtown Creek

Create a human timeline to demonstrate the change over time in Newtown Creek. Print out images of Newtown Creek from the Teachers Introduction, Newtown Creek Flora and Fauna Background, of the unit. Have students guess what time frame the image is from (ex: before 1600s). Student volunteers will hold up the image and together create a human timeline in class where they can embody the environmental history of Newtown Creek. Students will understand the Big Idea of Change Over Time in relation to place. (Consider using the second set of Discussion Questions in Lesson II to augment this activity)

Extension Lesson - Species Exploration

Use the Flora and Fauna ID Cards and the Newtown Creek Plant and Animal Relationships Cards to show the different native, non-aggressive introduced, and invasive plant and animal species found in and around Newtown Creek. Have each student select either a favorite species or select a pair of plants and animals and explain their relationship.

Lesson II - Introduced Species

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

A healthy ecosystem is one that is balanced and in which relationships between plants and animals are interdependent. An unhealthy ecosystem is one where that careful balance has been thrown off and only a few species dominate rather than many. In this lesson, students will play an active game where they take on the roles of native and invasive species and compete for limited resources in order to see how invasive species have the ability to out-compete native species. Acting out these roles will promote deeper understanding of balance and interdependence in an ecosystem.

Learning Objectives

- Students will understand that species depend on certain resources in order to survive and these resources are often limited within an ecosystem
- Students will understand the importance of balance and interdependence in ecosystems and begin to reflect on our role as humans in relation to that balance
- Students will understand that invasive organisms can upset the balance of an ecosystem

Time

45-60 minutes for each lesson

Vocabulary

See Flora & Fauna Introduction for a list of vocabulary words from which to choose

Tips for Teachers

- Consider using and/or modifying portions of the Flora & Fauna Introduction as a text for your students.
- To create space for the game push student desks to the side or consider using the gym or school yard.
- Game pieces should be evenly distributed around playing area for each round and students should be reminded not to run, push, or grab to get their game pieces.
- In this lesson students take on the roles of native and invasive species. You could play the game where the students represent the general concept of native and invasive species. Or you could assign the students specific, locally found

native and invasive species.
- Extension Lesson - Species Exploration (found in Lesson I) is extremely helpful in understanding the specific native, non-aggressive introduced and invasive species found locally. It is recommended that you spend time with those materials before leading this activity.
- If you assign students *specific* plants or animals species you can have a more in-depth discussion of exactly how the invasive species can outcompete the native species and what adaptations each species has that helps it survive. For example, the phragmites plant that we find around the Creek today is an invasive species and has an extensive underground rhizome system that grows quickly and densely thereby making it difficult for native cordgrass to continue to grow in the area.

Why is a species invasive?

"The term "invasive" denotes the biologically aggressive and exceptionally hardy characteristics of a plant, habitually denounced for taking over natural areas and stifling biodiversity. In non-urban conditions, these plants can at times be destructive on rural ecosystems. Monocultures of Tree of Heaven (Ailanthus altissima) or Common Reed (Phragmites australis) have been known to alter radically existing landscapes and wildlife habitats. With many invasive plants dispersing seeds multiple times throughout a season and with seed counts in the thousands per plant annually, the potential for a quick colonization of rural and suburban sites is a major concern."
(Source: http://urbanomnibus.net/2011/12/profiles-of-spontaneous-urban-plants/)

How do species become invasive?

Plants and animals are not inherently invasive but become so due to human interference and human relationships with with them. Native species in some locations become invasive species in other locations.

"Plants and animals have always traveled with us. The more we travel, the more species we unknowingly transport. Our transportation methods then become pathways for invasive species. For example, birds or the wind can carry seeds from garden plants into the wild. Exotic pets escape or are released into parks, lakes, and rivers. People can carry seeds on their clothing, in suitcases, or on cars. Packets of birdseed can contain seeds of invasive plants. Solid waste and soil that have invasive plants can be dumped as fill into wetlands. Plant seeds, insects, small animals, and organisms can hide in ship cargoes or ballast water, on the outside of boats, and on planes."
(Source: https://invasivespecies.wa.gov/how_do_they_get_here.shtml)

Materials

- Game pieces
  - Bingo chips, poker chips, ping pong balls OR something similar in three different colors
  - Resources for animals/plants represented by different colors (any colors available are fine):
    - Blue: Water/Water
    - Green: Food/Nutrients
    - Brown: Shelter/Space
  - You need at least one game piece of EACH color for EACH student in your class. (For example a class of 30 students - 30 Blue game pieces, 30 Green game pieces, 30 Brown game pieces)
- Colored arm bands (any kind fabric strip will do), one for each student
- Chart paper and marker for making chart below

	Native Species Survivors	Invasive Species Invaders
Round I		
Round II		
Round II		

Procedure - Round I

In this round, everyone is a native species and everyone gets enough resources and survives.

1. All students are a native species.
2. Everyone lines up along the edges of the playing area. At the signal, all students enter the playing area, searches for and collects ONE of the three different colored game pieces and returns to the sideline.
3. After all of the students have returned to the sideline, repeat this process again for the second colored game piece.
4. Students return a third time for the third colored game piece.
5. All players should survive the first round.
6. Record the number of native species survivors and invasive species invaders on the chart paper.

Procedure - Round II

In this round two students are invasive species and outcompete some of the native species for resources, causing some of the native species to die.

1. Choose two students to be invasive species. Have them wear colored arm bands.
2. The invasive species are more aggressive and are allowed to collect up to THREE game pieces per trip into the playing area.
3. The native species must act the same as they did in Round I - only collecting ONE game piece during each trip into the playing area.
4. The native species will be considered a survivor if s/he collects three different colors as they had done in Round I.
5. The invasive species must also collect three different colors in order to survive.
6. Identify the survivors.
7. Compare the surviving native and invasive species.
8. Record the number of native species survivors and invasive species invaders on the chart paper.

Procedure - Round III

In this round there are even more invasive species, which will eliminate or almost eliminate the native species..

1. Native species that did not survive Round II become invasive species. Give each new invasive species an armband.
2. Play Round III the same as Round II.
3. At the end of Round III, most, if not all, of the native species should not have survived.
4. Compare and evaluate as in Round II.
5. Record the number of native species survivors and invasive species invaders on the chart paper.
6. Collect game materials and have students take a seat in the play area and prepare for discussion.

Discussion Questions

1. What was the experience of this activity like for you? How did it feel to be a native species? How did it feel to be an invasive species?
2. What happened in each round to the native species as the invasive species were introduced and increased in population?
3. How did the introduction and population growth of invasive species impact the resources represented by the game pieces?

4. Why were the invasive species allowed to collect more game pieces? (*specific species adaptations and lack of natural predators*)
5. With both native and invasive species in the game, what could humans do to help the native species thrive? Think about how we could alter the game pieces, the players or the playing area.

(Additional discussion questions if students read the background information from the Flora and Fauna Introduction or were given the slideshow lecture)

1. How does the information you read about Flora and Fauna relate to the Introduced Species Game you just played? Cite specific parts of the text.
2. How has the Newtown Creek ecosystem (and the flora and fauna that live within it) changed over time? What has led to these changes?
3. What are some of the native, introduced and invasive species found in the Newtown Creek ecosystem?
4. How do you think these changes have affected the resources available for flora and fauna?
5. How do you think these changes have affected the species found in and around the Creek?
6. How has the availability of resources affected the populations of organisms in the Creek ecosystem?

Lesson III - Relationship Observations

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Making observations about species and their relationships reinforces concepts of interconnectivity and interdependence. This type of systems thinking is key to laying the foundations for applied learning in the field. Students will begin to learn about flora and their relationships with a few animals specific to Newtown Creek.

Learning Objectives

- Students will make observations about specific local species
- Students will understand the interdependence of plants and animals
- Students will demonstrate the interdependence of plants, animals and natural resources through an embodied activity

Time

45 minutes

Vocabulary

See Flora & Fauna Introduction for a list of vocabulary words from which to choose

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Tips for Teachers

- Consider using and/or modifying portions of the Flora & Fauna Introduction as a text for your students.
- Relationships between different plant and animal species are more like complex webs that overlap and cross and weave around each other. The relationships described in this activity are limited and overly simplified. Whenever possible try to incorporate other elements to the activity that adds dimension to the complexity of real life.
- This activity can easily be split into two seperate activities, one focused on reviewing the plants/animals and talking about their relationships and the second being the actual game physically making the connections.

Materials

- Journals or Notebooks
- Printouts of Plant and Animal Relationships Images (monarch butterfly / milkweed / black cherry tree /cedar waxwing bird, ribbed mussels / spartina grasses / menhaden fish / osprey) and images of natural resources (sun, water, nutrients, shelter, space)
- Herbarium plant specimens if possible (ex: milkweed plant, black cherry, spartina grass)
- String, twine, or rope

Procedure

1. Teacher presents the **Plant and Animal Relationship Cards** and references the accompanying notes that describe the specific reciprocal relationships between the different local plants and animals.
    a. If possible, teacher will hand out specimens of the different plants and animals for students to explore and observe while the virtual information cards are being presented.
    b. Using their journals, students will make observations of the different plants/animals by sketching or tracing the species (ex: milkweed). Students can also draw an arrow between the plant and the animal it is dependent on to signify the relationship. (ex: monarch butterfly/milkweed)
2. Teacher will initiate a discussion around the importance of *interdependence* between plants and animals. ("How does the monarch butterfly depend on the milkweed?")
3. Students will create a **Newtown Creek Web of Life** using the different plants/animals presented in the virtual information cards, to demonstrate the existence of interdependence. *(Web of Life Activity adopted from Shelburne Farms and CELF)*
4. **Procedure for Newtown Creek Web of Life Game:** Gather in a circle. Each player takes a card. The person with the Black Cherry Tree card can start. Give them the ball of yarn, they pass it to someone holding a card with a species that interacts with the Black Cherry Tree. As they pass the yarn, they can state, I am a Tree and I provide habitat for birds. The birds then take a turn, and so on. Let students help each other if they get stuck. When everyone is connected via the yarn, discuss the connections. Ask the students what would happen if one organism stepped away/the yarn was cut.
5. Students will describe the relationship with the other plant / animal or natural resource. (ex: "the monarch caterpillar is dependent on milkweed as it's only food source and milkweed is reliant on pollinators like monarchs for reproduction

and is also dependent on the sun for survival").

6. Introduce stress into the relationships by removing some cards and having students pull on the string demonstrating the increased pressure on that species. For example, there is a loss of habitat and less space for milkweed to grow therefore less food for young monarchs, the student acting as the butterfly pulls the string harder putting pressure on the relationship with milkweed, the student acting as milkweed pulls harder on space, and so on.
7. Teacher facilitates discussion with students around what their experience was like in the Newtown Creek Web of Life and what opportunities there may be to help relieve some of the stress on these interdependent relationships.

Discussion Questions

All of these plants and animals are native to the pre-colonial salt marsh or temperate forest that covered the Creek area:

1. What was your experience playing the Newtown Creek Web of Life?
2. How do plants and animals depend on each other? Give a specific example citing something we learned today.
3. How do plants and animals depend on natural resources?
4. Do you think the plants and animals of Newtown Creek have changed over time? How have they changed? Why have they changed?
5. What are the plants and animals you depend on in your life? Why do you depend on them?

Extension Lesson

Using the Flora Observation Worksheet and replicating many of the same discussion questions in Lesson III, take the classroom outside to make observations of Flora found around the school yard or nearby park. Use the Field Site Metadata and the Flora Observations Worksheets as a helpful aid and in order to get the students used to working with the worksheets in the field.

Field Lesson - Newtown Creek Flora & Fauna

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

This is an opportunity to bring your students outdoors and have them carefully observe the relationships between animals and plants that live within Newtown Creek. The Flora and Fauna found in and around Newtown Creek can vary tremendously depending on proximity to human activities and other plants and animals. Being able to experience, observe, and describe features of flora and fauna, as well as their specialized relationships, can help students connect classroom learning to the real world.

Learning Objectives

- Students will observe, map, and record flora and fauna data
- Students will identify different types of animal and plant species along the Creek
- Students will observe specific features and characteristics of the Creek organisms
- Students will sketch and label flora and/or fauna
- Students will begin to establish a relationship with place
- Students will learn how to make meaningful observations.

Time

Can vary from 60 minutes to several hours

Vocabulary

See Flora & Fauna Introduction for a list of vocabulary words from which to choose

Tips for Teachers

- Choose one or more of the sites listed in the Newtown Creek Field Sites Information section of the Curriculum Introduction.
- Always visit the Field Site prior to bringing your students there.
- Consider using and/or modifying portions of the Flora & Fauna Introduction as a text for your students.
- This field experience is an excellent opportunity to practice observation and inference skills with your students. Observation and inference ideally should be taught in the classroom before coming into the field.
- There are two types of observation that are worth considering when looking at

living organisms: **direct and indirect observation**. Direct observations may include observing with the naked eye, hand magnifier or via another apparatus. It may be used for any type of species. Direct observations may be made with or without collection of the organism in question. Indirect observations may include evidence of the species, such as dried plants, seeds, cast exoskeletons, feces, spent shells, tracks, feathers, or egg and larval stages.

- Observation in the field works well in pairs. This allows students the opportunity to discuss what they are seeing and what they think it means before writing it down.
- This field lesson is an excellent opportunity for students to use their phones and other electronic devices for practicing observation through taking photographs. If the use of phones is discouraged in your school, make sure you have set clear expectations and parameters with your students before asking them to pull out their phones.

Discussion Points

For each discussion point, decide which activity may work best for you and your students. They may not all work for each activity and are suggested guiding points. If needed, a field site expert can be a part of the field experience to help facilitate discussion.

1. Built vs. “Natural” environment
2. Examples of habitat for various species
3. Comparison of native, non-native, introduced and invasive species
4. Value of plants in an urban ecosystem beyond whether they’re “native” or “non-native”
5. “Stresses” on plants and animals in an urban ecosystem
6. Favorable vs. non-favorable locations for plants
7. Benefits of plants for animals and for humans
8. Permeable vs. impermeable surfaces (created by plants)
9. Different “jobs” or “niches” of plants (bioswale vs. shoreline)
10. Observed examples of food chains or food webs
11. Stewardship of flora and fauna

Journal Prompts

We recommend having students write in their journals at the *end* of the field experience; consider some or all of the following questions. Also refer to the “Journal Writing” section of the Introduction & Methodology for more suggestions about journaling.

1. Choose one plant you observed. Describe it in detail. Where did you see it? At

more than one location? How would you categorize it: native, introduced, invasive, other? Explain.

2. What features or adaptations did this plant have that makes it suitable to live along the Creek?
3. Choose one animal you observed. Describe it in detail. Where did you see it? At more than one location? How would you categorize it: native, introduced, invasive, other? Explain.
4. Choose a location along your walking tour that could be improved for plants and animals. What could you design/propose/build at that location that would help attract beneficial plants and/or animals?

Main Activity - Survey & Map the Flora & Fauna

Materials

- Clipboards
- Journals
- Flora and Fauna Field Research Survey
- Metadata Survey
- Site Map (for your chosen Field Site)
- Flora and Fauna ID Cards
- Field Guide to the Natural World of New York City, Leslie Day (optional)
- Organism collection and observation tools (optional) e.g. binoculars, ruler, magnifying glass, magnifying box, tweezers, organism collection containers, etc.

Procedure

1. In the classroom before going on the walk, teachers will review guidelines for the field visit and make sure all students have completed their permission slip forms.
2. If needed, an expert naturalist or educator from Newtown Creek Alliance is available to support the Field Lesson on site.
3. When arriving on site, gather as a group for initial discussion and orient the class to where they're located.
4. Teacher facilitates collection of metadata on site with class. Students can record data in their student journal or using Field Site Metadata worksheet.
5. If desired, separate students into small groups.
6. It may be useful to utilize the Flora and Fauna Field Research Survey and Site Map, if so hand them out to the students. Students can also record observations, drawing, notes, etc in their journals.
7. Assign each group an area to survey. (Note: if you have more than one group working in an area, have them start on opposite sides.)
8. Teachers or other educators may pause at or highlight certain locations and

provide content for student observations. All observations should be recorded in journals.
   a. Students are welcome to use all their senses (except taste) touch, feel and smell plants along the walk and listen to the birds, water, or industry.
   b. Students are allowed to gather plant leaves or natural items they find along the walk to add to their journal.
   c. Students are not to run, go in to the water, touch the water, or pull flowers, leaves off the plants if not fallen on the ground.
9. Students can identify, label and draw a map of all the different plants in their area using the Site Map or in their journals.
10. If using them, students should fill out the entire Flora and Fauna Field Research Survey.
11. Students note the conditions in which the plants are growing (e.g. growing up through cracks in the pavement, growing in a rain garden, growing right along the edge of the water, etc.) and any other observations.
12. Teacher and expert Naturalist can facilitate a group discussion with students about their observations and any relationships they saw while on site.
13. Bring Site Map, Metadata survey, Flora and Fauna Field Surveys and all other data captured in their journals back to the classroom for the Applied Learning Lesson.

Extension Activity - Observe a Plant

Materials

- Clipboards
- Flora Notes (previously collected by students
- Flora Observation Worksheet
- Newtown Creek Field Guides
- Field Guide to the Natural World of New York City, Leslie Day (optional)
- Any other applicable field guides
- Organism collection and observation tools; like magnifying glass, magnifying box, bags, ruler (optional)
- Disposable (nitrile) gloves or hand sanitizer (optional)

Procedure

This activity helps students practice observations before drawing conclusions. It helps students to slow down their thinking so that they can base their opinions on facts. It builds on the observations and analysis of a large group, thus helping students to see the benefits of hearing other’s perspectives on a topic. It can also be an excellent jumping off point for generating questions.

1. Hand out the **Flora Observation Worksheet** to each student.
2. Stand in a central area on the site with the whole class and model how to mkaed observations and inferences about the plants you see. Which plants are most prevalent in the area? Which plants (if any) seem to be competing with each other? Help students be attentive to the diversity of plants in the Creek.
3. *Note*: While looking carefully at plants and their habitat, students may also discover some fauna. They should include any observation about insects, birds, or other animals on their worksheets!
4. Students observe 2 to 4 plants in detail on their own or in pairs
    - Describe the plant in words. (Use at least three words)
    - Does it have leaves? What color are they? Are they rough or smooth? Are they clustered together or separate?
    - Does it have a stem or trunk? Is it woody or smooth? Fat or thin?
    - Does it have flowers? What color(s) are they?
    - Does it have fruit or seeds? Is it fleshy or dry? Who might eat these fruit or seeds?
    - Does it have signs of urban stress? Damage to the plant? Leaf discoloration?
    - Where is the plant growing? What kind of conditions is it growing in? What does this say about what the plant can tolerate?
    - Sketch the plant. If you are having trouble with your drawing try tracing a leaf (try not to pick the leaf off the plant!)
    - Label every part of the plant. Include the approximate size, texture and colors.

Extension Activity - Observe a Fish

Materials

- Clipboards
- Observation/Inference Chart
- Disposable (nitrile) gloves or hand sanitizer
- Small plastic fish tanks
- Marine Wildlife of Newtown Creek field guide poster

Optional

- Organism collection and observation tools
- Dip nets
- Magnifying glass
- Magnifying box
- Ruler

Procedure - Set Up

1. This activity ***must*** be done along with an expert from Newtown Creek Alliance (NCA) at either the Living Dock or North Brooklyn Boat Club Field Site locations. Access without assistance can be dangerous or impossible.

2. Most of the optional materials listed in the materials list will be provided for the class.
3. Confirm the trip and NCA will set up the observational experiment. For additional information refer to Field Site location guides.
4. Before the trip to the Field Site, review the Marine Wildlife of Newtown Creek field guide poster to familiarize yourself and students with the different species that can be found in the waterway. Many of the smaller fish, shrimp, and crabs are commonly seen at these locations. If time allows, talk about the different parts of the fish.

Procedure - Observe the Fish!

1. Within the Living Dock are several crates that hold various substrate; ropes, oyster and mussel shells, rocks, etc. A variety of species like to use these substrate filled crates as habitat. When a crate is pulled from the water and held over a container, fish, shrimp, crabs, and other animals of all sorts fall into the container for viewing. An experienced professional from NCA will perform this task for the class. The container will be brought to a table set up for student viewing.
2. Carefully take a few fish, leaving the shrimp or crabs, out the container with a net and put them in a small clear plastic fish tank (plastic fish tanks work better than tupperware because the sides are clear and make for easier viewing)
3. The more fish and fish tanks you have, the better. This way students can break into small groups in order to observe the organism up close.
4. Students carefully observe the fish and respond to the following prompts on their Observation Charts or in their Journals:
    - Sketch the fish. Label all the parts of the fish. Include colors, patterns and approximate size (you can use a ruler)
    - How does it move? Is it a fast swimmer? Does it sit on the bottom or hang out at the top?
    - What do its fins look like? How many fins does it have? Where are they located? What shape are they?
    - Describe what the fish's mouth looks like. Is it pointed up? Is it very small or very wide? What do you think the fish eats with this mouth?
    - Describe the fish's camouflage and coloring. What color is the fish when you look DOWN at it from above? What color is the fish when you look UP at it from below? Why do you think the fish is colored in this way? (Note: this is called "countershading" and it is a type of dual camouflage protecting the fish from predators above and below.)
5. Students can use the Marine Wildlife of Newtown Creek field guide poster to identify your fish. (Fish caught in the creek are most likely silverside, killie or mummichog.)

6. There will be other marine-vertebrates and invertebrates in the container (shrimp, crab, sea squirts, etc). Inspect them with the magnifying glass or magnifying box and students should include observations about them on the Observation Chart or in their Journals.

Applied Learning - Designing Plant Restoration

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Applied Learning is an opportunity for students to practically use their knowledge acquired during the Flora & Fauna Unit in a design project related to improving the native plant communities around Newtown Creek. Using data they collected during their Field Lesson, students will propose and design a plant restoration plan for the Field Site. Students will exercise their ability to make a difference by proposing solutions to an authentic site in their community.

Learning Objectives

- Students will organize the data they collected in the field
- Students will synthesize the data they collected in the field
- Students will develop a plant restoration proposal to increase biodiversity, habitat or aesthetics (or other related goals determined by student input)
- Students will defend their plant restoration proposals
- Students will demonstrate their ability to make a difference in their community

Time

45-60 minutes for each lesson

Vocabulary

See Flora & Fauna Introduction for a list of vocabulary words from which to choose

Tips for Teachers

- Remind students that they do not need to be proficient artists when doing sketches. Simple line drawings will suffice.
- Consider using and/or modifying portions of the Flora & Fauna Introduction as a text for your students.
- Check out National Wildlife Federation's Gardening for Wildlife website. There are useful tools for you and your students to learn how to enhance a site to support native flora and fauna. Consider having students use laptops to research ideas. https://www.nwf.org/Home/Garden-for-Wildlife/Create

Materials

Materials from Field Lesson

- Site Map - clean copy
- Flora & Fauna Field Survey
- Observation Chart
- Journal entries
- Other student work (e.g. photographs)
- Google image of Newtown Creek Neighborhood
- Flora & Fauna Site Improvement Proposal Worksheet
- Flora and Fauna ID Cards

Procedure

1. Separate students into the small groups. Consider whether you want the students in the group to have worked on the same area in the Field or different ones.
2. Project the **Google Image of Newtown Creek Neighborhood.**
3. Review the Field Site(s) visited during the Field Lesson as a class.
4. Find, as a class, on the Google image of Newtown Creek Neighborhood the location of the Field Site(s) visited. Consider pointing out the schools location or other recognizable landmarks in relation to the Field Site (or proposed design site).
5. Each student in the group shares some observations or thoughts about the Field Site based on their completed worksheets and/or journal entries.
6. If you visited more than one Field Site during the Field Lesson, choose one Field Site on which to focus.
7. Use the Site Maps from the Field Lesson to calculate the percentage of the site covered by plants. (Younger students can use general descriptive language -- lots of plants, no plants, etc. --, calculations are not necessary)
8. Review the Discussion Questions below, referring to the information from your Field Lesson (i.e. Site Map, Flora & Fauna Field Research Survey, Flora Observation Chart, journal entries).
9. Each student gets a **Flora & Fauna Site Improvement Proposal** Worksheet. (If this worksheet is difficult to use, it is designed to be a guide; consider reading the prompts out loud or writing them out for the whole classroom to hear or see.
10. Both the Discussion Questions and the **Site Improvement Worksheet** have been developed to guide the students in their designs.
11. Use the information from the Field Lesson to complete the Site Improvement Worksheet. Consider using additional images of thriving native plantings that support animals as inspiration.
12. Each student gets a clean copy of the Site Map.
13. Each student uses the Site Improvement worksheet ideas to sketch a design for

flora and fauna restoration on the clean Site Map.
14. Each student presents and explains his/her design to their group.
15. The group members critique each others' designs and write down the best elements from each sketch.
16. The group gets a clean copy of the Site Map.
17. The group works together to create ONE final design incorporating the best elements from each individual's design.
18. The group works together to write an explanation of the final design supporting each element of their chosen design.
19. Final designs are developed into a poster for display.
20. Each group shares their final design and explains the project to the class.
21. The class chooses the best elements of each group design and creates a final project that can be developed into a poster and presented to other classes, members of the community, Newtown Creek Alliance, employees of the Parks Department, or the Community Board.

Discussion Questions

1. Describe your field site, its location and what surrounds it.
2. Describe the current use(s) of the site.
3. How do you think the use(s) of the site should change, if at all? Explain.
4. How much of the site is covered in plants?
5. How are the plants doing? How do they look? Are they thriving?
6. Would you keep any of the existing plants as part of your restoration plan? Why or why not?
7. What other organisms do you think will be attracted to your site with your restoration design?
8. Why is it valuable to attract these other organisms?
9. Once you restore the site, what will need to be done to maintain it and keep it in good condition?
10. Why is your design worth building?

Common Core Standards

Lesson I
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grade 6-8
CCSS.ELA-LITERACY.RH.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
CCSS.ELA-LITERACY.RST.6-8.2
Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects
Texts Types and Purposes Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.
CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
CCSS.ELA-LITERACY.WHST.6-8.1.D Establish and maintain a formal style.
CCSS.ELA-LITERACY.WHST.6-8.1.E Provide a concluding statement or section that follows from and supports the argument presented.
Production and Distribution of Writing Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

English Language Arts Standards Reading: Informational Texts
Craft and Structure Grade 6
CCSS.ELA-LITERACY.RI.6.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.
Grade 7
CCSS.ELA-LITERACY.RI.7.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of a specific word choice on meaning and tone.
Grade 8
CCSS.ELA-LITERACY.RI.8.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.

English Language Arts Standards Speaking & Listening
Comprehension and Collaboration Grades 6-8

CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.6-8.1.A Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
CCSS.ELA-LITERACY.SL.6-8.1.B Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

Next Generation Science Standards MS.Interdependent Relationships in Ecosystems
MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Lesson II
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
Integration of Knowledge and Ideas Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
English Language Arts Standards Reading: Informational Texts
Integration of Knowledge and Ideas Grade 6
CCSS.ELA-LITERACY.RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
Next Generation Science Standards MS.Matter and Energy in Organisms and Ecosystems
MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Lesson III
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context

relevant to grades 6-8 texts and topics.
Integration of Knowledge and Ideas Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects
Texts Types and Purposes Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
English Language Arts Standards Reading: Informational Texts
Key Ideas and Details Grades 6
CCSS.ELA-LITERACY.RI.6.1 (WQ pre lesson I) Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
Grade 7
CCSS.ELA-LITERACY.RI.7.1 Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
Grade 8
CCSS.ELA-LITERACY.RI.8.1 Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.
Integration of Knowledge and Ideas Grade 6
CCSS.ELA-LITERACY.RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.
Next Generation Science Standards MS.Interdependent Relationships in Ecosystems
MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Field Lesson
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects

Texts Types and Purposes Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.
CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
Production and Distribution of Writing Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
English Language Arts Standards Speaking & Listening
Comprehension and Collaboration Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher- led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly. Next Generation Science Standards MS.Human Impacts
MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Applied Learning
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grade 6-8
CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
Integration of Knowledge and Ideas Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects
Texts Types and Purposes Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.
CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
Production and Distribution of Writing Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English Language Arts Standards Speaking & Listening
Comprehension and Collaboration Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.6-8.1.B Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
CCSS.ELA-LITERACY.CCRA.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
Grade 6
CCSS.ELA-LITERACY.SL.6.1.C Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.
Grade 7
CCSS.ELA-LITERACY.SL.7.1.C Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.
Grade 8
CCSS.ELA-LITERACY.SL.8.1.C Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.
Mathematics Standards Standards for Mathematical Practice Grades 6-8
CSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively

Next Generation Science Standards
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Additional Resources

Texts:

- ***"**Scientists say the tiny heroes of the Earth's ecosystem are all around us,**"*** **Washington Post**

https://newsela.com/read/frodo-nature/id/32680/

- ***Life Cycles: what is an ecosystem?*** **Encyclopedia Britannica**

https://newsela.com/read/elem-sci-ecosystems/id/29113/

- **"Australia builds a huge cat proof fence to save native animals," AFP**

https://newsela.com/read/elem-australia-cat-free-zone/id/31915/

Elementary ELA or Social Studies Texts

- ***Night of the Spadefoot Toad*** **by Bill Harley**

https://www.amazon.com/Night-Spadefoot-Toads-Bill-Harley/dp/1561456381

- ***People of Twelve Thousand Winters*** **by Trinka Hakes Noble**

https://www.amazon.com/People-Twelve-Thousand-Winters-Tales/dp/1585365297

- ***Earth Mother*** **by Ellen Jackson**

https://www.amazon.com/Earth-Mother-Ellen-Jackson/dp/0802789927

- ***Our Big Home*** **(poetry) by National Geographic Learning**

https://www.amazon.com/Our-Home-National-Geographic-Learning/dp/0761317767

- ***Hidden City: Poems of Urban Wildlife*** by Sarah Grace Tuttle

https://www.amazon.com/Hidden-City-Poems-Urban-Wildlife/dp/0802854591

Videos:

- **Biodiversity Bingo; PBS Learning Media**

https://ny.pbslearningmedia.org/resource/plum14.sci.life.biobingo/biodiversity-bingo/#.W3SdYehKg2w

- **A Forest in the City; PBS Learning Media**

https://ny.pbslearningmedia.org/resource/plum14.sci.life.findingforests/finding-forests/?#.W3ZEnOhKg2x

- **Why is biodiversity so important? – TED Ed**

http://thekidshouldseethis.com/post/why-is-biodiversity-so-important-ted-ed

- **What is Biodiversity? – Educational Tree of Life**

https://www.youtube.com/watch?v=iR2AyybowPc

Images and Powerpoints:

- **Flora and Fauna Introduction powerpoint**

https://docs.google.com/presentation/d/191HsSO6LS7XCmGdftk1kFoiWwCy5dLSTT3PoRW1cguE/edit#slide=id.p

- **Newtown Creek Plant and Animal Relationship Cards**

https://docs.google.com/presentation/d/153Ys8PkwbUZt7uto7G87WySOiLn7lMnDZ2Q_6HeCN3c/edit#slide=id.p

- **Newtown Creek Fauna ID Cards**

https://docs.google.com/presentation/d/1zk7plqZ67_TEuEzXyY2MMALJsZdLyJXdo0MSZ0mGwJA/edit#slide=id.g3d5a946b76_0_0

- **Newtown Creek Fauna ID cards_“Personified Fauna "I eat…”**

https://docs.google.com/presentation/d/1j6aNhJhMKmsoq7J-4hz6owr9ZLHUuA_706jDuGyCWJk/edit#slide=id.g3d5a946b76_0_0

- **Newtown Creek Flora ID Cards**

https://docs.google.com/presentation/d/1eCgAalDLGTfGUFIvgyluwQ0EPsMvIF-i2l0MQJKKFNc/edit#slide=id.g3d5a946b76_0_0

- **Newtown Creek Flora ID cards_“Personified Flora - “I grow…”**

https://docs.google.com/presentation/d/1ryQLljOeq_ULoDbxczY0NpvusvEKBfxdRwEfkEukPsk/edit#slide=id.g3d5a946b76_0_0

Newtown Creek Alliance Website Resources

- **Flickr: Wildlife Photographs**

https://www.flickr.com/photos/76572518@N04/albums/72157659614598334/with/6871221421/

- **Wildlife Posters (Marine Wildlife and Birds)**

Handouts

Field Site Metadata

Fill in the following information about the Field Site you are visiting

Student Name:

Location:

Site Name_______________________________________

Time______________ Day_______________

Year______________ Month_____________

Weather Temperature:_________

Describe the weather:

Cloud Type:

Cloud Cover:

- ☐ No Clouds
- ☐ Some Clouds (Partly Cloudy)
- ☐ Lots of Clouds

Description of Site & Conditions:

Flora Observation

Choose one plant to observe. Fill in the following information about the plant. If you're not able to identify the species, you will have time to research it later in class.

Student Name: Name of Site:

Common Name:

Scientific Name:

Estimate the following:

Height: ___________ Width: ___________

Number of individual plants: ___________

Percent cover: ___________

Observation Notes:
Do you see any animals or insects interacting with this plant?

Does the plant seem damaged or disturbed?

Do you think the plant is healthy? Why or why not?

Draw the leaf:

Describe the color and texture of the leaf:

Draw the flower or fruit:

Describe the color and smell of the flower or fruit:

Flora & Fauna Field Research Survey

Fill in the the following information about the site you are surveying and answer the questions. Take photographs and sketch the species you observe. If you are not able to identify the species you will have to research it later in class.

Student Name: Date:

Plant name (Common and Scientific)	**Growing Conditions** Planted? Growing wild? In Soil? Through Cracks?	**Is this species native, introduced, or invasive?**	**Other notes** Does it look healthy? Sickly? Alone? Are there many of the same species?

What else did you see on site that may be impacting plant and animal health? Add other notes, descriptions, questions or sketches here or on the back of this sheet.

Flora & Fauna Site Improvement Proposal

Using your site observations and research, outline a plan to improve this site. Answer the following questions to explain why your choices will be an improvement over the current site conditions.

Student Name:

Name of Site:

1. What benefits for the ecosystem should plants provide at this site?

3. How would you improve growing conditions at this site?

2. What benefits for humans should plants provide at this site?

4. Based on the previous questions, what plants would you install on this site, and where? Why?

5. *On a clean Site Map sketch a design for installing new plants and improving the site based on the information above.*

Water Quality

In this Unit:

This Unit has been modified by permission by the Newtown Creek Alliance from the original with assistance from the National Wildlife Federation's Greenpoint Eco-Schools Program. The original module was developed by the Gowanus Canal Conservancy.

Unit Overview

Essential Questions:

- What are some indicators of a healthy aquatic ecosystem?
- How is water important to life?
- How can we effectively test the water quality of Newtown Creek?
- What can water quality testing tell us about the health of Newtown Creek?
- What are the ecosystem benefits of improving the water quality in Newtown Creek?
- What is the function of water quality within the greater sewershed?
- How has water quality of Newtown Creek changed over time?

Lessons & Objectives:

- Describe the seven different water quality tests and what they test for
- Perform two of the water quality tests with accuracy
- Make predictions about water quality results in Newtown Creek

- Describe two factors that influence the amount of dissolved oxygen in the water
- Compare and contrast results of the dissolved oxygen experiment
- Analyze the results of the experiment in writing
- Discuss how and why dissolved oxygen is important to life

- Make observations about the water quality testing location
- Accurately measure at least one water quality parameter
- Interpret the results of each test and explain what might be impacting the test result
- Draw preliminary conclusions about the health of Newtown Creek based on the water quality data
- Compare water quality data if testing at more than one time or location

- Review water quality data
- Compare and contrast to other WQ data sets (e.g. NYC Department of Environmental Protection (DEP), Riverkeeper, other schools' data)
- Discuss validity of results: What should be repeated or done differently next time
- Reiterate interventions for improving water quality
- Create a plan to build something that would help improve one or more of the water quality indicators (dissolved oxygen, pH, fecal coliform, nitrates).

Teacher's Introduction

What is Water Quality?

Water quality refers to the conditions of water. Water can include chemical, physical and biological characteristics, usually with respect to the needs of one or more biotic species, including humans, plants and animals.

Why Teach Water Quality Testing in Newtown Creek?

Water quality testing provides a window into the health and vitality of Newtown Creek. It can:

- Help to identify specific pollutants and sources of pollution
- Determine whether the waterbody is meeting standards for specific uses, such as recreation or fishing
- Monitor and analyze trends over time
- Monitor impacts of disturbances, such as flooding or a chemical spills

Water quality testing provides a strong basis for inquiry. For example, how does salinity, temperature and dissolved oxygen change as the tide rises and recedes, and what might this information tell us about the flushing action of the tides? Do runoff and combined sewer overflow events have an impact on Newtown Creek? If so, what is that impact and how can it be measured? Do different testing locations along the Creek reveal different results (e.g. near an outfall, near the Mouth of the Creek, in the far tributaries, or in the Turning Basin)?

When testing, students will see a "snapshot" of the water quality in Newtown Creek. It should be noted that the most interesting and meaningful water quality data sets emerge when the Creek is tested over time. Such long-term monitoring reveals the trend over days, months, seasons, and years. It could also uncover the presence of currently unknown sources of pollution.

Water quality testing involves using the steps of the **Scientific Method** and always includes following safety procedures.

- **Making observations**
- **Forming a hypothesis**
- **Testing that hypothesis using an experiment**
- **Taking measurements and the importance of accuracy**
- **Data collection and recording**
- **Comparison of data**
- **Analysis and interpretation of data to draw conclusions**
- **Communicating results**

Visible pollution on Newtown Creek (Source: Newtown Creek Alliance)

Newtown Creek Water Quality Background

Newtown Creek is one of the most polluted bodies of water in the U.S. and an important place in which to monitor water quality. It is a relatively stagnant body of water, especially in the back tributaries or headwaters, that has remained intensely polluted for more than 150 years from industrial waste, untreated sewage discharges and storm water runoff.

From the beginning of European settlement in the late seventeenth century until the latter part of the 20th Century, industries along the Creek had free reign over the disposal of unwanted byproducts. Industry decided what and how waste products were dealt with and much of it went directly into the creek itself. With little-to-no government regulation or knowledge of the impact on human health and the environment, it was often easier and cheaper to discard waste in and around the Creek The legacy of this abuse has left local scars and environmental burdens including the infamous Greenpoint Oil Spill, a 17 to 30 million gallon underground plume of oil caused by Standard Oil and its progeny companies. While much of the historic pollution is being cleaned up, these contaminants, along with the dumping of old tires, cars and everyday plastics still have a negative impact on the water quality in the Creek.

Oil sheens on surface waters are common sights in many areas of the Creek.
(Source: Newtown Creek Alliance)

Combined Sewer Overflows (CSO) are a major source of pollution in the Creek, past and present. CSOs are triggered during wet weather events; either snow or rain, when stormwater runs off the streets and other impermeable surfaces into the sewer system via catch basin. That stormwater combines with the sanitary sewage coming from our toilets, showers and sinks and then heads to a local wastewater treatment plant. Unfortunately, these plants can only clean so much wastewater and once they hit capacity during rain events, the combined sewage backs up and is discharged directly into local waterways through outfall pipes. In some instances, as little as 1/10th and inch of rain can overwhelm the system and cause CSO.

Every public waterway in NYC is impacted by CSOs. Included in CSOs are oils and chemicals that wash off the streets such as road salt, gasoline, trash and dog waste. Additional pollutants come from sanitary sewers, such as human feces, harsh household and industrial cleaning chemicals, personal care products, and pharmaceuticals. The contaminants in CSOs cause excessive nutrient levels in the waterways which trigger algae population explosions resulting in decreased oxygen levels. This combination poses risk to human health, is detrimental to habitat conditions and dangerous for the health of marine life. CSOs can create cloudy or turbid water, preventing sunlight from passing through to the marine plants below. This prevents sunlight dependant plants from performing photosynthesis, plants cannot survive for very long in turbid waters. Polluted sediment can build up on the bottom of the stream and river floors, which damages benthic habitats (ecological zone at the lowest level of a water body), especially in waters that don't experience much natural mixing or flow.

An active combined sewer outfall in a Newtown Creek tributary. (Source: Newtown Creek Alliance)

Improvements to Newtown Creek Water Quality

Below is a brief overview of the history of water quality standards to highlight the importance of having state and federal regulations. The 1972 Clean Water Act [1] created a set of water quality standards which must be implemented by the New York State Department of Environmental Conservation (DEC) and New York City Department of Protection (DEP), these both are overseen by the Environmental Protection Agency (EPA), all of these entities are government regulatory agencies. These are the primary

[1] Summary of the Clean Water Act https://www.epa.gov/laws-regulations/summary-clean-water-act

agencies that are responsible for improving water quality in Newtown Creek and in the surrounding harbor.

In order to comply with the federal Clean Water Act DEP has developed a Long Term Control Plan[2] (LTCP) to improve water quality in the Creek. The Newtown Creek LTCP is a set of proposed infrastructure upgrades which would reduce the approximate 1.2 billion gallons of CSO entering the Creek each year.

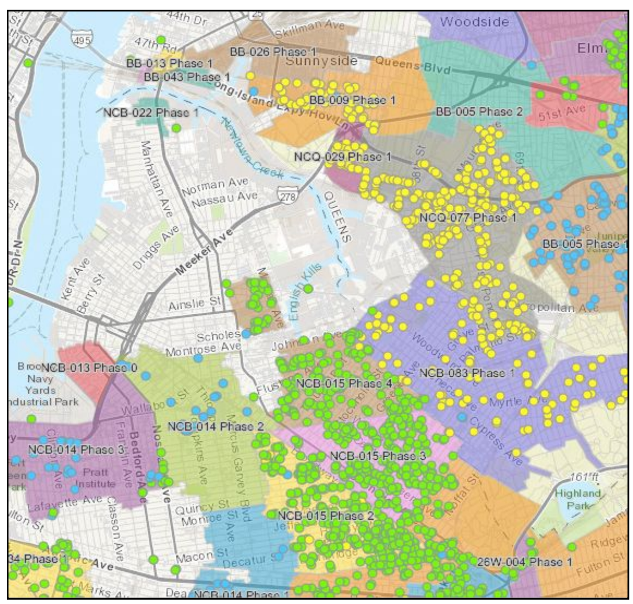
The plan will reduce pathogen levels, as well as odors and marine debris, while also improving dissolved oxygen levels. The main component of the proposed LTCP is a massive *39 million gallon underground tunnel* that will collect over 60% of annual CSO discharges from the 3 largest outfalls on Newtown Creek. The tunnel is scheduled for completion by 2042 which means the significant impacts of ongoing CSOs, including the severe ecological stresses and threats to human health. CSO's will continue to impact the surrounding communities for at least the next 25 years.

Map of the proposed LTCP retention tunnel. Source: DEP

[2] Newtown Creek CSO LTCP
http://www.nyc.gov/html/dep/pdf/cso_long_term_control_plan/ltcp-newtown-creek-cso.pdf

A typical Right of Way (ROW) Rain Garden captures stormwater as it flows down city streets. They are often planted with native plants that are chosen for tolerance for extreme conditions like flooding and drought, salt, metals and other traits that make them more likely to withstand the harsh conditions on the street. Even with these careful selections, rain gardens need care in order to thrive. (Source: Waterfront Alliance)

This map shows the expansion of DEP's *Right of Way Rain Garden*[3] program. This Green Infrastructure expansion is critical to capturing stormwater before it makes its way into the sewer system. Green dots are completed Rain Gardens, blue dots are under construction (as of 2018) and yellow dots are those that are in design. (Source: DEP)



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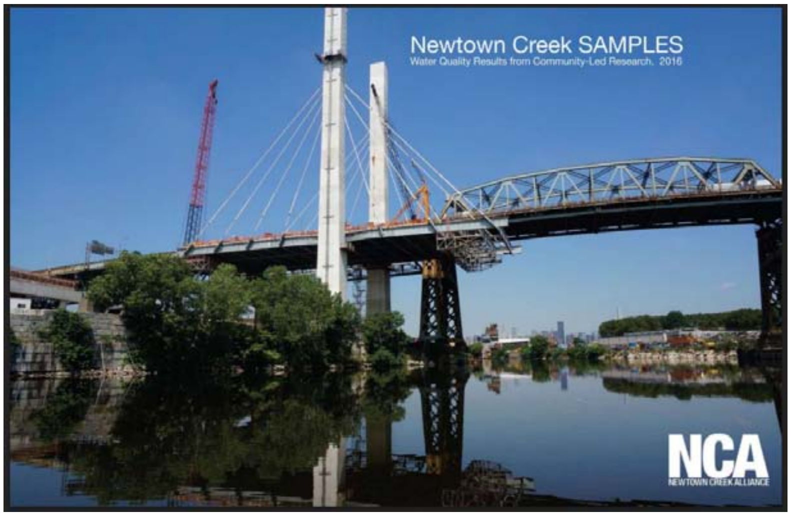
[3] US EPA Newtown Creek Superfund
https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.topics&id=0206282

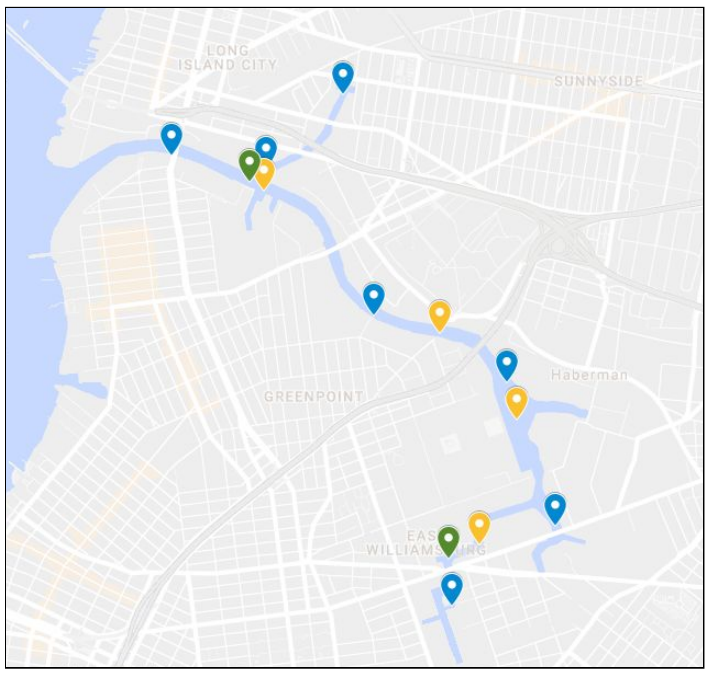
Water Quality Testing in Newtown Creek

Improving water quality is key to the revitalization of Newtown Creek. Through our water quality monitoring programs we track bacteria and oxygen levels at various Creek locations, while also analyzing factors like rainfall and temperature to understand where water quality varies and why.



In 2016 the Newtown Creek Alliance published *Newtown Creek SAMPLES* an intensive six month water quality monitoring program in collaboration with the Environmental Science department at LaGuardia Community College. The project tested for enterococcus (a sewage related bacteria), dissolved oxygen, salinity as well as nitrogen and phosphate levels at eight different locations.

The project booklet summarizes a number of key findings from the sampling program, as well as information about what impairs water quality and how community members can help improve conditions. The 2017 Report was released in early 2018, testing continues through the 2018 season and funding has been secured for ongoing monitoring in the 2019 season. A number of organizations and agencies conduct water quality testing in the Creek, including NYCDEP, contractors working for the EPA, and water advocacy organizations Riverkeeper and Newtown Creek Alliance.



Newtown Creek Water Quality Sampling Sites: NYCDEP (Yellow), NCA (Blue) and Riverkeeper (Green).

The New York State Department of Environmental Conservation uses two metrics - dissolved oxygen (DO) and fecal coliform bacteria - as indicators of ecosystem health and degradation. State standards reflect a range of acceptable water quality conditions corresponding to state designated "best usage" of the water body. In addition, the Environmental Protection Agency (EPA) recommends a standard for enterococci in marine recreational waters (see table below). All the efforts to improve water quality in Newtown Creek and around the City reflect the need to meet these federal and state standards. They have been developed to protect life and human health. Without these regulatory standards who knows how bad our water would be!

EPA Water Quality Standards			
Best Usage	**Dissolved Oxygen** *(Never less than…)*	**Fecal Coliform**[(a)] *(Less than…)*	**Enterococci Bacteria**[(a)] *(Less than…)*
Bathing/Recreation	5.0 mg/L	200 cells/100 mL	35 cell/100 mL
Fishing/Boating	4.0 mg/L	2,000 cell/100 mL	No Standard
Fish Survival	3.0 mg/L	No Standard	No Standard
Note: (a) geometric Mean			

Source: http://www.nyc.gov/html/dep/pdf/hwqs2012.pdf

Determining the water quality of Newtown Creek requires completing a battery of tests. There are over a dozen different tests that are regularly used by organizations and agencies that monitor water quality.

This unit will focus on the four of the seven of the most fundamental water quality tests:

1. **Temperature**
2. **Salinity**
3. **Dissolved Oxygen**
4. **pH**
5. Turbidity
6. Nitrates
7. Fecal Coliform

Temperature Background

No doubt you already have a good idea of what temperature is. You probably define it as how hot or cold something feels. In physics, temperature is defined as the average kinetic energy of the particles in an object. When particles move more quickly, temperature is higher and an object feels warmer. When particles move more slowly, temperature is lower and an object feels cooler.

Temperature is measured with a thermometer. A thermometer shows how hot or cold something is relative to two temperatures; the freezing and boiling points of water. Scientists often use the Celsius scale for temperature. On this scale, the freezing point of water is 0°C and the boiling point is 100°C.

Look at the thermometer below. Particles of the red liquid have greater energy when they are warmer, so they move more and spread apart. This causes the liquid to expand and rise higher in the glass tube. Like the liquid in a thermometer, most types of matter expand to some degree when they get warmer.

Something that has a high temperature is said to be hot. Does temperature measure heat? Not really. Heat is the transfer of thermal energy between objects that have different temperatures. Thermal energy always moves from an object with a higher temperature to an object with a lower temperature. When thermal energy is transferred in this way, the warm object becomes cooler and the cool object becomes warmer. Sooner or later, both objects will have the same temperature. Only then is the transfer of thermal energy complete. Picture a spoon and a cup of hot chocolate. The spoon is cool to the touch. When you put the spoon in the hot chocolate the thermal energy begins to transfer from the hot chocolate to the spoon. The spoon quickly gets warmer and the hot chocolate gets a bit cooler until they are the same temperature.

Specific heat is the amount of energy needed to raise the temperature of 1 gram of a substance by 1°C. Metals such as iron have relatively low specific heat. It doesn’t take much energy to raise their temperature. That’s why a metal spoon heats up quickly when placed in hot chocolate. Sand also has a relatively low specific heat, whereas water has a very high specific heat. It takes a lot more energy to increase the temperature of water than sand. This explains why the sand on a beach gets hot while the water stays cool. It takes all winter for the estuary to cool down and all summer for the estuary to warm up because water has a high specific heat.

Text Source: https://www.ck12.org/c/physical-science/

Salinity Background

Most of the salt in the oceans has come from rain falling on the land and dissolving the salts in eroding rocks. These salts are carried down the rivers and out to sea. The salts accumulate in the ocean as water evaporates to form clouds. This process has been going on for millions of years and progresses very slowly. The oceans are getting saltier every day, but the rate of increase is so slow that it is virtually immeasurable. Ocean water is currently about 3.5 percent salt (or 35 parts per thousand).

There are many different instruments and methods for measuring salinity. You will use a less expensive, but fairly accurate hydrometer in this unit. This hydrometer is influenced by density.

The density of something has to do with its mass (usually expressed in grams) relative to the amount of space it takes up (volume). At a temperature of 3 degrees Celsius, a glass of fresh water has a density of 1 gram per cubic centimeter (1g/cm3). For example, a quart of one particular type of oil has a larger mass than a quart of water. Therefore, the oil is denser than the water. Similarly, as water becomes saltier, its mass increases relative to its volume, making it more dense.

Salinity is measured in parts per thousand (ppt). What does that mean? If you have a total of 1000 gumballs, and 999 of them are white, and one of them is black, the black gumball could be expressed as 1 part per 1000. Let's say you use the hydrometer and it gives you a measurement of 20 ppt. That means for every 1000 molecules, 20 of them are salt molecules and 980 of them are water molecules.

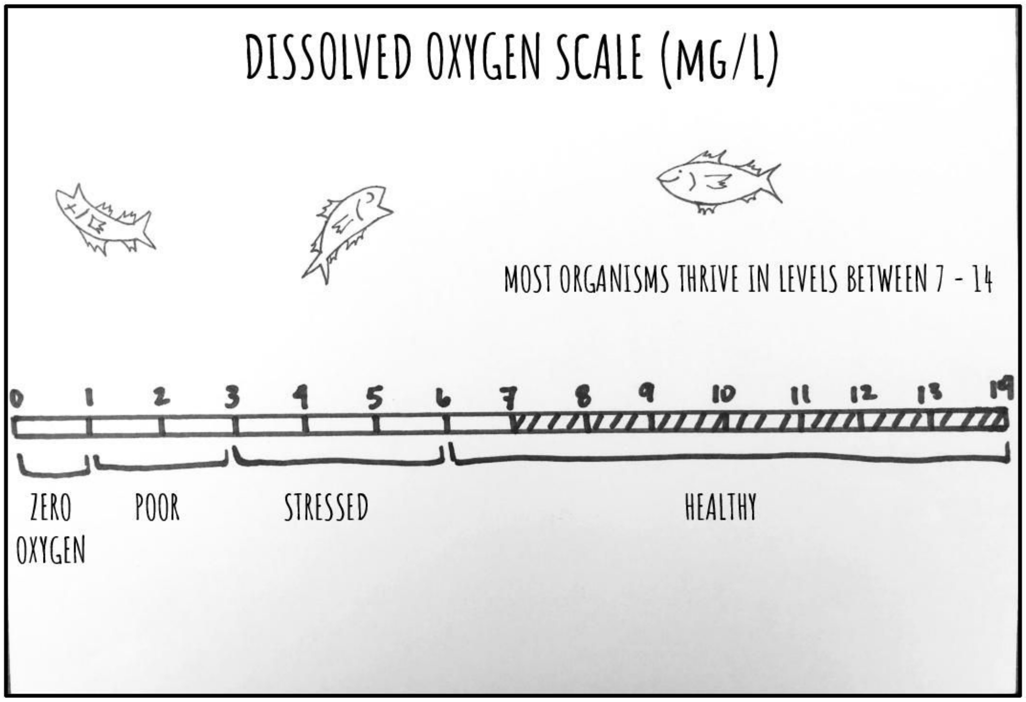
When the hydrometer is placed in the water, it will float to a certain level, depending on how dense the water is. The extra minerals, or salts, in saltwater make the water more dense, which means it can support more weight than water lacking those salts. This makes the hydrometer arm float higher as the water gets saltier.

Text Source:
http://mddnr.chesapeakebay.net/eyesonthebay/lesson_plans/salinity_lesson_plan.pdf

Dissolved Oxygen in a Tidal Estuary Background

To survive, fish, crabs, oysters and other aquatic animals must have sufficient levels of dissolved oxygen (DO) in the water. The amount of dissolved oxygen in an estuary's water is a major factor that contributes to the type and abundance of organisms that can live there. Aquatic organisms such as zooplankton, invertebrates and fish require sufficient levels of dissolved oxygen (DO) to survive. Each species has a DO threshold within which it can survive.

Dissolved oxygen (DO) refers to the concentration of molecular oxygen (O2) dissolved in water. Aquatic animals need oxygen to breathe and live, but they cannot use the oxygen in a water molecule (H_2O) because it is bonded too strongly to the hydrogen atoms (2H).DO is measured in milligrams per liter of water.



DO percent saturation depends on temperature (and also elevation, the deeper you go the less oxygen will be present). Percent Saturation is the amount of oxygen dissolved in the water sample compared to the maximum amount that could be present at the same temperature.

Oxygen is supplied to estuarine waters through three natural processes: (a) diffusion of atmospheric oxygen into the water, (b) aeration of water, and (c) photosynthesis by phytoplankton, aquatic seaweeds and seagrasses. **Diffusion** from the surrounding air into the water occurs as oxygen moves from an area of higher concentration to an area of lower. If the air in the atmosphere has a higher concentration of oxygen than the water - the oxygen is “pushed” into the water. The speed of this movement of oxygen is related to the difference in the concentration of oxygen in air to water and the barometric pressure. **Aeration** of water can occur during the mixing of surface waters by wind and waves. **Photosynthesis** is a chemical reaction that occurs in plants as they “breathe” in carbon dioxide and release oxygen into their environment. Macroscopic plants, such as marsh and bay grasses, and microscopic plants, such as phytoplankton, also oxygenate the water as a product of photosynthesis. Large daily fluctuations in DO are characteristic of areas that have extensive plant growth. As a result of photosynthesis, DO levels rise throughout the day, reaching a peak in mid-afternoon. Since photosynthesis stops at night, but organisms continue to respire, DO levels are lowest just before dawn.

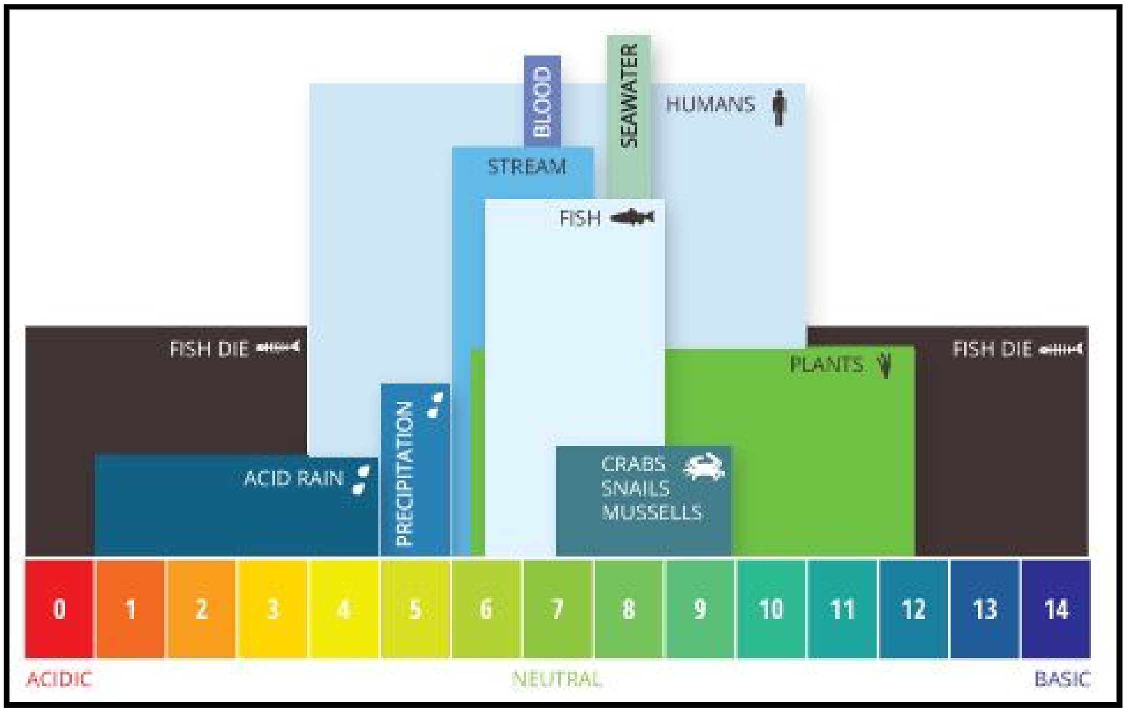
Oxygen is removed from estuarine water in two natural processes: (a) aerobic respiration and (b) bacterial decomposition. **Respiration** is a process in which animals and plants take up oxygen and produce carbon dioxide. During the process energy from sugars is also released. Respiration occurs all the time, while photosynthetic production of oxygen by plants occurs only during daylight hours. As a result, dissolved oxygen levels in an estuary may vary widely because of differences in the amount of oxygen produced by plants. **Decomposition** by bacteria, fungi, and other organisms affect DO levels in an estuary because they consume oxygen while breaking down organic matter. These decomposers consume oxygen in the process of gaining energy through the breaking of chemical bonds in organic matter.

Oxygen depletion may occur in an estuary when many plants die and decompose, or when runoff or poorly treated wastewater containing large amounts of organic matter enters the estuary. In some estuaries, large nutrient inputs, normally from sewage or fertilizer, stimulate phytoplankton blooms. When these organisms die, their bodies fall to the bottom of the estuary and begin to decompose. The decomposition process depletes the surrounding water of oxygen and, in severe cases, may lead to anoxic (very low or no oxygen) conditions that kill bottom-dwelling organisms. Shallow, well-mixed estuaries are less susceptible to this phenomenon because wave action and circulation patterns can easily supply the waters with oxygen.
Text Sources:
http://mddnr.chesapeakebay.net/eyesonthebay/lesson_plans/do_lesson_plan.pdf
https://coast.noaa.gov/data/estuaries/pdf/dissolved-oxygen-in-an-estuary-combined-teacher-student.pdf

pH Background

pH stands for the "potential of hydrogen" and it is a measure of acidity. pH ranges from 0 (extreme acid) to 14 (extreme base) with 7 being neutral. When you measure pH there are no units needed because pH is simply on a scale of 0-14.

Lemon juice has a pH of 3, which makes it an acid. Lemon juice stings if it gets in a cut, and stronger acids even have the ability to eat through solid objects. On the other end of the scale, bleach has a pH of 11, which makes it a base. Strong bases, just like acids, can burn your skin. How do strong acids and bases compare to the middle of the pH scale? Pure water has a pH of 7 and therefore is considered neutral. Our bodies are made mostly of water. Things that are close to pH 7 work well with our bodies. If we were to drink something that is extremely acidic or extremely basic, it could make us sick or kill us.



The same holds true for organisms that live in the water (i.e. aquatic organisms). If the water becomes too acidic or basic, it can kill them. Most organisms that live in an estuary need the pH to be between 6.5 and 8.5. pH levels in an estuary generally range from 7.0 to 7.5 in the areas with more fresh water influence, to a range of 8.0 to 8.6 in the areas with more salt water. The slightly basic pH (greater than 7 on the scale) of salt water is due to bicarbonate that comes from the weathering and erosion of rocks on land as water runs downhill toward the estuary or ocean.

The pH of water is critical to the survival of most aquatic organisms. Many species have trouble surviving pH levels below 5.0 or above 9.0. Changes in pH can also change other aspects of the water's chemistry, which may harm aquatic organisms. For example, if the pH levels are lowered, toxic metals in the estuary's sediment can be resuspended in the water column. This can harm many aquatic species. pH is an important indicator of water that is changing chemically in the water.

The pH of the estuary can be affected by the minerals dissolved in the water, aerosols and dust from the air, human-made wastes and by photosynthesis and respiration of organisms. Human activities that cause significant, short-term fluctuations in pH or long-term acidification of a waterbody are extremely harmful. For example, acid rain on the river of an estuary can diminish the survival rate of eggs deposited there by spawning fish. Another example is that algae blooms cause pH to change dramatically within just a few hours, which stresses the organisms.

Other factors that influence the pH of the water, include:

- bacterial activity;
- water turbulence;
- chemicals in runoff flowing into the waterbody;
- sewage overflows; and
- impacts from other human activities both in and outside the drainage basin (e.g., acid drainage from coal mines, accidental spills, and acid precipitation).

Image Source:
http://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/

Overview of Water Quality Tests and Equipment

Below is some general information about the water quality test results you can expect to find for Newtown Creek. More detail is provided for each test and the rationale behind performing the test within the Lesson and Activities Materials.

If you are studying:	Perform the following tests:
Food Webs	dissolved oxygen, nitrates, pH
Sewersheds or Combined Sewer Overflows	dissolved oxygen, fecal coliform,
Tides, seasonal changes	temperature, salinity, pH
Pollutants	temperature, dissolved oxygen, nitrates, turbidity, fecal coliform

Recommended Test Kits

Test	Example	Measure	Results	What it Indicates
Temp.	 Measured using a shielded Celsius thermometer.	A measure of the average kinetic (heat) energy of molecules in the object.	Varies based on the season at the site of an external input such as ground water or effluent. Ranges from approximately 4 - 23°C (39 - 71°F)	Temperature can influence water density, physical and biological processes of aquatic organisms and distribution of aquatic organisms.
Salinity	 Measured using a SeaTest or Instant Ocean hydrometer with an indicator arm that floats based on the density of the water.	A measure of the amount of salt and other dissolved solids in the water.	Varies based on tidal flow and freshwater discharge. Ranges from 10 ppt to 22 ppt	Salinity can influence water density and can affect vertical stratification of water column. Salinity is also an important habitat variable as a number of aquatic species have a limited salinity tolerance.
Dissolved Oxygen (DO)	 Measured using a CHEMets Dissolved Oxygen kit with a chemical reagent ampoule and color comparator.	The amount of oxygen dissolved in the water.	Varies based on temperature, salinity, algae growth, sewage input, diffusion and aeration, photosynthesis, respiration and decomposition. Ranges from 0.1 ppm to 8 ppm	Dissolved oxygen will influence the survival or presence of marine organisms (e.g. fish, shellfish, macro and micro invertebrates, phytoplankton, fungi and bacteria).

Test	Example	Measure	Results	What it Indicates
pH	 Measured using Carolina Universal pH indicator strips.	A relative measure of acidity/ alkalinity.	Varies based on a large number of factors including CO2 levels in the water, salinity or freshwater input, and sewage input. Ranges from mildly acidic (6.2) to mildly alkaline (7.9)	pH can influence how marine organisms access nutrients and how they reproduce and grow (shells and skeletons grown by many marine organisms do not grow well in mildly acidic pH).
Turbidity**		Measures clarity of water using a turbidity tube. Dark colored water can be clear and not turbid.	Varies based on the amount of sediment or particles in the water coming from soil erosion, runoff, algal blooms, or sewage Test results range from 0 - 100 JTU (Jackson Turbidity Unit).	Excess sediments block sunlight from passing through water, which make it difficult for aquatic plants to photosynthesize and reduces food sources for fish.
Nitrates*	 Measured using a CHEMets kit with a chemical reagent ampoule and color comparator.	A water soluble form of nitrogen and an essential nutrient for living things.	Varies based on amount of sewage, industrial runoff and fertilizer that enters a water body. Test results range from 5 ppm to 40 ppm	High levels of nitrate causes excess plant growth and decay which increases harmful bacteria. Excess nitrate decreases the amount of oxygen available in water.

Test	Example	Measure	Results	What it Indicates
Coliform Bacteria*	 Measured using a Coliform Test kit with a lactose broth that changes color if coliform bacteria are present after a 48-hour incubation period at room temperature.	A presumptive test of the presence of total coliform bacteria.	Varies based on the amount of sewage or other fecal matter in the water Ranges from 4/100 mL to 109,000/100 mL	Fecal coliform bacteria indicate the presence of sewage contamination of a waterway and the possible presence of other pathogenic organisms.
All-in-One	 The GREEN Low Cost Estuary & Marine Monitoring Kit	An all-in-one kit that includes test for coliform bacteria, salinity, dissolved oxygen, biochemical oxygen demand, nitrate, pH, phosphate, temperature, and turbidity.	Less expensive than buying the above kits separately, but will need to be replaced as it only has enough materials to test ten water samples (two for coliform).	See above.

** Testing for Nitrates and Coliform Bacteria are bonus tests that can be performed at the teachers discretion, they are not included in the following Lesson Activities.*
***Turbidity is only included in the Field Lesson.*

These recommended test kits were chosen based on their ease of use, durability and their rapid result time.

Tips for Teachers

- If you do not have time to do all the tests in class, complete the tests before the class meets again, so you can still include the results in your discussion.

Vocabulary

Note: Some of this vocabulary is referenced in other parts of this curriculum. All vocabulary and definitions appear in the glossary of the curriculum.

Background Vocabulary:
analyze
average
control
data
decrease
dependent variable
hypothesis
independent variable
increase
mean
median
measure
mode
photosynthesis
precipitation
salt marsh
variable
water cycle

Essential Vocabulary:
aerate
brackish
buoyancy
coal tar
combined sewer overflow (CSO)
contamination
density
dissolved oxygen
estuary
eutrophication
fecal coliform
industrial
metadata
nitrates
non source point pollution
nutrients
ph
remediate
Respiration
runoff
salinity
saturate
sediment
sewage
silt
stagnant
temperature
tide
trend
turbidity
water quality

Extension Vocabulary:
algal bloom
dredge
green infrastructure
industrial
retention tank

Lesson I Water Quality Test Kit Practice

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Water quality is important for the health of Newtown Creek's ecosystem. A variety of tests reveal different indicators that help determine the health of the waterway. Students will have the opportunity to practice using the water quality test kits in the controlled environment of the classroom using neutral tap water. By performing the water quality tests, students will practice the skills that will be applied later in the field. Students will also become familiar with how salt, pH, and oil interact with water and how these elements can be easily modified to impact the water.

In Activity 2, students will explore creating conditions similar to Newtown Creek and begin to understand the diverse characteristics of different types of waterways (freshwater vs. saltwater). Before a site visit, it is advisable to devote at least one class period for students to practice the tests and learn to use the equipment. The success of your field testing will depend upon the ability of your students to perform tests properly.

Learning Objectives

- Students will describe different water quality tests and what they measure.
- Students will perform water quality tests with improving accuracy.
- Students will make predictions about water quality results in Newtown Creek.
- Students will understand the importance of water quality in nearby waterways like Newtown Creek.

Time

45-90 minutes

Vocabulary

Try to incorporate vocabulary words from the “Water Quality Introduction” word list throughout the lesson.

Tips for Teachers

- Consider using and/or modifying portions of the water quality introduction as a text for your students.
- Depending on the age and experience of your students, your class may need to practice simple measuring techniques with plain water before performing the

tests. For example, some students have difficulty pouring water into a test tube to a certain metered line, or squeezing just one drop of water from a dropper.

- Even though students will only fill out a small portion of it during this lesson, hand out the water quality data sheet. Your experience in the field will go more smoothly if the students have seen the data sheet prior to being in the field.

Materials

- 4 one-gallon buckets (1 for each water quality test) half-filled with tap water
- 4 aluminum baking pans (placed under water buckets, to catch spills)
- Towels or paper towels
- Clipboards
- Graduated cylinder
- Pipette droppers
- Water quality test equipment/ kits:
  - Temperature
  - Salinity
  - Dissolved Oxygen
  - pH
- Water Quality Data Sheets
- Water Testing Test & Procedures Worksheets
  - Test & Procedures - Dissolved Oxygen
  - Test & Procedures - pH
  - Test & Procedures - Salinity
  - Test & Procedures - Temperature

Procedure

1. Set up four stations for water quality tests, one for each test.
2. Separate students into small groups (ideally, the same groups they will work with in the field).
3. Before, they perform water quality tests, students should practice pouring water from the sample bottle to specific metered lines, such as 5 mL.
4. Students should practice using pipettes. Have them add a specific number of drops (such as one, five and ten) to a sample using the pipette.
5. Because of surface tension, water in a test tube or graduated cylinder takes on a concave shape called the meniscus. Students should read the water level by looking at the tube at eye level and reading from the bottom of the meniscus.
6. Hand out the Water Quality Data Sheet and review.

7. Hand out the Test & Procedures worksheets.Student groups rotate to water quality testing stations. At each station, students read the background information and procedure for each test
8. Students perform the water quality test and fill out the Water Quality Data Sheet.
9. Students answer questions on the Test & Procedures worksheet.
10. Recombine students into new groups so they are now with other students that had different tests.
11. Students in the new groups share what they learned about their tests and demonstrate how to perform their test with the goal of identifying similarities and differences between the different test and test procedures.

Activity #2 Create Your Own Creek Water

In order to create water conditions similar to the conditions of Newtown Creek, students will add materials to tap water and perform water quality tests for pH and salinity. During the procedure, teachers can project vocabulary terms related to the content of the activity, as many of these terms will be new to students.

Learning Objectives

- Students will understand that water conditions in Newtown Creek, a tidal estuary, differ from the water conditions of tap water.
- Students will be able understand the differences between freshwater and brackish water.
- Students will understand that Newtown Creek is a tidal estuary, and contains brackish water (a mix of of salt and freshwater).
- Students will learn how it's possible to mimic and alter pH and salinity in various marine environments.

Materials for all Tests

- Journals
- Tapwater
- Measuring cups
- Tablespoon
- 1 one-gallon bucket for each student group
- Stirrer (a spoon or tablespoon will work)

pH Test Materials

- 2 containers or cups for each group
- White vinegar or lemon juice
- Baking soda

Salinity Test Materials

- Table salt
- 1 container of water (enough to fill hydrometer, more than one cup)
- Hydrometer for testing salinity

Procedure

Test #1: Measuring changes in pH

1. Divide students into small groups.
2. Explain the testing procedure to students.
3. Have students write down the procedure in their journals. Make predictions or record a hypothesis.
4. Each group gets 1 one-gallon bucket filled with tap water, plus 2 smaller containers (large enough to hold 1 cup of water)
5. Students test the pH of the tap water. Record data in journals. (*pH tests should be at or near neutral-7*)
6. Students measure and pour 1 cup of water into each of the smaller containers.
7. Students add 1 tablespoon of vinegar to one cup and 1 tablespoon of baking soda to the other cup. Stir until completely mixed.
8. Measure pH of both cups.
9. Record data on worksheets or in journals.
10. Repeat the above steps until noticeable changes are observed. Be sure to record data at each step.

Test #2 Measuring changes in Salinity

1. Explain the testing procedure to students.
2. Have students write down the procedure in their journals. Make predictions or record a hypothesis.
3. Each group gets 1 one-gallon bucket filled with tap water, plus 1 smaller container (with enough water to fill hydrometer with water)
4. Pour tap water into hydrometer. Record data in journals. (*salinity of tap water should be at or near 0*).
5. Pour water back into cup. Add 1 tablespoon of table salt, stir until completely dissolved.
6. Pour water back into hydrometer. Test for salinity, record data in journals.
7. Repeat until noticeable changes are indicated, up to 35 ppt (parts per thousand) which mimics the salinity of ocean water.

Discussion Questions

1. Why do we test for water quality?
2. What was your experience testing neutral tap water?

3. How does human behavior affect water quality? (Ask about specific tests.)
4. How does water quality affect Newtown Creek ecosystems?
5. What was your favorite part of the experiment?

Lesson II Dissolved Oxygen Lab

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Animals need oxygen to breathe, including those that live underwater. The amount of oxygen available is directly related to the health of animals and the complex ecosystem they are a part of. Many factors influence the levels of oxygen in the water at any given time and place. Students will experiment with the water of different temperatures to delve deeper into factors that can affect the amount of dissolved oxygen in a water body.

Learning Objectives

- Students will describe two factors that influence the amount of dissolved oxygen in the water.
- Students will compare and contrast results of the dissolved oxygen experiment.
- Students will analyze the results of the experiment in writing.
- Students will describe how dissolved oxygen is important to life.

Time

90-120 minutes

Vocabulary

See “Water Quality Introduction” for a list of vocabulary words from which to choose

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Tips for Teachers

- Consider using and/or modifying portions of the Water Quality Introduction as a text for your students.
- This lab will go more smoothly with your students if you do each experiment yourself before introducing it to the class.

Materials

- Dissolved Oxygen Reading
- Dissolved Oxygen Lab Instructions
- Dissolved Oxygen Lab
- Water Samples
- Containers for Water (wide-mouthed jar, 1000mL, beaker, ect)
- Dissolved Oxygen (DO) test kits
- Waste Containers for consumable DO materials
- Equipment needed for chosen variables:
  - Hot Plate
  - Oven Mitts
  - Ice
  - Stirrer

Procedure

1. Students read and annotate Dissolved Oxygen Tests and Procedures worksheet.
2. Separate students into small groups.
3. Students share annotations with the group. What did they find most important?
4. Hand out Dissolved Oxygen lab Instructions and review with your students.
5. You may want to assign a job to each group member (e.g. recorder, group leader, timekeeper, ect.)
6. Hand out Dissolved Oxygen Lab.
7. Students complete Lab "Introduction"
8. Distribute materials needed for experiment.
9. Students fill out "Materials" section.
10. Students complete experiment and record results.
11. Once experiment is concluded collect all lab materials.
12. Have a place (e.g. poster, smartboard projection, whiteboard, ect) that each group can post their results for the whole class to see and copy.
13. Students complete "Procedure, Diagram and Results."
14. Review Results Data Table with the class
15. Students complete "Graph, Discussion and Analysis.

Discussion Questions

1. What is a control and why is it important?
2. Do you think this data is accurate? Why or why not?
3. What difficulties did you encounter when doing the experiment? Which of these difficulties may have affected the data.
4. What trends do you see in the data?

5. Why do you think we got these results?
6. How do the variables we tested for relate to conditions you will find at Newtown Creek?
7. How is dissolved oxygen impacted?
8. Why is it important to understand how dissolved oxygen is impacted in the environment?

Field Lesson: Water Quality

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Newtown Creek is a complex ecosystem. The health of the Creek depends on the quality of water and the environment surrounding the Creek. This is an opportunity to bring your students outdoors and have them interact with the Newtown Creek by making observations and inferences and testing the quality of the water using several different parameters.

Learning Objectives

- Students will practice making observations about the environment surrounding the Creek and predictions about the quality of water in the creek.
- Students will practice how to accurately measure at least one water quality parameter using water from the Creek.
- Students will interpret the results of each test and explain what might be impacting the test result.
- Students will draw preliminary conclusions about the health of the Newtown Creek based on the water quality data.
- Students will compare water quality data if tested multiple times.
- Students will begin to understand the relationship between the environment surrounding the Creek and the quality of water in the Creek.
- Students will experience the importance of being in the field at Newtown Creek to learn about real issues.

Time

Can vary from 60 minutes to several hours.

Vocabulary

See “Water Quality Introduction” for a list of vocabulary words from which to choose.

Tips for Teachers

- Choose one or more of the sites listed in the Newtown Creek Field Sites Information section of the Curriculum Introduction.
- Always visit the Field Site prior to bringing your students there.

- Consider using and/or modifying portions of the Water Quality Introduction as a text for your students.
- Each student group will collect a water sample and conduct one or more tests. Working in small groups will help these tests go smoothly and help guard against error.

Discussion Points

- For each discussion point, decide which teaching method works best for you and your students.
- Hypothesis/ predictions of the test results
- Importance of testing procedure/ protocols
- Importance of metadata (location, date, time, tide, ect)
- Testing once vs. testing multiple times and taking an average
- Impact of weather on test results
- Impact of time of year on test results
- Surface vs. deep water test results
- Upstream vs. downstream results
- Pollutants that may influence test results (e.g. sewage can impact dissolved oxygen)
- Other factors that may influence test results (the tide can influence salinity)
- Other observations about the Creek
- Stewardship of the Creek

Discussion Questions

1. How is the environment surrounding the Creek related to the health of the Newtown Creek?
2. How was your experience being in the field and testing the water in Newtown Creek?
3. What did the water quality test in Newtown Creek tell you about the health of the Creek?
4. Why is testing water quality in nearby creeks like Newtown Creek important?

Journal Prompts

We recommend having students write in their journals at the end of the field experience and consider some or all of the following questions. Also refer to the “Journal Writing” section of the Introduction & Methodology for more suggestions about journaling.

1. What observations do you think are important to note on your water quality data sheet? What observations did you make?
2. Why do we collect multiple results for the same water quality test?
3. Why should we always test the dissolved oxygen first?
4. How can the weather or precipitation impact water quality data.
5. What factors could be influencing dissolved oxygen? Salinity? pH? Turbidity? Nitrates? Fecal coliform?
6. What results would you expect to find if we compared the surface water with a deep water sample?
7. What results would you expect to find if we compared water quality at the top of the creek to water quality in the mouth of the creek.
8. Choose one water quality result that you think should be improved in the Newtown Creek. What could you design/ propose/ build within the Newtown Creek or watershed that could have a positive impact on this water quality parameter?
9. Alternatively, what other kind(s) of stewardship could you participate in that could improve the health of the water in the Newtown Creek? Explain.
10. What was the experience being in the field, Newtown Creek, like for you?
11. What did you learn about Newtown Creek?
12. Why is water quality important?
13. Why does the water in Newtown Creek need to be improved?
14. How was your experience working together and coming up with ways to improve the quality of the Creek?
15. What does it mean to improve the quality of water in a Creek and how will that help support the health of the ecosystems in the Creek?

Main Activity: Testing Water Quality of the Newtown Creek

Materials

- Clipboards
- Journals
- Water Quality Data Sheet and Tests & Procedures.
- Site map (For your chosen field site)
- Water quality test kit tools (Depending on which tests you choose to do)
    1. Bucket and line
    2. Cloud chart
    3. Wind speed gauge
    4. Dissolved oxygen test kit
    5. Thermometer (one for water, one for air)
    6. Hydrometer
    7. pH test kit
    8. Turbidity tube

9. Nutrient test kit
10. Fecal coliform test kit

- Calculator (Optional; for calculating averages)
- Hand sanitizer
- Fresh water (For rinsing equipment)

Procedure

1. Separate students into small groups
2. Hand out site map and a water quality data sheet to each group
3. Stand in a central area on the site with the whole class and compare the boundaries on the quadrant site map to where those boundaries are on the actual site. Point out where the boundaries are for the site.
4. Students make observations on site map, based on elements they notice are degraded (e.g. litter, floatables (plastic trash), oil, compacted soil, dilapidated bulkheads/waters edge) or other things that may impact water quality.
5. Students collect metadata information (date, time, cloud cover, location, tide, etc) and record on Water Quality Data sheet. Note: You may want to collect the metadata with the whole class, or you may assign this as a task to one or more small groups. It is important to collect metadata first because it sets the stage for the water quality tests.
6. Student groups test the water and record results.
7. Facilitate students sharing test results so that their data sheets are complete as possible.
8. Students calculate averages with the students.
9. Students complete the water quality analysis at the end of the data sheet.
10. Students clean their equipment and hands.
11. Bring site maps, water quality data sheets and all other collected data back to the classroom for use in the Applied Learning Lesson.

Extension Activity - Observe a Fish

Note: This activity is also included in the Flora & Fauna Field Lesson, and is represented here because is complements water quality studies.

Materials

- Clipboards
- Observation/Inference Chart
- Disposable (nitrile) gloves or hand sanitizer
- Small plastic fish tanks
- Marine Wildlife of Newtown

Creek field guide poster

Optional
- Organism collection and observation tools
- Dip nets
- Magnifying glass
- Magnifying box
- Ruler

Procedure - Set Up

1. This activity ***must*** be done along with an expert from Newtown Creek Alliance (NCA) at either the Living Dock or North Brooklyn Boat Club Field Site locations. Access without assistance can be dangerous or impossible.
2. Most of the optional materials listed in the materials list will be provided for the class.
3. Confirm the trip and NCA will set up the observational experiment. For additional information refer to Field Site location guides.
4. Before the trip to the Field Site, review the Marine Wildlife of Newtown Creek field guide poster to familiarize yourself and students with the different species that can be found in the waterway. Many of the smaller fish, shrimp, and crabs are commonly seen at these locations. If time allows, talk about the different parts of the fish.

Procedure - Observe the Fish!

1. Within the Living Dock are several crates that hold various substrate; ropes, oyster and mussel shells, rocks, etc. A variety of species like to use these substrate filled crates as habitat. When a crate is pulled from the water and held over a container, fish, shrimp, crabs, and other animals of all sorts fall into the container for viewing. An experienced professional from NCA will perform this task for the class. The container will be brought to a table set up for student viewing.
2. Carefully take a few fish, leaving the shrimp or crabs, out the container with a net and put them in a small clear plastic fish tank (plastic fish tanks work better than tupperware because the sides are clear and make for easier viewing)
3. The more fish and fish tanks you have, the better. This way students can break into small groups in order to observe the organism up close.
4. Students carefully observe the fish and respond to the following prompts on their Observation Charts or in their Journals:
    - Sketch the fish. Label all the parts of the fish. Include colors, patterns and approximate size (you can use a ruler)
    - How does it move? Is it a fast swimmer? Does it sit on the bottom or hang out at the top?

- What do its fins look like? How many fins does it have? Where are they located? What shape are they?
- Describe what the fish's mouth looks like. Is it pointed up? Is it very small or very wide? What do you think the fish eats with this mouth? (Note: small mouths of these fish indicate they feed primarily on plankton and other small organic materials in the water as opposed to the larger striped bass that has a larger mouth with teeth and feeds on other smaller fish)
- Describe the fish's camouflage and coloring. What color is the fish when you look DOWN at it from above? What color is the fish when you look UP at it from below? Why do you think the fish is colored in this way? (Note: this is called "countershading" and it is a type of dual camouflage protecting the fish from predators above and below.)

5. Students can use the Marine Wildlife of Newtown Creek field guide poster to identify your fish. (Fish caught in the creek are most likely silverside, killie or mummichog.)
6. There will be other marine-vertebrates and invertebrates in the container (shrimp, crab, sea squirts, etc). Inspect them with the magnifying glass or magnifying box and students should include observations about them on the Observation Chart or in their Journals.

Applied Learning: Designing Water Quality Improvements

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

All the lessons previously build up to this lesson where students can explore ways to apply their knowledge to the real world. Based on experience in the field and data gathering during the Field Lesson, students will either recommend a strategy for working towards improvement of the health in Newtown Creek or design an improvement to a specific parameter of water in the Newtown Creek.

Learning Objectives

- Students will understand the health of Newtown Creek depends on the water quality of the Creek.
- Students will review water quality data
- Students will compare and contrast to other water quality data (Newtown Creek Alliance or DEP)
- Students will discuss validity of results - what should be repeated or done differently next time.
- Students will practice applying their gained knowledge to a real world issue by creating a plan to design something that would help improve one or more of the water quality indicators (dissolved oxygen, pH, fecal coliform, nitrates).
- Students will understand what it means to recommend a strategy or design improvement to a local place that affects them and their community.
- Students will practice working in teams and sharing out design ideas with classmates.

Time

45-60 minutes

Vocabulary

See Water Quality Introduction for a list of vocabulary words from which to choose.

Tips for Teachers

- Remind students that they do not need to be proficient artists when doing sketches. Line drawings will surface

- Consider using and/ or modifying portions of the Water Quality Introduction as a text for your students.

Materials

Materials from Field Lesson

- Site Map
- Site Map - clean copy
- Water Quality Data Sheet
- Journal entries
- Other student work from Field Lesson (e.g. photographs, sketches)
- Google image of Newtown Creek Neighborhood
- Newtown Creek Alliance Water Quality Testing booklet, or NYC Department of Environmental Protection (DEP) Newtown Creek Water Quality Data. (Both of these can be found on the respective websites)

Design Procedure

1. Separate students into the same small groups they were in during the Field Lesson.
2. Project the Google Map of Newtown Creek Neighborhood.
3. Review the Field Sites visited during the Field Lesson.
4. Point out on the Newtown Creek map the location of the Field Site(s) visited. Consider pointing out the schools location or other recognizable landmarks in relation to the Field Site (or proposed design site).
5. Each student in the group shares some observations or thoughts about their field site based on their worksheets and/ or journal entries.
6. If you visited more than one Field Site during the Field Lesson, choose one on which to focus.
7. Use the Water Quality data Sheet to calculate averages if it was not completed in the field. (Do this as a class if the students don't yet know how to calculate averages)
8. Review the Discussion Questions below, referring to the information from your Field Lesson (i.e. Site Map, Water Quality Data Sheet, journal entries, ect).
9. Hand out the Newtown Creek Alliance Water Quality Testing booklet data or DEP Newtown Creek Water Quality Data or another set of comparison data.
10. Discuss the similarities and differences of their results to the closest location tested by the DEP

11. Students choose one water quality parameter they would like to see improved (e.g. dissolved oxygen, pH, turbidity, nitrates).
12. Students revisit their observations from the field and discuss what observations might be impacting the water quality.
13. Each student gets a copy of the Site Map.
14. Brainstorm ideas that will improve water quality at your Field Site.
15. Each student uses the brainstorm ideas to sketch the design for water quality improvements on a blank Site Map.
16. Each student presents and explains his/ her design to the group.
17. The group members critique each others' designs and write down the best elements from each sketch.
18. The group gets a blank copy of the Site Map.
19. The group works together to create ONE final design incorporating the best elements from each individual's design.
20. The group works together to write an explanation and defend each element of their design.
21. Groups recombine so all students are with new group members.
22. Each student shares the sketch and explains the design with the new group members.

Discussion Questions

1. Describe your Field Site, its location and what surrounds it.
2. What types of pollutants did you observe on the Field Site
3. What other observation did you make at your Field Site?
4. How do the results compare to the water quality ranges we would expect to see in the Newtown creek?
5. Are there any results that are surprising? Explain why.
6. Are there any results that are questionable? (e.g. a group knows they made a mistake while performing the test) Explain why.
7. How might one or more of the of the observations you made be impacting the water quality results?
8. How do your results compare to data in the NCA Water Quality Data document or other data set?
9. Which of your test results do you find most concerning? Why?
10. Which of your test results do you feel you should focus on improving? Why?

Common Core Standards

Lesson 1
English Language Arts Standards
Science and Technical Subjects

Key Ideas and Details
Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.1
Cite specific textual evidence to support analysis of science and technical texts.
CCSS.ELA-LITERACY.RST.6-8.2
Determine the central ideas or conclusions of a text; provi de an accurate summary of the text distinct from prior knowledge or options.
CCSS.ELA-LITERACY.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure
Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics

Integration of Knowledge and Ideas
Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.9
Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

English Language Arts Standards
Writing: History/ Social Studies, Science, & Technical Subjects
Production and Distribution of Writing
Grades 6-8
CCSS.ELA-LITERACY-WHST.6-8.4
Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose and audience.

English Language Arts Standards
Reading; Informational Texts
Craft and Structure
Grade 6
CCSS.ELA-LITERACY.RI.6.4
Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.

Lesson 2
English Language Arts Standards
Science and Technical Subjects
Key Ideas and Details
Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.1
Cite specific textual evidence to support analysis of science and technical texts.
CCSS.ELA-LITERACY.RST.6-8.2
Determine the central ideas or conclusions of a text: provide an accurate summary of the text distinct from prior knowledge or opinions.
CCSS.ELA-LITERACY.RST.6-8.3
Follow precisely a multi step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure
Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific or technical context relevant to grades 6-8 texts and topics.

English language Arts Standards
Writing: History/ Social studies, science, & Technical Subjects
Texts Types and Purposes
Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.1
Write arguments focused on discipline- specific content..
CCSS.ELA-LITERACY.WHST.6-8.1.C
Uses words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons and evidence.
CCSS.ELA.-LITERACY.WHST.6-1.D
Establish and maintain a formal style.
CCSS.ELA-LITERACY.WHST.6-8.1.E
Provide a concluding statement or section that follows from and supports the argument presented.

Production and Distribution of Writing
Grades 6-8

CCSS.ELA-LITERACY-WHST.6-8.4
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge
Grades 6-8

CCSS.ELA-LITERACY-WHST.6-8.7

Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English Language Arts Standards
Speaking & Listening
Comprehension and Collaboration
Grades 6-8

CCSS.ELA-LITERACY.ACY.SL.6-8.1
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Mathematics Standards
Standards for Mathematical Practice
Grades 6-8

CSS.MATH.PRACTICE.MP2
Reason abstractly and quantitatively.
CSS.MATH.PRACTICE.MP4
Model with mathematics.
CSS.MATH.PRACTICE.MP5
Use appropriate tools strategically.
CSS.MATH.PRACTICE.MP6
Attend to precision.

Mathematics Standards
Statistics & Probability
Grade 6

CCSS.MATH.CONTENT.6.SP.B.4
Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
CCSS.MATH.CONTENT.6.SP.B.5
Summarize numerical data sets in relation to their context, such as by:
CCSS.MATH.CONTENT.6.SP.B.5.A
Reporting the number of observations.
CCSS.MATH.CONTENT.6.SP.B.5.B
Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

Next Generation Science Standards
MS. Matter and Energy in Organisms and Ecosystems

` MS-LS2-1
Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4

Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Field Lesson
English Language Arts Standards
Science and Technical Subjects
Key Ideas and Details
Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.3
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

Craft and Structure
Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards
Writing: History/ Social Studies, science, & Technical Subjects
Texts Types and Purposes
Grades 6-8

CCSS.ELA.LITERACY.WHST.6-8.1
Write arguments focused on discipline-specific content.
CCSS.ELA.LITERACY.WHST.6-8.1B
Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrates an understanding of the topic or text, using credible sources.

Production and Distribution of Writing
Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.4
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge
Grades 6-8

CCSS.ELA.LITERACY.WHST.6-8.7
Conduct a short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English language Arts Standards
Speaking & Listening
Comprehension and Collaboration
Grades 6-8

CCSS.ELA-LITERACY.ACY.SL.6-8.1
Engage effectively in a range of collaborative discussions (one-to-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others ideas and expressing their own clearly.

Next Generation Science Standards

MS. MAtter and Energy in Organisms and Ecosystems

MS-LS2-4
Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Applied Learning

English Language Arts Standards

Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure

Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 text and topics.

English Language Arts Standards

Writing: History/ Social Studies, Science & Technical Subjects

Text Types and Purposes

Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.1
Write arguments focused on discipline-specific content.

CCSS.ELA-LITERACY.WHST.6-8.1B
Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Production and Distribution of Writing

Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.4
Produce a clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience

Research to Build and Present Knowledge

Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English Language Arts Standards
Speaking & Listening
Comprehension and Collaboration
Grades 6-8

CCSS.ELA-LITERACY.SL.6-8.1
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.6-8.1.B
Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

CCSS.ELA-LITERACY.CCRA.SL.1
Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

Grade 6

CCSS.ELA-LITERACY.SL.6.1.c
Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

Grade 7

CCSS.ELA-LITERACY.SL.7.1.c
Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.

Grade 8

CCSS.ELA-LITERACY.SL.8.1.c
Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.

Next Generation Science Standards

MS-ETS1-1
Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2
Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Additional Resources:

Texts:

- **“Water Quality Monitoring,” by Sam Wagner; Newtown Creek Alliance**

http://www.newtowncreekalliance.org/water-quality-monitoring-by-sam-wagner/

- **“Swimmer braves stinky New York City Canal on Earth Day,” Scientific American article**

https://newsela.com/read/swim-pollutedwater/id/9057/

- **“Teens find and test streams to reintroduce Virginia’s brook trout,” Washington Post article**

https://newsela.com/read/students-saving-brook-trout/id/43196/

- **Dissolved Oxygen in an Estuary (Teacher Resource)**

https://coast.noaa.gov/data/estuaries/pdf/dissolved-oxygen-in-an-estuary-combined-teacher-student.pdf

- **Teacher’s Guide The Harlem/Hudson Interpretive Project (Teacher Resource)**

https://drive.google.com/file/d/0B2aiebDFrsKxNU5sRVFMdHBZXzg/view?ts=5b685ba6

- **Newtown Creek Alliance Water Quality Testing Booklet**

http://www.newtowncreekalliance.org/water-quality-sampling/

ELA or Social Studies Texts

- ***A River Ran Wild: An Environmental History* by Lynne Cherry**
  https://www.amazon.com/River-Ran-Wild-Environmental-History/dp/0152163727

- ***Riparia’s River* by Michael J. Caduto**

https://www.amazon.com/Riparias-River-Michael-J-Caduto/dp/0884483274

- ***Water Rolls, Water Rises: El agua rueda, el agua sube* by Pat Mora; (English and Spanish edition)**

https://www.amazon.com/Water-Rolls-Rises-English-Spanish/dp/0892393254

Videos:

- **The Invisible Creek**

https://www.youtube.com/watch?v=m0OFd3PRk50&feature=youtu.be

- **Swimming the Newtown Creek in New York City**

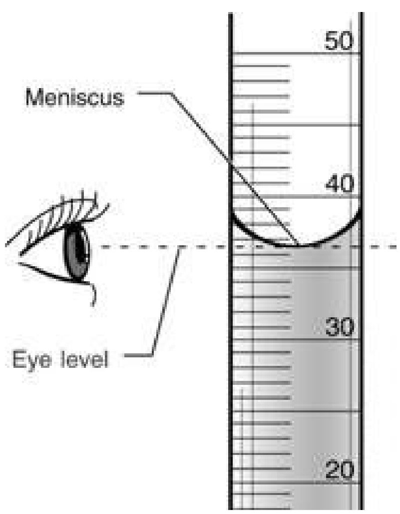
https://www.youtube.com/watch?v=eJ_kYlzIBx4

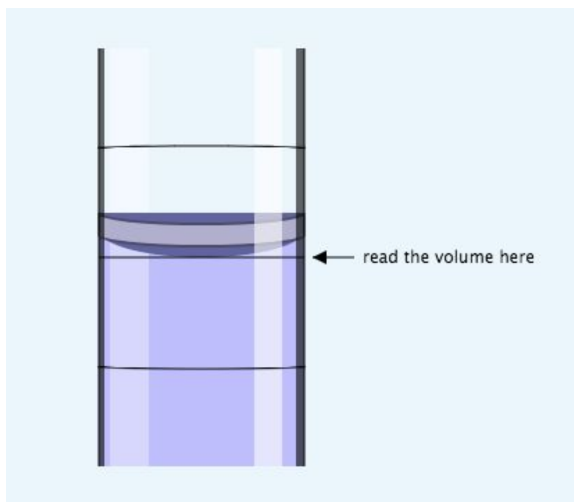
- **"A Billion Gallons a Day," New York Times**

https://www.nytimes.com/video/nyregion/100000003176142/living-city-a-billion-gallons-a-day.html

Images:

Reading Water Levels/Meniscus Line:





Handouts

Newtown Creek Water Quality Data Sheet

Student Name: Name of Site: Water Body:

Description of Site

____
____
____
____
____
____
____
____

Time

Year: __________ Month: __________ Day: __________ Local Time: __________ am/pm

Weather

Precipitation in last 48 hours? YES/NO Current Weather: ________

Cloud Type: ______________________________

Cloud Cover:

O No Clouds
O Clear (<10%)
O Isolated clouds (10%-24%)
O Scattered (25%-49%)
O Overcast (>90%)
O Broken (50%-90%)

Air Temperature: _______ °C _______ °F

High Tide: __________

Direction (set): __________

Ebb / Slack / Flood: __________

Wind Speed: __________ mph

Sea State: __________ (0-12)

Low Tide: __________

Speed (drift): __________ knts

Water Sample Depth: __________

Dissolved Oxygen

Observer Name:	Results:
1)	
2)	
3)	
Average:	

Water Temperature

Observer Name:	Results:
1)	
2)	
3)	
Average:	

Salinity

Observer Name:	Results:
1)	
2)	
3)	
Average:	

pH

Observer Name:	Results:
1)	
2)	
3)	
Average:	

Newtown Creek Water Quality Data Sheet

Student Name: Name of Site: Water Body:

Turbidity

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Nutrient Test

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Fecal Coliform Test (24 - 48 hour wait period)

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Water Appearance

O Foam
O Muddy
O Milky
O Oily Sheen
O Scum
O Floatables
O Other ____________________

Odor

O Rotten Eggs
O Musky
O Acrid
O Chlorine
O None
O Other ____________________

Water Quality Analysis

What do these results tell us about Newtown Creek?

Other Observations or Notes:

Field Site Metadata

Fill in the following information about the Field Site you are visiting

Student Name:

Location:

Site Name_______________________________________

Time______________ Day_______________

Year______________ Month_____________

Weather Temperature:_________

Describe the weather:

Cloud Cover:

Cloud Type:

- [ ] No Clouds
- [ ] Some Clouds (Partly Cloudy)
- [ ] Lots of Clouds

Description of Site & Conditions:

Temperature Test & Procedures

Student Name:____________________________________Date:___________

Temperature Procedure

1. Carefully fill the sampling container with water.
2. Place the thermometer in the sampling container.
3. Leave the thermometer undisturbed for two minutes.
4. Leaving the bulb (bottom-most part) of the thermometer submerged in the water, pull the thermometer out of the water just enough to read the numbers.
5. Bring your eyes down to the level of the thermometer.
6. Record your result using the unit °C.

Temperature Questions

1. What do you predict the temperature of the Newtown Creek will be? (Remember to consider what time of year you will be measuring the temperature.)

2. What factors do you think causes the temperature Newtown Creek water to change?

3. Why is it important to monitor temperature in the Newtown Creek?

Salinity Test & Procedures

Student Name:____________________________________Date:___________

Salinity Procedure

1. Carefully fill the hydrometer with water – up to the skinny part of the neck.
2. Tap hydrometer down gently to release any bubbles.
3. Put hydrometer on a flat surface (the palm of your hand is not a flat surface!).
4. Bring your eyes down to the level of the hydrometer.
5. Look at the level of the plastic pointer and read the corresponding numbers that are measured in "PPT" (parts per thousand).
6. Record your result using the unit "ppt" (parts per thousand).

Salinity Questions

1. What do you predict the salinity of Newtown Creek will be? (Remember ocean water is approximately 35 ppt and fresh water is close to 0 ppt.)

2. Based on what you know, explain why the plastic pointer floats more with higher salinity.

3. Why is it important to monitor salinity in Newtown Creek?

pH Test & Procedures

Student Name:______________________________________Date:____________

pH Procedure

1. Fill the 5mL test tube to the black line with sample water.
2. Put 10 drops of “pH indicator” in the test tube.
3. Place cap on test tube.
4. Invert test tube 10 times.
5. Place test tube in the comparator.
6. Record your results.
7. Dispose of sample water and indicator in a specified waste container.
8. Rinse out test tube with distilled water.

pH Questions

1. What do you predict the pH of Newtown Creek will be?

2. Based on what you know, what factors do you think causes the pH in Newtown Creek to change?

3. Why is it important to monitor pH in Newtown Creek?

Dissolved Oxygen Test & Procedures

Student Name:____________________________________Date:___________

Dissolved Oxygen Procedure

1. Carefully fill the sample cup (included in the test kit) with 25 mL of sample water.
2. Place one ampoule in the cup with the tip of the ampoule at the bottom corner of the cup.
3. Pull the top of the ampoule slowly but firmly towards the side of the cup until the tip breaks off.
4. Allow the ampoule to fill with sample water.
5. Take the ampoule out of the cup.
6. Dispose of the water left in the sample cup in a specified waste container.
7. Invert the ampoule, allowing the bubble to travel from one end of the ampoule to the other.
8. Invert the ampoule ten times.
9. Compare the amouple to the comparator by putting the ampoule in-between the comparator colors.
10. Record your result using the unit “ppm” (parts per million).
11. Rinse out the cup with distilled water.

Dissolved Oxygen Questions

1. What do you predict the dissolved oxygen in Newtown Creek will be?

2. Based on what you’ve learned, what factors do you think causes the dissolved oxygen in the Newtown Creek to change?

3. Why is it important to monitor dissolved oxygen in the Newtown Creek?

Watershed & Sewershed

In this Unit:

This Unit has been modified by permission by the Newtown Creek Alliance from the original with assistance from the National Wildlife Federation's Greenpoint Eco-Schools Program. The original module was developed by the Gowanus Canal Conservancy.

Unit Overview

Essential Questions:

• How does the land around the Creek (both above and below ground) affect the health of the Creek?
• How does the movement of water through either natural or built systems differ in form and function?
• How does your behavior and other human activities impact the health of the Creek?
• How can individuals and communities restore our natural watersheds and human-made sewersheds?
• How can individuals and communities positively impact the functions of the Creek?

Teacher's Introduction: page 4

Lessons & Objectives:

- Understand and explain how water flows through a watershed
- Understand and explain how water flows through a sewershed
- Understand and explain how a combined sewer works
- Describe the difference between a watershed and sewershed

- Observe a topographic map of Newtown Creek
- Determine where the water flows on a topographic map of the Creek
- Compare the boundaries of the Newtown Creek Watershed and Sewershed
- List pollutants that exist within the Newtown Creek Watershed and Sewershed
- Predict how pollutants move through the Newtown Creek Watershed and Sewershed

- Understand how some surfaces absorb water
- Compare the difference between a permeable and impermeable surface
- Compare surfaces in the Newtown Creek Watershed and Sewershed and describe which ones are more desirable for the ecosystem
- Draw conclusions about what types of surfaces do the best job absorbing water

- Observe different types of land surfaces next to the Creek
- Map and record data about land surfaces
- Compare and contrast how water and pollutants move over different land surfaces
- Identify Combined Sewer Overflow discharge points on the Creek
- Explain impacts of CSOs on the Creek
- Discuss different ways to lessen the negative impact of Combined Sewer Overflows
- List at least three ways to increase stormwater retention.

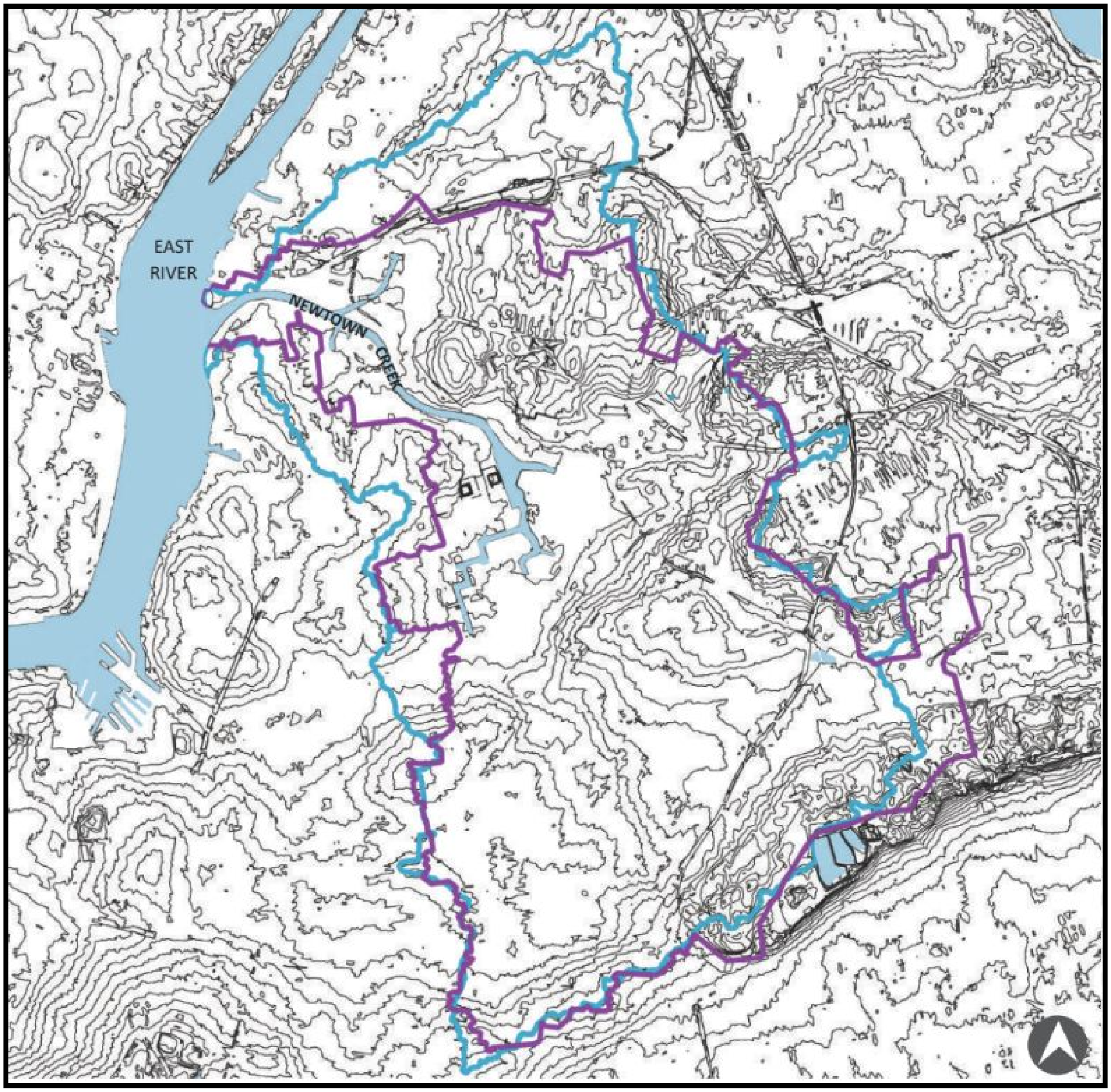
- Name and locate on a map the sites visited during the Field Lesson
- Use the data collected to calculate and graph percentages of different surfaces.
- Design site improvements that increases stormwater retention in the Newtown Creek

watershed.

Teacher's Introduction

What are Watersheds and Sewersheds?

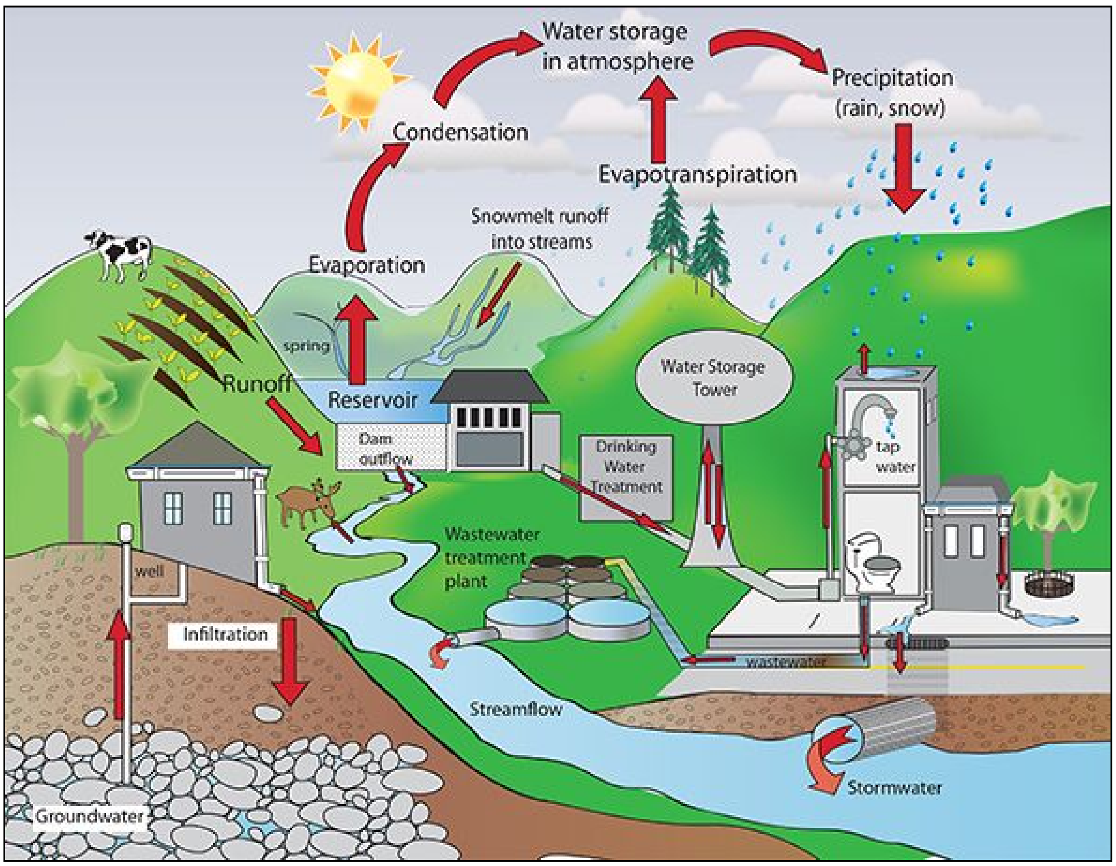
Both a watershed and a sewershed describe an area of land and how water flows within that area.



Newtown Creek Topographic Map with Watershed and Sewershed Outline. This map shows contour lines which represent a change in elevation. The Newtown Creek Watershed outline (in blue) represents the highest points in the area of land around Newtown Creek. The Sewershed outline (in purple) represents the area of stormwater capture that affects Newtown Creek. (Source: Korin Tangtrakul NYC Soil & Water

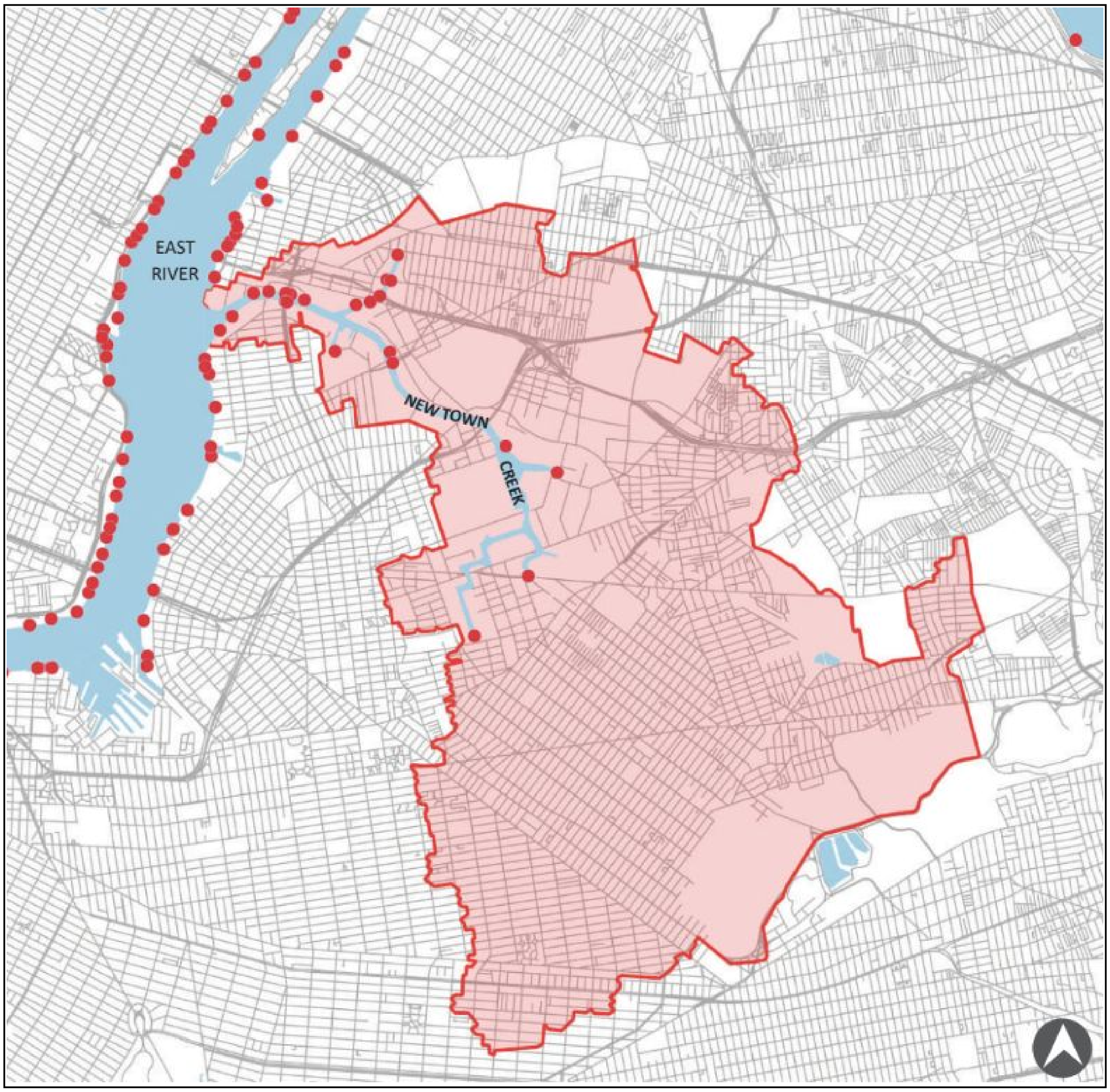
Conservation District)

A **watershed** is a basin-shaped area of land defined by high points (ridges) and low points (receiving water body). Imagine an umbrella turned upside down in the rain, and how water would flow and collect in the center. Since rain falls everywhere, all land is part of a watershed with a receiving body of water. Water “sheds” or flows off the ridges, down the slope and into the lowest lying body of water, which may be a lake, reservoir or river. As water flows downhill, it is also absorbed into the ground, lessening the amount that ends up directly running into the waterbody.



Typical watershed/sewershed graphic (Source: Cary Institute)

When sewage infrastructure is constructed, drainage patterns in a watershed are altered. A **sewershed** describes an area of land and how water flows through the built environment; over the streets, sidewalks, buildings and how it drains into pipes that carry it to treatment plants or to surrounding waterbodies. Sometimes watershed and sewershed boundaries overlap closely. A sewershed may be constructed to utilize the natural topography of the watershed. NYC is made up of 14 sewersheds, each of which direct stormwater and wastewater to a wastewater treatment plant. When the sewer pipes reach their capacity of volume, which usually happens during a rainstorm, an overflow system is triggered and the excess effluent is discharged at combined sewage overflow (CSO) points, which are located on NYC water bodies. Combined sewage overflow is a significant source of pollution in our public waterways. It contains both the untreated stormwater runoff and any pollution that has collected on the streets and the untreated sanitary sewage from homes, restaurants, businesses, and factories.



This map shows the area of land that drains to Newtown Creek during a rainstorm and CSO outfall points (red dots) along the Creek. (Source: Korin Tangtrakul NYC Soil & Water Conservation District)

Why Teach About Watersheds and Sewersheds?

The concepts of a watershed and sewershed illuminate how human activity around the Creek — even a mile upland — affects water quality.

In the case of the Creek, humans in the surrounding the Newtown Creek Sewershed are the primary source of ongoing pollution that perpetuates poor water quality in the Creek. **Combined Sewer Overflow (CSO)**, or, untreated sewage and stormwater that pollutes local waterbodies, is the most important concept to understand when considering the Creek.

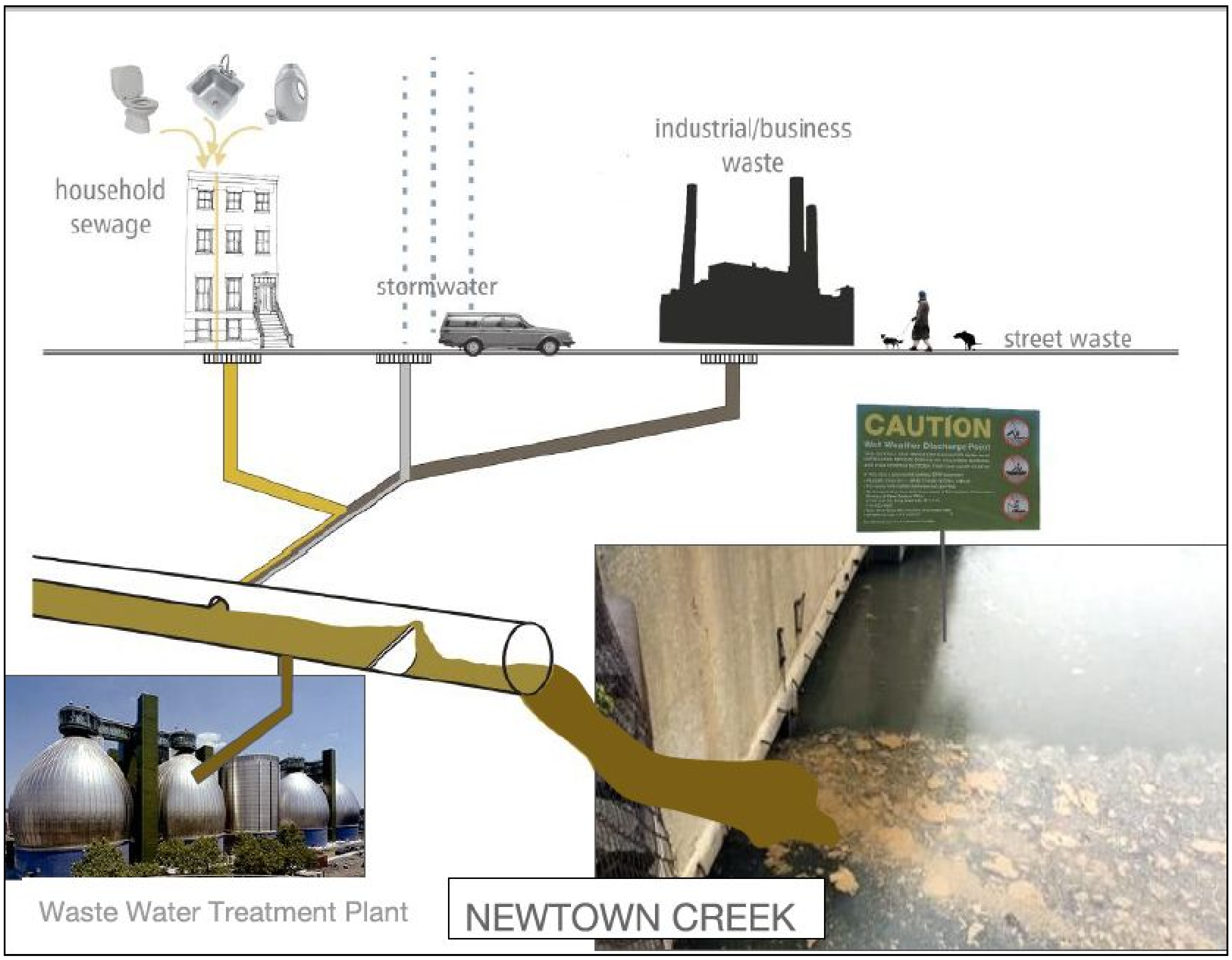


Diagram depicting how sewage, stormwater and street waste travel to the same pipe during a rain storm and end up in our urban waterbodies, such as Newtown Creek.

NCA
NEWTOWN CREEK ALLIANCE

Combined Sewer Overflow
The Biggest Source of Ongoing Pollution in Newtown Creek

While the NYC sewer system significantly improved how waste water is managed, it has its limits. As little as 1 inch of rainfall can overwhelm the capacity of the sewer system in New York City, which occurs in about 75 out of 100 annual rainfall events. This is because the sewer system simply is not large enough to carry both stormwater and a normal volume of sewage at the same time to a water treatment plant.

Learning about the Newtown Creek Sewershed will reveal how day-to-day activities in cities can impact waterbody health.

During most rainstorms in the Newtown Creek Sewershed:

- Stormwater runoff collects chemicals and pollutants off the surrounding streets, discharging pollution in the Creek
- Waste flushed down a toilet or dumped down a drain can be discharged into the Creek.
- Impermeable surfaces, such as concrete pavement and rooftops, which are common in cities, increase combined sewage overflow.
- Permeable surfaces, such as gardens, green roofs, and bioswales, can absorb stormwater before it reaches the sewer system, and decrease combined sewage overflow and improve water body health

This unit focuses on measuring and analyzing land surface permeability, or how surfaces either absorb or shed water in a sewershed. Students measure and compare land surfaces, and learn how land around the Creek and combined sewage overflow affect the Creek's water quality. By understanding the benefits of green infrastructure and simple ways to decrease sewage overflow, students can advocate for healthier water quality for the Creek and influence the behavior of their peers and families.

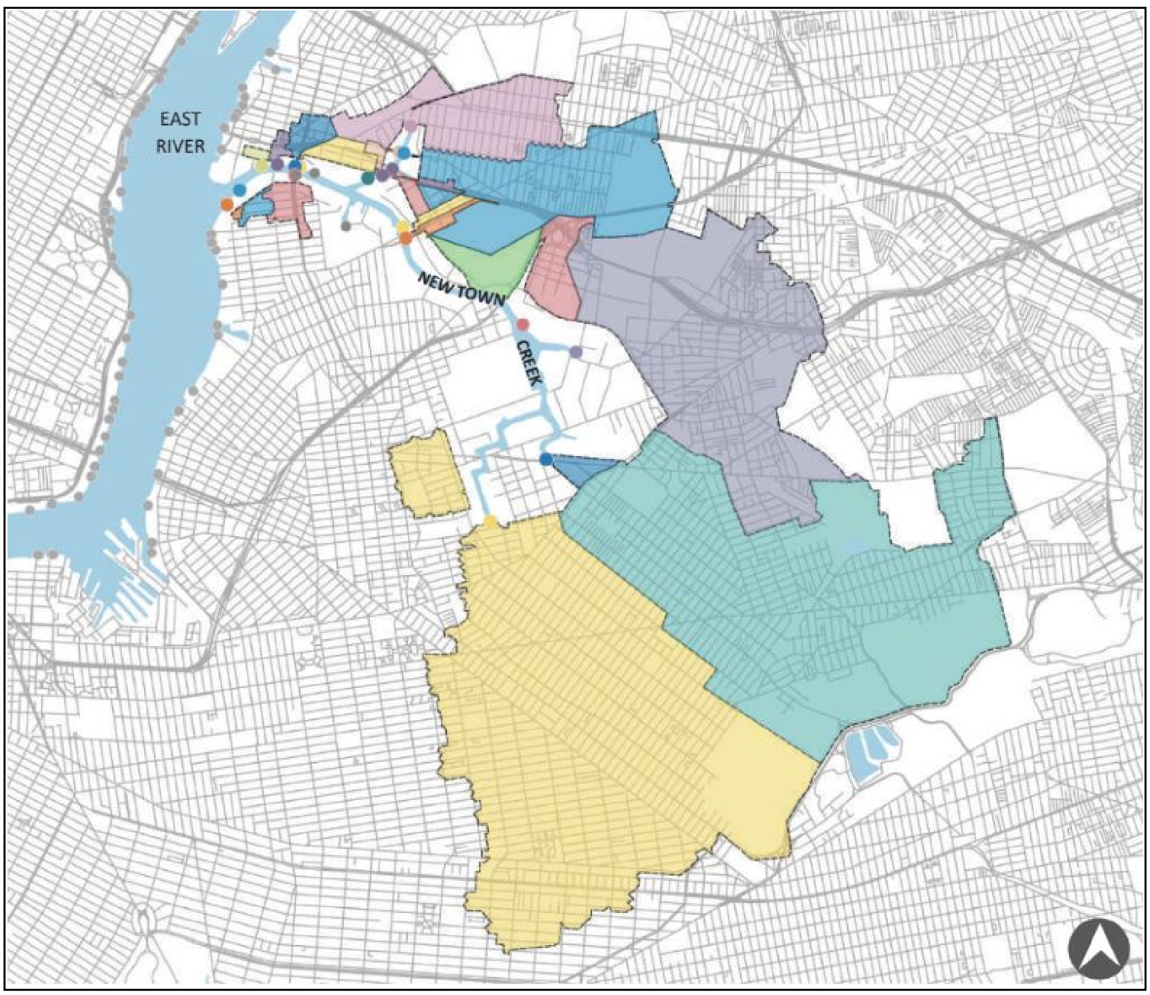
Measuring permeability builds additional skills, including:

- Reading Maps, specifically topographic
- Making predictions and hypotheses
- Measurement and accuracy
- Data collection and recording
- Analysis and interpretation of data
- Comparison of data

How Does it Work?

The flow of water along streets collects oil, litter, dog poop, road salt and other chemicals and debris along its path, and all which enter sewer drains as stormwater runoff. The flow of sewage generated from households, businesses and industry enter the same system of pipes. Contaminates from sanitary waste include cooking oils, human feces, detergents, dyes, bleach, pharmaceuticals, and anything else poured down residential, commercial or industrial drains.

When the sewer pipes reach their capacity of volume, an overflow system is triggered and the excess effluent is discharged at combined sewage overflow (CSO) points, which are located on nearby water bodies. There are 450 CSO outfall points in water bodies throughout NYC, each of which is connected to the drainage system of a sub sewershed.



This map shows the areas of land that drain to Newtown Creek during a rainstorm and which CSO outfalls each area drains to, or the CSO-shed. (Source: Korin Tangtrakul NYC Soil & Water Conservation District)

City wide, 27 billion gallons of stormwater runoff and untreated sewage are discharged into NYC water bodies each year. CSO events pollute the Creek with pathogens, nutrients (too much of a good thing becomes a bad thing in this case - see algae blooms), sediment, debris, chemicals, oil and more. This contamination comes from normal daily business and household activity in the Newtown Creek sewershed during a rainstorm, including flushing toilets and draining sinks, along with all of the untreated runoff from streets. Combined sewer overflow is the primary source of ongoing contamination coming from the sewershed that negatively impacts the water quality of the Creek.

CSO & Stormwater Discharges into Newtown Creek

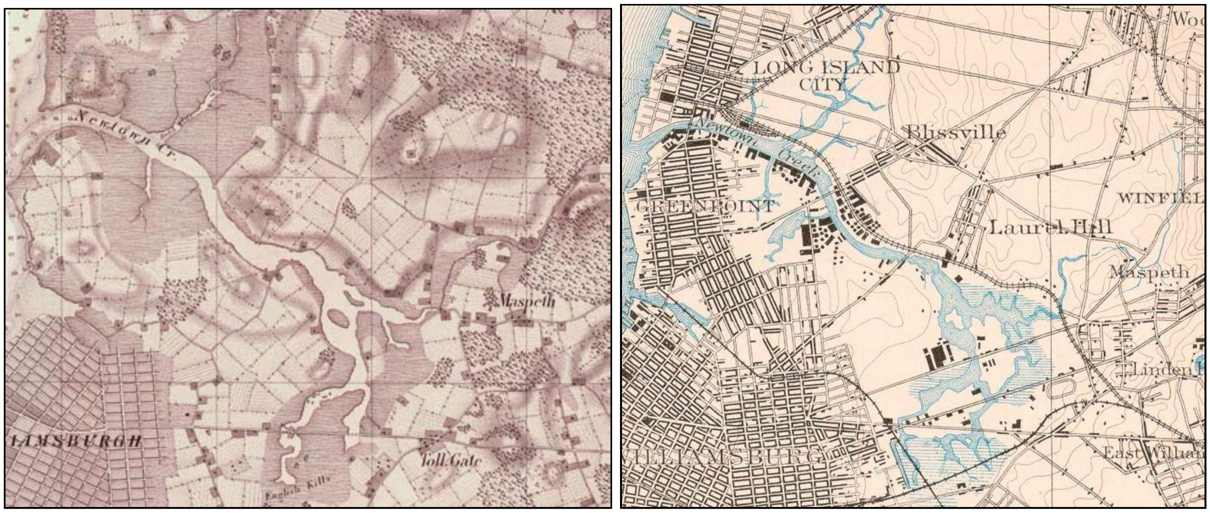
Type of Event	Number of Events[(a)]	Total Annual Volume[(b)]
CSO Discharge	438	1,162.9

Notes:
(a) from 22 individual outfalls located around the Creek
(b) Measured in millions of gallons

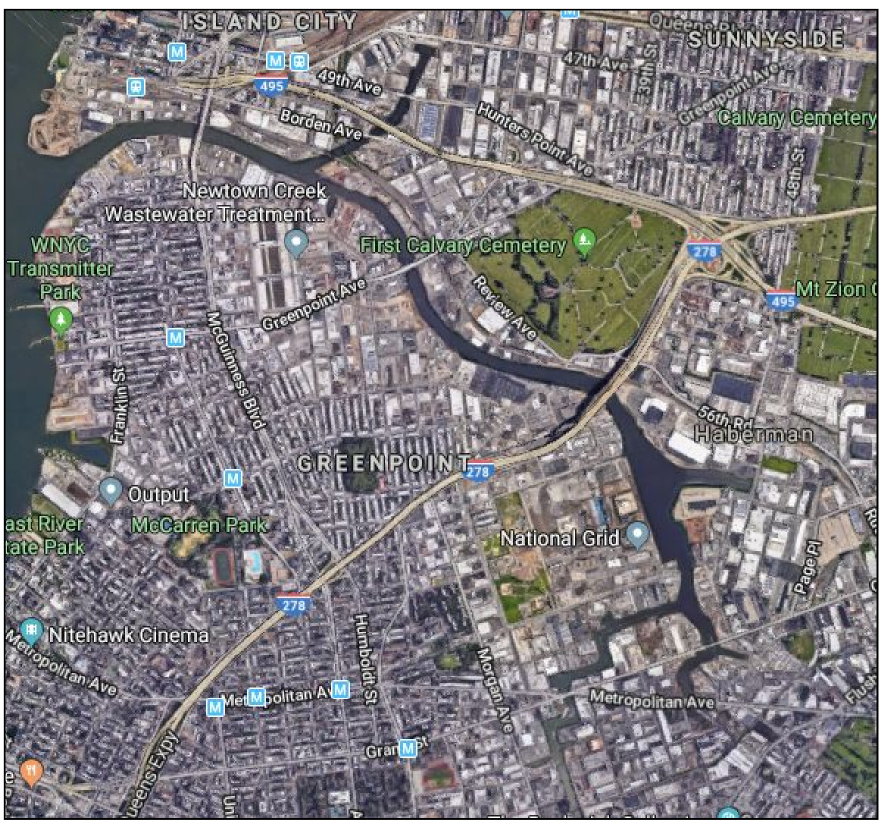
Source: 2017 Long Term Control Plan NYCDEP

Background on Newtown Creek Watershed & Sewershed.

Why do we have problems with Combined Sewer Overflow today? Today's Newtown Creek Sewershed functions as a drainage system, but in a very different way than the historic tidal Creek, salt marsh and cultivated land that once surrounded this body of water.



These two images show the transition of the land surrounding Newtown Creek changing from thousands of acres of salt marsh and few farms in 1844 (left) to 1891 communities around Newtown Creek already beginning to develop and heavy industry is already present.



Today, all of the land surrounding the Creek, except for First Calvary Cemetery, is heavily built up.

Key Changes in the Newtown Creek Watershed during Urbanization of the 1800's

• Much of the ground surface that previously absorbed rainwater was covered with non-absorptive (impermeable) paved streets and buildings.
• Sewers were built to direct rainwater into underground pipes, which either discharge directly into the Creek or connect into the combined sewer system that overflows into the Creek.

Population growth and industrial activity in Brooklyn caused increased trash and sewage, which was often dumped directly into nearby water bodies. This waste caused water bodies all over NYC, including the Newtown Creek, to become cesspools of pathogens. Poor water quality negatively impacted human, plant and wildlife health and destroyed populations of native aquatic species, such as oysters. The city began constructing sewer and water treatment infrastructure to manage waste and create more sanitary conditions. The construction of the sewer system changed the way that water flowed across the urbanizing landscape and created a patchwork of 14 areas of land across NYC called sewersheds.

Sewershed infrastructure is comprised of roads, drains, pipes, overflows and treatment plants. Every impermeable road has at least a slight slope along its length and width, to move water to a drain at the low point, generally next to the curb. Water runs down to the curb, and along the curb to the drain. The drain connects to underground pipes that either discharge directly into nearby waterbodies, or connect into the combined sewer system and nearest wastewater treatment plant.

The Newtown Creek Sewershed/Watershed area includes the neighborhoods of Greenpoint, East Williamsburg, Bushwick, Bed Stuy, Crown Heights, Ridgewood, Maspeth, Sunnyside, and Long Island City it also includes parts of the Upper East Side, Lenox Hill, Midtown East, Murray Hill, the East Village, Greenwich Village, Tribeca, Lower East Side, Two Bridges, and Battery Park, all Manhattan neighborhoods. Just about 1.2 million people live in the Newtown Creek sewershed/watershed area, 658,400 in Brooklyn, 33,900 in Queens and 484,200 in Manhattan. It includes residential, industrial and commercial land use. Before these neighborhoods in the three different boroughs were built and before the Creek's edges were hardened with bulkheaded edges, water would infiltrate into the ground or flow across this watershed to the tidal creeks that flowed into a salt marsh. The salt marsh Creek functioned as a natural drainage system during rainstorms, tides and flooding.

Accumulated Newtown Creek Watershed & Sewershed Data

	Acreage	Approximate Population	Approximate Stormwater: 1" storm
Brooklyn	9,045	658,400	245.60
Queens	1,272	33,900	34.53
Manhattan	3,744	484,200	101.63
Totals	**14,061**	**1,176,500**	**381.76**

This table shows the area, population, and approximate stormwater runoff during a 1 inch storm in the three boroughs that rely on the Newtown Creek Waste Water Treatment Plant (the sewershed) to manage waste water.

Improvements to Stormwater Management

While the Creek continues to be polluted by combined sewer overflow, there are coordinated efforts underway to positively improve its water quality. One strategy is to reduce CSO through **Green Infrastructure (GI)**.

In New York City, Green Infrastructure (GI) describes an array of practices that use or mimic natural systems to manage urban stormwater runoff. Green Infrastructure controls stormwater by using it as a resource rather than a waste. Water is either directed to engineered systems for infiltration or detained at a slower rate into the ground, and/or vegetative uptake and evapotranspiration before it enters the combined sewer system.

A NYC Rain Garden (also known as a bioswale) captures stormwater as it flows down the street. (Source: NYC Department of Environmental Protection)

NYC has identified priority watersheds that have high rates of combined sewage overflow causing very low water quality. Under the Federal Clean Water Act, the NYC Department of Environmental Protection is required to improve the water quality of these waterbodies by limiting the discharge volume during CSO events. GI is an integral strategy in the DEP Long Term Control Plan (LTCP) for achieving higher water quality standards. DEP is the city agency primarily responsible for NYC water and is the governmental agency that constructs Green Infrastructure.

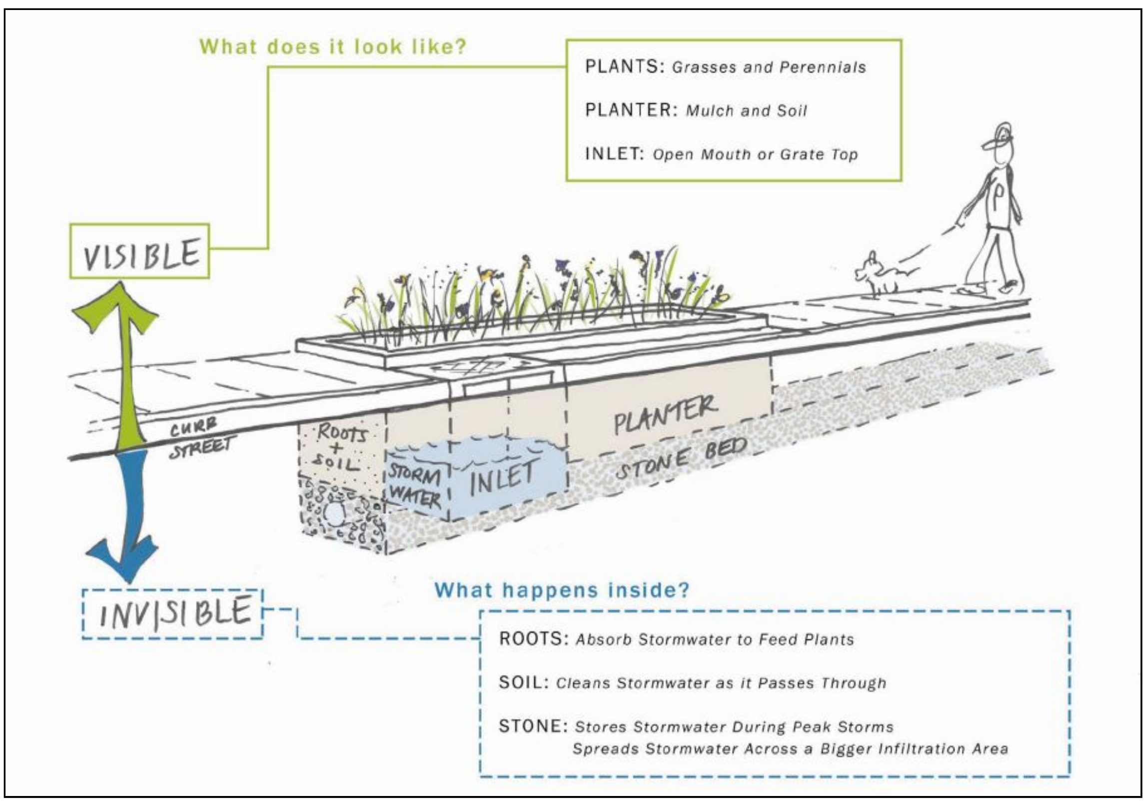
Rain Gardens

A rain garden is also scientifically known as a bioswale. “Bio” comes from the Greek meaning “life” and a “swale” is a low-lying or hollow stretch of land, especially a wet or marshy depression between ridges. Therefore it can be understood as a sunken, planted area that absorbs and retains rainwater as it runs along a street towards a sewer drain.

Bioswales can manage about a 1-inch rainfall — most of the rain events in NYC are 1.2 inches and below. They are not designed to manage significant flooding or sea level rise, but can reduce the burden on the sewer system from rain storms, thus decreasing sewage overflow into local waterways like Newtown Creek. The typical 20’L x 5’W bioswale can capture roughly 2,244 gallons of stormwater during one storm.

Starting in 2015, thousands of bioswales have been constructed across NYC in order to manage stormwater runoff, including hundreds in the Newtown Creek Watershed.

Once bioswales are built they need ongoing maintenance in order to be effective for stormwater management. Litter and sediment can build up and block inlets and outlets; plants need to be pruned and weeded, and soil needs to be graded. While the city takes care of most bioswales, volunteers have an important role in helping to maintain these important gardens.



What a bioswale looks like underground. (Source: NYC Department of Environmental Protection.)

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Other Solutions to CSOs and increased stormwater absorption

• Greenstreets could decrease CSOs by 14,800 gallons
• Street trees could decrease CSOs by 13,170 gallons
• New green roofs could decrease CSOs by 810 gallons; retrofitted green roofs could decrease CSOs by 865 gallons; and incentivized green roofs could decrease CSOs by 12,000 gallons
• Rain barrels could decrease CSOs by 9,000 gallons.

Types of GI include:

• Bioswales
• Blue Roofs
• Stormwater Detention tanks
• Stormwater Greenstreets
• Rain Gardens
• Cisterns & Rain Barrels
• Green Roofs
• Permeable Paving

Right-of-Way (ROW) Bioswale | Greenstreet | Green Infrastructure Playgrounds
Green Roof | Rain Garden | Cistern
Blue Roof | Porous Concrete | Permeable Pavers

(Source: Riverkeeper)

Vocabulary

Vocabulary Note: Some of this vocabulary is referenced in other parts of this curriculum. All vocabulary and definitions appear in the glossary of the curriculum.

Background Vocabulary:

brackish
bulkhead
canal
conservation
contaminate
ecosystem
estuary
habitat
organism
pollutants
pollution
stewardship
toxic
urban
water cycle

Essential Vocabulary:

adaptation
bioswale
buffer
catch basin
conservation
combined sewer system (cso)
combined sewer
detention
discharge
drainage
erosion
field site
floatables
flood zone
green infrastructure
green roof
groundwater
impermeable
impervious
infrastructure
outfall
permeable
point source pollution
retention
runoff
stormwater management
sewershed
storm drain
topographic map
topography
urban ecology
watershed

Lesson I Watershed & Sewershed Models

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Watersheds and sewersheds are two different systems that water moves through and both are vital for the health of a community. There are complex relationships between humans and the environment in relation to both watersheds and sewersheds. Students will explore 3D models of general watersheds and sewersheds (either bought or handmade) in order to understand how they work and how they compare to each other. Watersheds are topography based and reflect how water moves in according to gravity and geography. Sewersheds are made entirely of human-made *built* systems. Simply put, watersheds run down hills and sewersheds through pipes.

Learning Objectives

- Students will understand and explain how water flows through a watershed.
- Students will understand and explain how water flows through a sewershed.
- Students will understand and explain how a combined sewer works.
- Students will describe the difference between a watershed and sewershed.
- Students will understand the relationship between the environment and a watershed system and sewershed system.
- Students will understand the relationship between humans watershed and sewershed systems.

Vocabulary

Try to incorporate vocabulary words from the “Watershed & Sewershed Introduction” word list throughout the lesson.

Tips for Teachers

- Consider using and/or modifying portions of the Watershed & Sewershed Teacher’s Introduction or one of the other Units as a text for your students.
- In this lesson students make their own, simple watershed and sewershed models. You can also buy watershed and sewershed models.

- Watershed models are expensive and bulky to store, but can last many years if well cared for. www.enviroscape.com
- A great sewershed model is called "Sewer in a Suitcase" and made by the Center for Urban Pedagogy (CUP). http://welcometocup.org/Projects/Workshops/SewerInASuitcase
- Both homemade and purchased models work best with students in small groups.
- Consider having students stand, instead of sit, around the models so they can easily see all aspects of the model.
- If you use a model as a demo in front of the whole class take extra care to make sure all students can see the model.

Activity #1 Create A Watershed (Short Version)

Students will create a watershed model in the classroom to represent their local watershed. Teachers prepare materials ahead of time as this lesson will take some set-up and clean up.

Materials

- paper (photocopy paper works well)
- permanent marker
- washable marker
- spray bottle
- water

Procedure

1. Separate students into pairs or small groups.
2. Pass out 2 pieces of paper and markers to each group.
3. Crumple up the two pieces of paper together.
4. Open both papers on the desk and separate the papers so the students have two similar, hilly terrains (i.e. two watershed models).
5. Draw the ridgelines (high points) on both models to mark the watershed boundary using permanent marker.
6. Explore the different parts of the model (e.g. hills and valleys).
7. Spray one of the two models with water using the spray bottle and discuss results.
8. Set aside the first model (that is now wet).
9. Name and then place different pollutants on the second model using the

washable marker.
10. Spray the second model with water and discuss results.

Activity #2 Create A Watershed (Extended Version)

This is an extended version of Activity #1 using more materials and thus more time. Students will create a watershed model using more materials in the classroom to represent their local watershed. Teachers prepare materials ahead of time as this lesson will take some set-up and clean up.

Materials

- large aluminum tray
- several pieces of paper (newspaper or variety of colored powders or dyes (cocoa, fruit drinks, food coloring, etc.),
- spray bottle
- water.

Procedure

- Separate students into pairs or small groups.
- Pass out paper, tape, aluminum foil or plastic wrap, and small model pieces to each group.
- Crumple several pieces of paper.
- Place paper in aluminum pan to represent different elevation levels of land. Use tape if necessary.
- Cover the paper with aluminum foil or plastic wrap.
- Place small model pieces on the watershed if desired.
- Explore the different parts of the model (e.g. hills, valley, river, creek, estuary).
- Spray the model with water using the spray bottle and discuss results.
- Name and then place different pollutants (i.e. powders and food coloring) on the model.
- Spray the now polluted model with water and discuss results.

Discussion Questions

Note: Discussion questions are designed to be inserted throughout the procedures.

1. What is a watershed?
2. Why are watersheds important?
3. What are the features of a watershed that we represented in our model?
4. How does water flow in the watershed?
5. What features are similar to something you know or have seen in the Creek?
6. Sketch your watershed model. Add to your sketch throughout the procedure.
7. What do you predict will happen when you spray water on your watershed model?
8. What happened when you sprayed water on your watershed model? Record your observations in words and/or diagrams.
9. Which direction did the water flow? What factors influence the direction of the water flow?
10. Where did the water collect? Explain why it's collected there.
11. Where does the water collect in the Creek watershed?
12. Name some different types of things you might find that could pollute the Newtown Creek watershed? (Think about what you see on the street outside your school.)
13. What do you predict will happen when you spray water over the pollutants on your watershed model?
14. What happened to the pollutants when you sprayed water over them?

Activity #3 Create A Sewershed

Students will create a sewershed model in the classroom to represent a real sewershed in their neighborhood. Teacher prepare materials in advance, as it will take time to set-up and clean-up.

Materials

- Yogurt container - 32 oz.(*Prep the yogurt containers by carefully cutting two holes: a dime-sized hole in the bottom-center of the yogurt container and a second, stamp-sized hole in the side of the yogurt container approximately a half-inch up from the bottom).*
- Knife
- Permanent marker

- Aluminum tray
- Small cup
- Large cup
- Coffee filter - large
- Rubber band
- Glitter
- CSO Diagram

Procedure

1. Separate students into pairs or small groups.
2. Pass out materials.
3. Place the coffee filter on the bottom of the yogurt container and secure in place with rubber band. Be careful NOT to cover the hole on the side of the container.
4. Fill the small cup with water and mix in glitter.
5. Discuss what the mixture represents. Then write “Sanitary Sewer” on the small cup.
6. Hold yogurt container over the aluminum tray, pour “Sanitary Sewer” effluent into the yogurt container and discuss results. (The coffee filter should catch the glitter and the filtered water should pour out the hole in the bottom of the yogurt container.)
7. Discuss what each part of the model represents. Then label the yogurt container “Newtown Creek Sewershed,” the coffee filter “Sewage Treatment Plant”
8. Refill the small cup with water and mix in glitter.
9. Fill the large cup with water and mix in glitter.
10. Discuss what the mixtures represent, then write “Storm Sewer” on the large cup.
11. Quickly pour both the “Sanitary Sewer” and “Storm Sewer”” effluent into the yogurt container (i.e. create a rainstorm) and discuss the results. (The coffee filter should continue to catch some glitter, but some water and glitter should also flow out the hole in the side of the container.)
12. Discuss what each part of the model represents. Then label the hole in the side of the container “Combined Sewer Outfall (CSO).” *See Teacher’s Introduction and Resources at the end of the Unit for more on CSO’s.*
13. Students receive the CSO Diagram and use it to compare and contrast with their model.

Discussion Questions

Note: Discussion questions are designed to be inserted throughout the procedures.

- Describe what the sewershed model looks like. What features does it include?

- Sketch your sewershed model. Add labels to your sketch throughout the procedure.
- What is a sewershed? How is it different from a watershed?
- What features are similar to something you know or have seen in the Newtown Creek sewershed?
- Why are sewersheds important?
- What are the features of a sewershed that we represented in our model?
- How does water flow in the sewershed?"
- What is a sanitary sewer? What does it connect to? What kinds of waste or pollutants might you find in a sanitary sewer?
- What is a sewage treatment plant? What happens to the sewage there?
- What do you predict will happen when you pour the sanitary sewer effluent into the Newtown Creek sewershed? What did happen? What was the result? What role did the coffee filter play?
- What is a storm sewer? What does it connect to? What kinds of waste or pollutants might you find in a storm sewer?
- What is a combined sewer? What does it connect to? What kinds of waste or pollutants might you find in a combined sewer?
- What does CSO stand for?
- What do you predict will happen when you pour the combined sewer effluent into the Newtown Creek sewershed? What did happen? What was the result? What role did the hole in the side of the yogurt container play?
- How could you reduce the pollutants in the sanitary sewer?
- How could you reduce the pollutants entering the storm sewer?
- How could you reduce the amount of water and pollutants coming out of the CSO?
- What are some larger scale actions that could reduce the amount of pollutants affecting the Newtown Creek sewershed?
- What types of Green Infrastructure or other possible interventions could be designed and built that would help prevent pollutants from entering Newtown Creek?
- Describe the similarities and difference between the watershed and sewershed.
- (If you read some background information from the Watershed and Sewershed Introduction) How does the information you read about watersheds and sewersheds compare and contrast to your sewershed experiment?

Lesson II Newtown Creek Watershed and Sewershed Maps

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Newtown Creek is part of a large estuary and also has it's own watershed and sewershed. In this lessons students will expand their knowledge about watersheds and sewersheds by focusing on their local waterway as an example. Students will explore various maps of the Newtown Creek Watershed and Sewershed in order to understand how water and other materials flow through them. This lesson will allow them to become familiar with map reading and the topography and geography of Newtown Creek.

Learning Objectives

- Students will become familiar with reading and understanding topographic maps.
- Students will determine where the water flows on a topographic map of the Creek.
- Students will compare the boundaries of the Newtown Creek Watershed and Sewershed.
- Students will learn about the different pollutants that exist within the Newtown Creek Watershed and Sewershed and how they're managed.
- Students will predict how pollutants move through the Newtown Creek Watershed and Sewershed.

Time

45 minutes

Vocabulary

Incorporate Watershed & Sewershed vocabulary words throughout the lesson.

Tips for Teachers

- Consider using and/or modifying portions of the Watershed & Sewershed Introduction as a text for your students.

Map Exploration Activity

Materials

Required

- Newtown Creek Topographic Map
- Newtown Creek Topographic Map with Watershed Outline
- Newtown Creek Topographic Map with Watershed and Sewershed Outline
- Markers
- Colored pencils
- Eye droppers
- Water
- Newtown Creek Street Map with Watershed and Sewershed Outline
- Newtown Creek Watershed Map with Water Flow Arrows
- NYC Map with Newtown Creek
- Newtown Creek Sewershed Map
- New York City Topographical Map
- Newtown Creek Sub-sewershed Map

Optional

Procedure

1. Hand out the **Newtown Creek Topographic Map**.
2. Explain how contour lines show elevation on topographic maps.
3. Color contour rings to see differences in elevation.
4. Use the eye droppers to drip water on either side of the ridgeline and record where the water goes.
5. Hand out a **Newtown Creek Topographic Map *with Watershed Outline***.
6. Compare their your own ridgelines to the watershed outline.
7. Draw arrows on the Newtown Creek Topographic Map with Watershed Outline to indicate the flow of water.
8. Hand out the **Newtown Creek Topographic Map with Watershed *and Sewershed Outline***.
9. Review the definition of sewershed and compare the similarities and differences between the watershed and sewershed boundaries.
10. Hand out the **Newtown Creek *Street Map* with Watershed and Sewershed Outline**.
11. Mark your school, your home or another significant landmark on the map with an ‘X.’

12. Draw an arrow that predicts how water would flow from this location. (You may need to provide an additional resource like Google Maps or a street map in order for students to pinpoint their location.)

Discussion Questions

- What is a topographic map? What are contour lines?
- How are topographic maps helpful when studying watersheds?
- Look at the topographic map of the Newtown Creek Watershed. Describe what you see. Where are the contour lines far apart? Close together? Where do they create circles?
- What does the topographic map tell you about land and shape of the Newtown Creek Watershed?
- Compare the ridgelines you drew to the Watershed Outline map. Where are they the same? Where are they different?
- What could account for the differences between the ridgelines on the two maps?
- Where is the steepest topography on the map? What is at the top of this hill? What is at the bottom? What is the name of this neighborhood?
- What factors cause water to flow toward Newtown Creek?
- Knowing where the sewershed is, how does that change where or how you would draw your arrows on the map? Why?
- What do you predict will happen with water that falls within the Newtown Creek watershed, but outside the sewershed? (see the map for areas that do NOT overlap).
- After reviewing these maps, what do we know about Newtown Creek as a watershed and as a sewershed?
- Where would the precipitation flow that originates where you drew an ‘X’?
- List pollutants you have seen at the location where you drew an ‘X’. What would happen to these pollutants during a rainstorm?
- Where do you predict pollutants would end up considering both the watershed and the sewershed and any other contributing factors? Explain why.
- How could we minimize the effect of pollutants on the Newtown Creek Watershed and Creek based on what we know about how water flows through the watershed and sewershed?
- How are maps a helpful resource in providing us information about a specific place?

Lesson III Permeable vs. Impermeable Surfaces

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Permeable surfaces absorb water and impermeable surfaces do not. This is a very important concept for how stormwaters, and therefore waste, flows in a watershed and sewershed system. Students will soak up water with different types of sponges and pour water on different outdoor surfaces to understand the differences, and the pros and cons of permeable and impermeable surface. Sponges are an excellent representation of how different types of ground interact with stormwater. Some absorb a good deal of water, like highly permeable soil, some only a little, just like compacted soils, and some not all, like asphalt and much of the built environment. Understanding these concepts and term terms is important for the Applied Learning Lesson especially in relation to green infrastructure.

Learning Objectives

- Students will understand how some surfaces absorb water
- Students will compare the difference between a permeable and impermeable surface
- Students will draw conclusions about what types of surfaces do the best job absorbing water and the value of those permeable surfaces
- Students will compare surfaces in the Newtown Creek Watershed and Sewershed and describe which ones are more desirable for the ecosystem

Time

45-90 minutes

Vocabulary

See Watershed & Sewershed Introduction for a list of vocabulary words from which to choose

Tip for Teachers

- This lesson ties in very closely to the Flora and Fauna Mini-Unit. You could easily change what the different types of sponges represent to correspond with different types of plants and trees.
- Consider using and/or modifying portions of the Watershed & Sewershed Introduction or the Flora & Fauna Introduction as a text for your students.

Materials

- Observation/Inference Chart
- Surface Types Examples in the Newtown Creek Watershed
- Aluminum trays
- Water
- Aluminum foil (or something else non-absorbent like fleece or wool) different types of sponges. Below are some suggestions as to what different types of surfaces different types of sponges could represent in the watershed.
- Water bottle
- Sponges

Sponges

- Sponge surface diagram
- Car-washing sponge to represent loose, very permeable soil.
- Green scouring sponge to represent compacted, barely-permeable soil.
- Hard sponge that has totally dried up for the “bone-dry sponge”.
- Dishwashing sponge to represent compacted, less-permeable soil.
- Aluminum foil, or even certain types of fleece or wool (something that does not absorb liquid to represent an impermeable surface.)

Activity #1: Surface Type Exploration/Teacher Demonstration

Procedure – Surface Types Exploration

Teacher Demonstration

1. Separate students into small groups.
2. Hand out Observation/Inference Chart.

3. Each group gets an aluminum tray, a measuring cup and several types of sponges.
4. Observe the different sponges and describe what they look like in the “Observation” section of the Observation/Inference Chart.
5. Predict which sponges will hold the most water based on the observations and record predictions in the “Inferences/Predictions” section of the Observation/Inference Chart.
6. Fill the aluminum tray with a 1⁄2 inch of water.
7. Place one sponge in tray and gently hold down for 10 seconds. Do not touch the sponge in any other way!
8. Take sponge out and squeeze it into the measuring cup and record results in the “Notes/Results” section of the Observation/Inference Chart.
9. Do this with each sponge.
10. Compare your predictions with your results.
11. Hand out the Surface Types Example in the Newtown Creek Watershed.
12. Compare the results of the sponge experiment with the Surface Types Example in the Newtown Creek Watershed.

Discussion Questions

- Which sponge held the most water? Why do you think this was the case?
- Which sponge held the least? Why do you think this was the case?
- How did the size of the holes in the sponge relate to how much water it could hold?
- How did the absorption of the impermeable object (i.e. the aluminum foil or the wool) compare to the sponges?
- Which sponges match which surface types best? Explain why.
- Where in the Newtown Creek Watershed would you expect to find these different surface types? Where would you find impermeable surfaces? Where would you find highly permeable surfaces?
- What are some of the pros and cons of impermeable surfaces? (e.g. Impermeable surfaces are better to play basketball on because you can’t dribble on gravel, but impermeable surfaces create a lot of runoff.)
- What are some pros and cons of permeable surfaces?
- Why are permeable surfaces important for absorbing water?
- Why are they important in relation to the health of the Creek?

Activity #2 Surface Type Exploration

Procedure – Dry vs Damp Sponges/ Water Absorption

1. Use the Observation Chart.
2. Hand out one sponge that is “bone dry” and one that is damp (wet all the way through and wrung out).
3. Observe the two sponges and describe what they look like in the “Observation” section
4. of the Observation/Inference Chart.
5. Predict which sponge will hold more water and how much water each will hold.
6. Record predictions in the “Inferences/Predictions” section of the Observation Chart
7. Place sponge in tray and gently hold down for 10 seconds. Do not touch the sponge in any other way.
8. Take sponge out and squeeze it into the measuring cup and record results in the “Notes/Results” section of the Observation/Inference Chart.
9. Do this with each sponge.
10. Compare your predictions with your results.

Discussion Questions

- Which sponge held the most water? Why do you think this was the case?
- Which sponge held the least? Why do you think this was the case?
- Why do you think one type of sponge holds more water than the other?
- How does the wetness of the soil relate to the soil’s ability to hold water?
- How do the dry and damp sponges compare to the environment? Which surface types are like the dry sponge? Which surface types are like the damp sponge?
- In the Newtown Creek Watershed why might we want some surfaces to absorb rainwater? Why might we want other surfaces to cause rainwater to runoff?
- Which surface types are more desirable for the health of the Newtown Creek and watershed ecosystems? Explain your answer.
- (If you read some background information from the Watershed and Sewershed or Flora and Fauna Introduction) How does the information you read compare and contrast to your experiment? Cite specific parts of the text.

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Activity #3 - Explore the Schoolyard

Materials

- Observation/Inference Chart
- Water bottles or bucket

Procedure

1. Use the Observation/Inference Chart.
2. Take students outside, around the school grounds.
3. Observe, list, and describe all the different surfaces they encounter (concrete, asphalt, tree pit, grass, mulch, etc.) in the “Observation” section of the Observation/Inference Chart.
4. Predict which surfaces are permeable and impermeable, based on the previous sponge experiments and record predictions in the “Inferences/Predictions” section of the Observation/Inference Chart.
5. Choose one particular surface type to experiment on.
6. Using your water bottle or bucket, pour water on your chosen surface type.
7. Record results in the “Notes/Results” section of the Observation/Inference Chart.
8. Compare your predictions with your results.
9. Repeat steps 5-7 as many times as you have time for.
10. Compare how quickly the water is absorbed (if at all) on the different surfaces.

Discussion Questions

- What types of surfaces did you observe in your schoolyard?
- Based off your observations, how do you imagine rainwater flowing in your schoolyard?
- Which types of surfaces will create the most runoff?
- Which types of surfaces do we see the most of in the Newtown Creek Watershed?
- How do you think the different surfaces will impact the Newtown Creek ecosystem?
- Which surfaces do you think generally have a positive impact on the ecosystem? Why?
- Which surfaces do you think generally have a negative impact on the ecosystem? Why?

Field Lesson: Watershed and Sewersheds

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

This is an opportunity to bring your students outdoors and introduce them to various aspects of the Newtown Creek watershed and sewershed and to specifically look at the permeable and impermeable surfaces in the Newtown Creek watershed/sewershed. Hands-on and place based experiential learning adds dimensions to learning that is difficult to recreate in the classroom. The field lesson can be applied to any Field Trip Site listed below.

Suggested Field Trip Sites (please refer to Field Trips Section of Intro Unit for site-specific details).

1. McCarren Park Demonstration Garden
2. Kingsland Wildflowers Rooftop
3. Manhattan Ave. Street End Park
4. Newtown Creek Nature Walk

Learning Objectives

- Students will practice applying their knowledge in a classroom to a specific location in the field.
- Students will become familiar with how a local waterway can function both as part of a watershed and a sewershed.
- Students will observe different types of land surfaces next to the Creek.
- Students will observe, map and record surface land type.
- Students will compare and contrast how water and pollutants move over different land surfaces.
- Students will explain impacts of CSOs on the Creek.
- Students will discuss different ways to reduce the negative impact of CSOs.
- Students will practice making observations on both the natural and built environment and the relationship between water and waste systems.

Time
Can vary from 60 minutes to several hours

Vocabulary
See Watershed & Sewershed Introduction for a list of vocabulary words from which to choose.

Tips for Teachers
- Choose one or more of the sites listed in the Newtown Creek Field Sites Information section of the Curriculum Introduction.
- Always visit the Field Site prior to bringing your students there.
- Consider using and/or modifying portions of the Watershed & Sewershed Introduction as a text for your students.

Discussion Points
For each discussion point, decide which teaching method works best for you and your students. You may want to directly point to a particular a feature of the watershed/sewershed and describe it or you may want students to scavenger hunt for a feature or something in-between.
- Topography
- Watershed vs. sewershed
- Built vs. “Natural” environment
- Different forms of pollutants (e.g. litter, oil, detergents, sediments)
- Point source vs. non-point source pollution
- Permeable vs. impermeable surfaces
- Direct runoff vs. conservation buffer
- Green Infrastructure
- Retention and Detention of stormwater
- Soft shore vs. hard shore (i.e. bulkheads)
- CSOs and storm drains
- Flood management
- Stewardship of watershed

Group #1 Activity - Mapping the Permeable and Impermeable Surfaces

Materials

- Clipboards
- Journals
- Ruler, yardstick or tape measure
- Land Surface Survey
- Site Map (for your chosen Field Site)

Procedure

1. Separate students into small groups.
2. Hand out a Site Map and a Land Surface Diagram to each group.
3. Stand in a central area on the site with the whole class and compare the boundaries on the Site Map to where those boundaries are on the actual site.
4. Assign each group an area to survey. If you have more than one group working in an area, have them start on opposite sides.)
5. Students identify all the different surface types in their area and other observations on their Land Surface Survey .
6. ***Optional:*** Students pace out the length and width of each surface area and draw it on the Site Map as accurately as possible. For example, students may pace out the size of a sidewalk, the size of a tree pit and the size of a patch of bare soil.
7. ***Optional:*** Allow students to problem solve how they can pace out the areas accurately. You may also choose to provide them with a measuring tool such a ruler, yardstick or measuring tape.
8. Students note any other features of their area on the Site Map (e.g. trees, piles of trash, bulkhead, soft shore, etc.)
9. Bring Site Map, Land Surface Surveys and all data back to the classroom for
10. the Post Lesson.

Group #2 Activity - Make It Rain

Materials

- Clipboard
- Observation Inference Chart
- Water

Procedure

1. Find ways to bring water with you in the field. For example:

   a. carry a gallon jug of water
   b. have each student carry an extra bottle of water for this purpose
   c. portable water sprayer ($50-$100)
2. Hand out the Observation Inference Chart.
3. At each possible location on your walking tour have the students predict what will happen when it rains at that location. Will the pollutants on the street (litter, oil, etc.) enter the storm drain or runoff directly into the Creek?
4. Pour water on the street. Try to choose a location that has at least a slight grade to it so that the water will clearly flow downhill. Try to choose a location that has some litter or sediment that will flow along with the water.
5. Have the students observe and record the results as the water flows.
6. Compare the results to their predictions.

Group #3 Activity - Litter Picker

Materials

- Garbage bags
- Disposable gloves
- Hand sanitizer
- Trash Grabbers

Procedure

1. Have students predict what will happen to the litter in the next rainstorm.
2. Discuss the specific issues litter presents for our water bodies (e.g. animals confuse it for food).
3. Have students pick up litter and bag it.
4. Bring it back to the school and weigh it.
5. Give prizes to the students who collected the most litter.

Journal Prompts

We recommend having students write in their journals at the end of the field experience and consider some or all of the following questions. Also refer to the “Journal Writing” section of the **Introduction & Methodology** for more suggestions about journaling.

- Where along your walking tour did you see examples of the watershed? The sewershed?

- How has the human population and consumption of resources in the Newtown Creek Watershed impacted the Creek's ecosystem?
- What pollutants did you observe? Describe them in detail including material, size, shape, color, smell, etc.
- Where did you predict these pollutants may end up after a rainstorm?
- In your opinion, which pollutant that you observed would be most harmful to the health of the Creek?
- What evidence do you have to support your opinion?
- Describe something you observed along your walking tour (that is either part of the built environment or the urban ecology) that you believe helps improve the health of the Creek? Describe in detail.
- Choose a location along your walking tour that is in need of improvement. What could you design/propose/build at that location that would help improve the health of the Creek?

Applied Learning Lesson: Designing Green Infrastructure Improvements to the Newtown Creek Watershed

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Design Challenge

Activity Overview

Green infrastructure mimics the natural water cycle by creating permeable surfaces, designed to absorb water. This is critical, especially in urban areas with old infrastructure (CSO's) and heavily built communities with a good deal of precipitation. Based off of previous Lessons and their experience in the field, students will apply their knowledge to design and develop ways to improve water quality and ecosystem health of Newtown Creek. Students will have the opportunity to share their green infrastructure recommendations and ideas with Newtown Creek Alliance and other members of the community.

Learning Objectives

- Students will name and locate on a map the sites visited during the Field Lesson.
- Students will use collect data to calculate and graph percentages of permeable and impermeable surfaces at the design site.
- Students will apply their previous knowledge to design site improvements that will increase stormwater absorption or collection in the watershed.
- Students will practice applying their knowledge from the classroom to a real world issue and specific local place.
- Students will learn the importance of building a relationship with a specific site over time.
- Students will gain experience designing green infrastructure improvements to benefit a local waterway that has been historically polluted.

Time

45-90 minutes

Vocabulary

See Watershed & Sewershed Introduction for a list of vocabulary words from which to choose.

Tips for Teachers

- Remind students that they do not need to be proficient artists when doing sketches. Stick figure drawings will suffice.
- Consider using and/or modifying portions of the Watershed & Sewershed Introduction as a text for your students.

Materials

Materials from Field Lesson (completed)

- Site Map (and blank copy)
- Surface Types Examples in Newtown Creek Watershed
- Journal entries
- Other student work (e.g. photos)
- Google image of Newtown Creek Neighborhood
- Green Infrastructure Images

Design Procedure

1. Separate students into the small groups. You may choose to use the same groups they were in during the Field Lesson or new groups. Consider whether you want the students in the group to have worked on the same area in the field or different ones.
2. Hand out the Site Map (Manhattan Ave Street End Park)
3. Review the Field Sites visited during the Field Lesson.
4. Mark on the Newtown Neighborhoods Map the location of the Field Site(s) visited.
5. Each student in the group shares some observations or thoughts about their field site based on their worksheets and/or journal entries. Students, think back to what you observed in the field!
6. If you visited more than one Field Site during the Field Lesson, choose one Field Site on which to focus.
7. Use the Site Maps and Land Surface Survey from the Field Lesson to calculate the percentage of permeable and impermeable surface on their site.
8. Graph the percentages of permeable and impermeable surface.
9. Review the Discussion Questions below, referring to the information from your Field Lesson (i.e. Site Map, Land Surface Survey, journal entries).
10. Each student gets a clean copy of the Site Map.

11. Brainstorm ideas that will increase stormwater retention on the field site.
12. Each student uses the brainstorm ideas to sketch the site improvements for stormwater retention on the clean Site Map.
13. Each student presents and explains his/her design to the group.
14. The group members critique each others' designs and write down the best elements from each sketch.
15. Hand out Green Infrastructure Images.
16. Compare the Green Infrastructure Images with the list of best elements from each sketch and decide if there is any other elements you want to include in your design.
17. The group gets a clean copy of the Site Map.
18. The group works together to create ONE final design incorporating the best elements from each individual's design.
19. The group works together to write an explanation and defend each element of their design.
20. Groups recombine so all students are with new group members.
21. Each student shares the sketch and explains the design with the new group members.

Discussion Questions

1. Describe your Field Site, its location and what surrounds it.
2. What types of pollutants did you observe on the Field Site?
3. What types of human behaviors lead to these pollutants being in the watershed? (e.g. littering, dumping chemicals down storm drains, not securing garbage can lids)
4. How will water move over this Field Site when it rains? Where will it go?
5. What will happen to the pollutants when it rains?
6. Where is stormwater being retained on this Field Site?
7. Where is stormwater draining into the sewer system?
8. Where would more permeable surfaces be beneficial? Why?
9. What types of additional permeable surfaces would work best this Field Site? Why?
10. What is green infrastructure and why is it important, especially in urban areas?"
11. "How will your design improvements help the health of the Creek?
12. Why is your design worth building?

13. How does it feel to design something that could help your local waterway?

Extension Lesson – Bronx River Compare and Contrast

The Bronx River provides an interesting point for comparison, because unlike Newtown Creek it has a freshwater source that is an important part of its watershed. In fact, the Bronx River is the only freshwater river within the borders of New York City. The Bronx River Watershed, which extends from the Kensico Dam in Westchester to the East River in New York City, is approximately 24 miles long. The watershed is relatively long and narrow and drains about 56 square miles. In the Bronx, the Bronx River watershed covers about 4,150 acres of land and is densely developed. The Hunts Point water treatment plant, located west of the Bronx River watershed, receives stormwater captured from about 60% of the Bronx River watershed. The majority of the remaining stormwater either enters the Bronx River in the form of run-off or is released into the in the Bronx River at CSOs. Like the Newtown Creek, the Bronx River also has significant sewershed.

In order to learn more about the Bronx River in order to compare and contrast with the Creek, you could visit the Bronx River with your class by working with organizations such as Rocking the Boat or The Bronx River Alliance. If you are not able to take the time to visit the Bronx River you can take a virtual tour online.

Resources

Rocking the Boat - http://www.rockingtheboat.org/
The Bronx River Alliance - http://www.bronxriver.org
Bronx River Virtual Tour -
http://www.nycgovparks.org/park-features/virtual-tours/bronx-river/band- select

Common Core Standards

Lesson I

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

Integration of Knowledge and Ideas Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCSS.ELA-LITERACY.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

English Language Arts Standards Speaking & Listening

Comprehension and Collaboration Grades 6-8

CCSS.ELA-LITERACY.SL.6-8.1

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Next Generation Science Standards

MS.Human Impacts

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson II

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
Integration of Knowledge and Ideas Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
CCSS.ELA-LITERACY.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
English Language Arts Standards Speaking & Listening
Comprehension and Collaboration Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
Next Generation Science Standards
MS.Human Impacts
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson III
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
Integration of Knowledge and Ideas Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
CCSS.ELA-LITERACY.RST.6-8.9
Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
English Language Arts Standards Speaking & Listening

Comprehension and Collaboration Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Next Generation Science Standards

MS.Human Impacts

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS4-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Field Lesson

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects
Texts Types and Purposes Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.
CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
Production and Distribution of Writing Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

English Language Arts Standards Speaking & Listening

Comprehension and Collaboration Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
Grade 6
CCSS.ELA-LITERACY.SL.6.1.D
Review the key ideas expressed and demonstrate understanding of multiple perspectives

through reflection and paraphrasing.
CCSS.ELA-LITERACY.CCRA.SL.1
Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
Next Generation Science Standards
MS.Human Impacts MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS4-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Applied Learning Lesson
English Language Arts Standards Science and Technical Subjects
Key Ideas and Details Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
Craft and Structure Grades 6-8
CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects
Texts Types and Purposes Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.
CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
Production and Distribution of Writing Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
Research to Build and Present Knowledge Grades 6-8
CCSS.ELA-LITERACY.WHST.6-8.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
English Language Arts Standards Speaking & Listening
Comprehension and Collaboration Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and

issues, building on others' ideas and expressing their own clearly.
CCSS.ELA-LITERACY.SL.6-8.1.B Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
CCSS.ELA-LITERACY.CCRA.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
Grade 6
CCSS.ELA-LITERACY.SL.6.1.C Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.
Grade 7
CCSS.ELA-LITERACY.SL.7.1.C Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.
Grade 8
CCSS.ELA-LITERACY.SL.8.1.C
Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.
Mathematics Standards Standards for Mathematical Practice
Grades 6-8
CSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively
CSS.MATH.PRACTICE.MP5 Use appropriate tools strategically
CSS.MATH.PRACTICE.MP6 Attend to precision
Mathematics Standards Statistics & Probability
Summarize and describe distributions Grade 6
CCSS.MATH.CONTENT.6.SP.B.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
Next Generation Science Standards
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Additional Resources

Texts:

- **Open Sewer Atlas Grey to Green**

http://openseweratlas.tumblr.com/greytogreen

- **Paddling Down Newtown Creek is Actually Awesome; Curbed.com**

https://ny.curbed.com/2014/7/17/10072014/paddling-down-polluted-newtown-creek-is-actually-awesome

- **Mr. Trash Wheel Cleans Up Baltimore Harbor with a Dash of Humor; PBS Newshour**

https://newsela.com/read/elem-mr-trash-wheel-cleans-up-baltimore-harbor/id/42309/

Videos:

- **A great video by the Bronx RIver Alliance illustrating CSO's and GI.**

http://bronxriver.org/greeninfrastructure

- **Clips of CSO's on Newtown Creek**

http://www.newtowncreekalliance.org/combined-sewer-overflow/

- **Rain Garden/ Bioswale during a storm**

https://www.youtube.com/watch?v=qbHZ748AbEU

- **Recycled Toilets for Rain Gardens**

https://www.youtube.com/watch?v=VdeC5XDC9M4

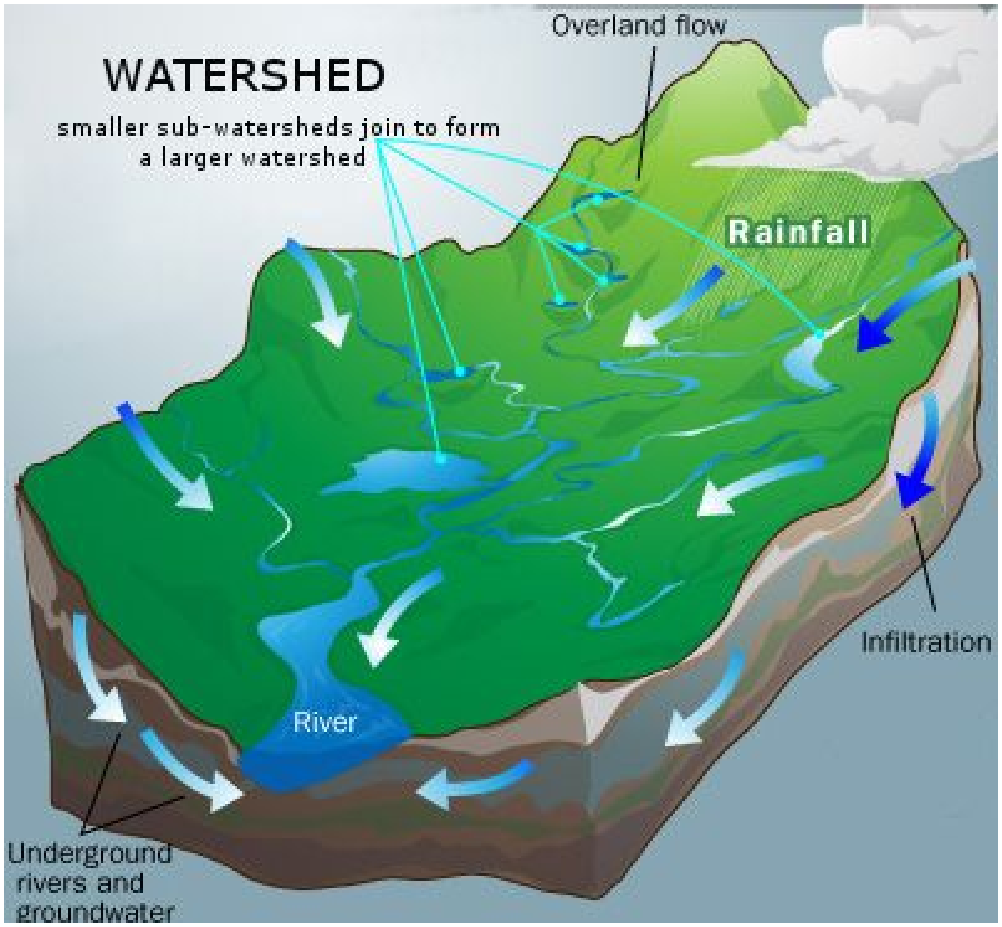
- **Natureworks; Sustainable Urban Design: Green Infrastructure**

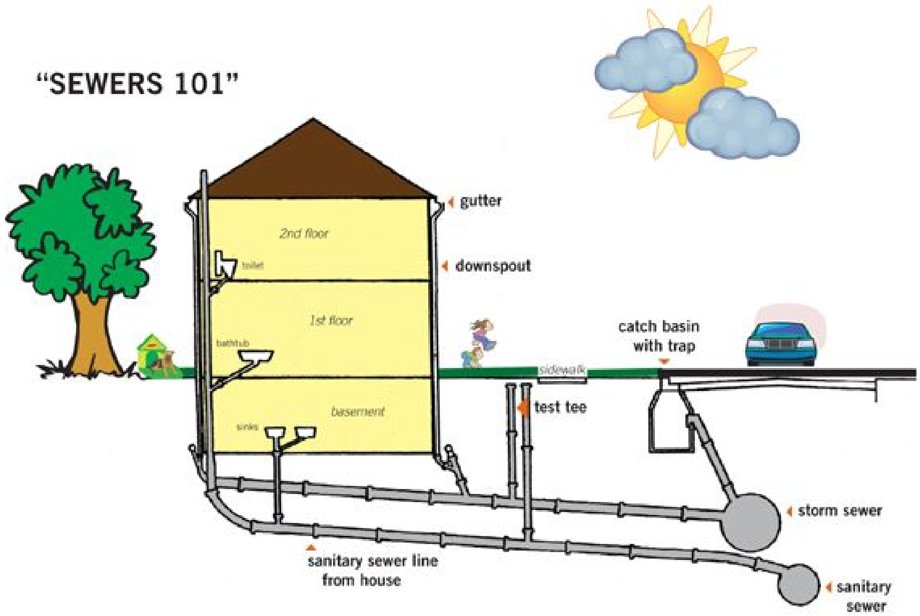
https://www.natureworkseverywhere.org/resources/sustainable-urban-design-toolkit/

Rainwater Collection Calculator

- **https://www.gardeners.com/how-to/rain-barrel-for-rainwater-collection/5497.html**

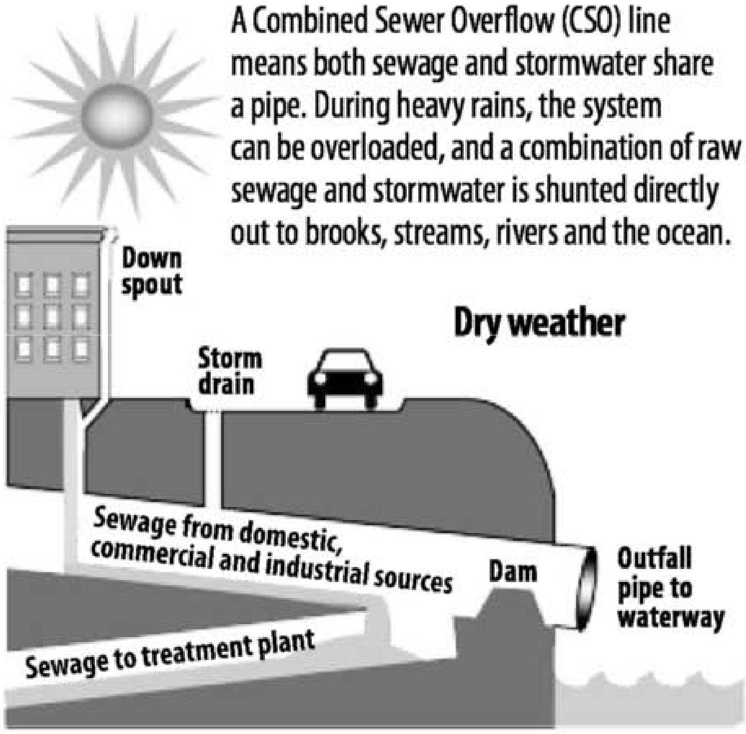
Images:

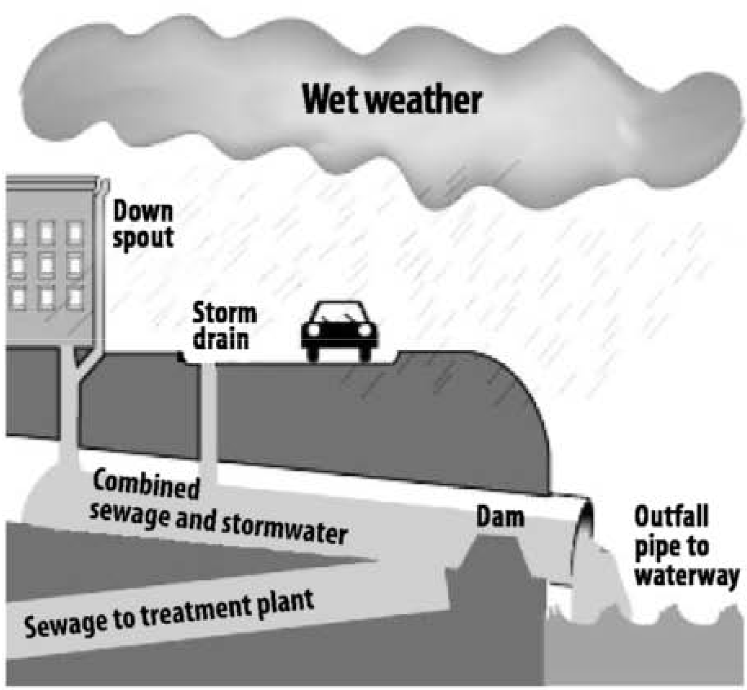



"SEWERS 101"
gutter
2nd floor
toilet
downspout
1st floor
bathtub
catch basin
with trap
sidewalk
basement
sinks
test tee
storm sewer
sanitary sewer line
from house
sanitary
sewer

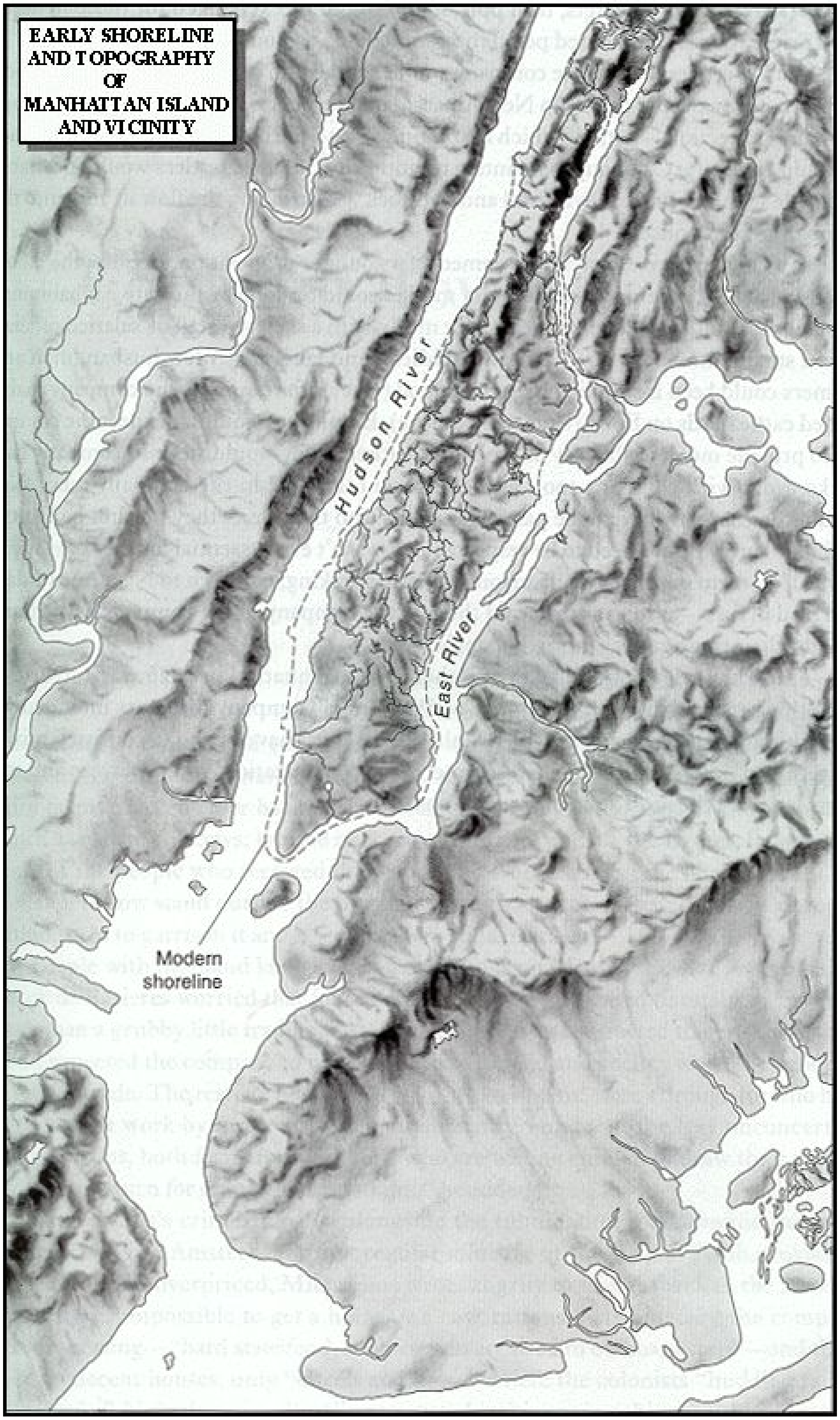
Explaining Combined Sewer Overflows

A Combined Sewer Overflow (CSO) line means both sewage and stormwater share a pipe. During heavy rains, the system can be overloaded, and a combination of raw sewage and stormwater is shunted directly out to brooks, streams, rivers and the ocean.





SOURCE: U.S. Environmental Protection Agency


EARLY SHORELINE
AND TOPOGRAPHY
OF
MANHATTAN ISLAND
AND VICINITY
Hudson River
East River
Modern
shoreline

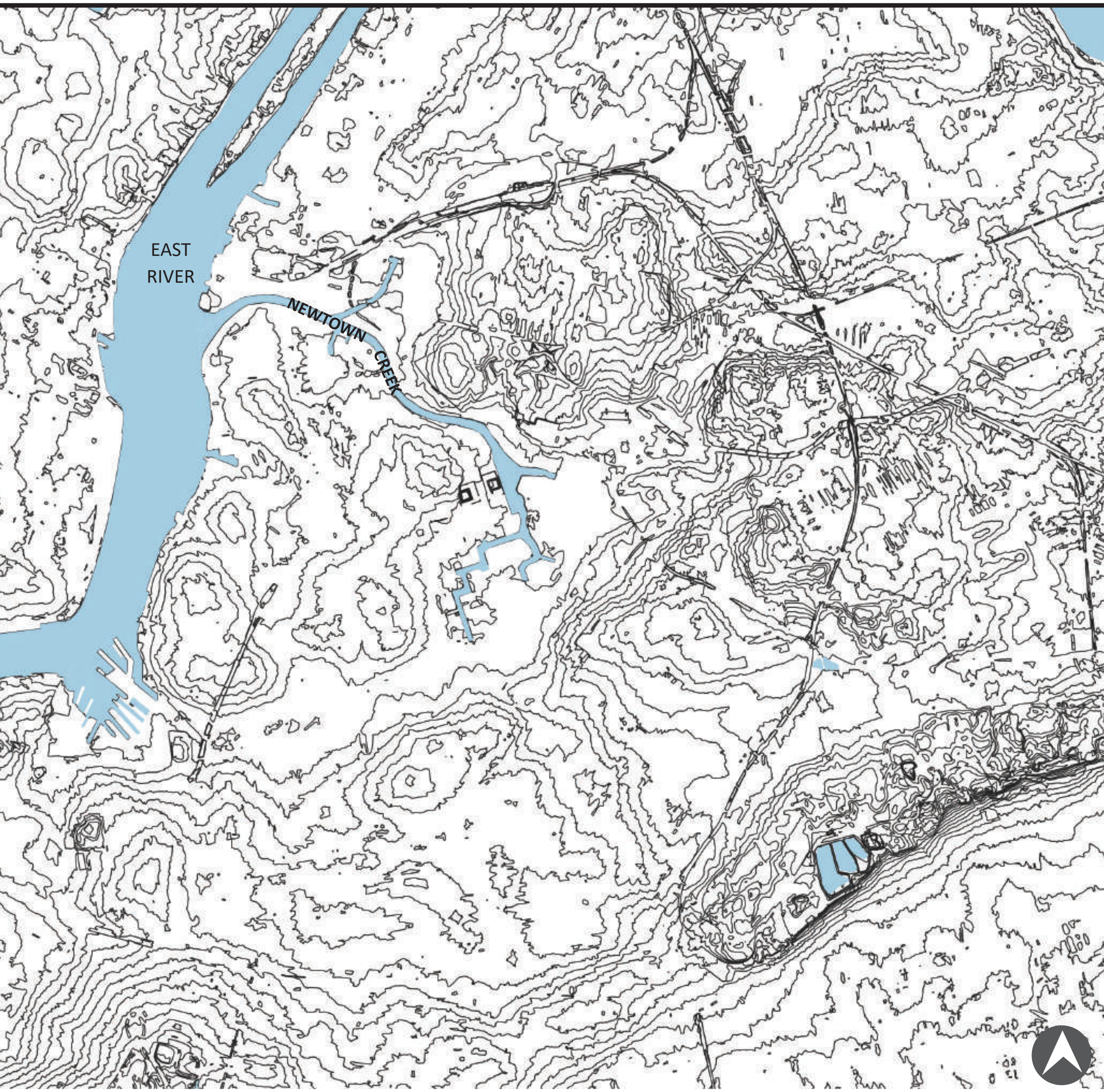
Handouts

Field

Fill in the t

Newtown Creek Topographic Map

This map shows contour lines which represent a change in elevation.



Notes:

Map Key:

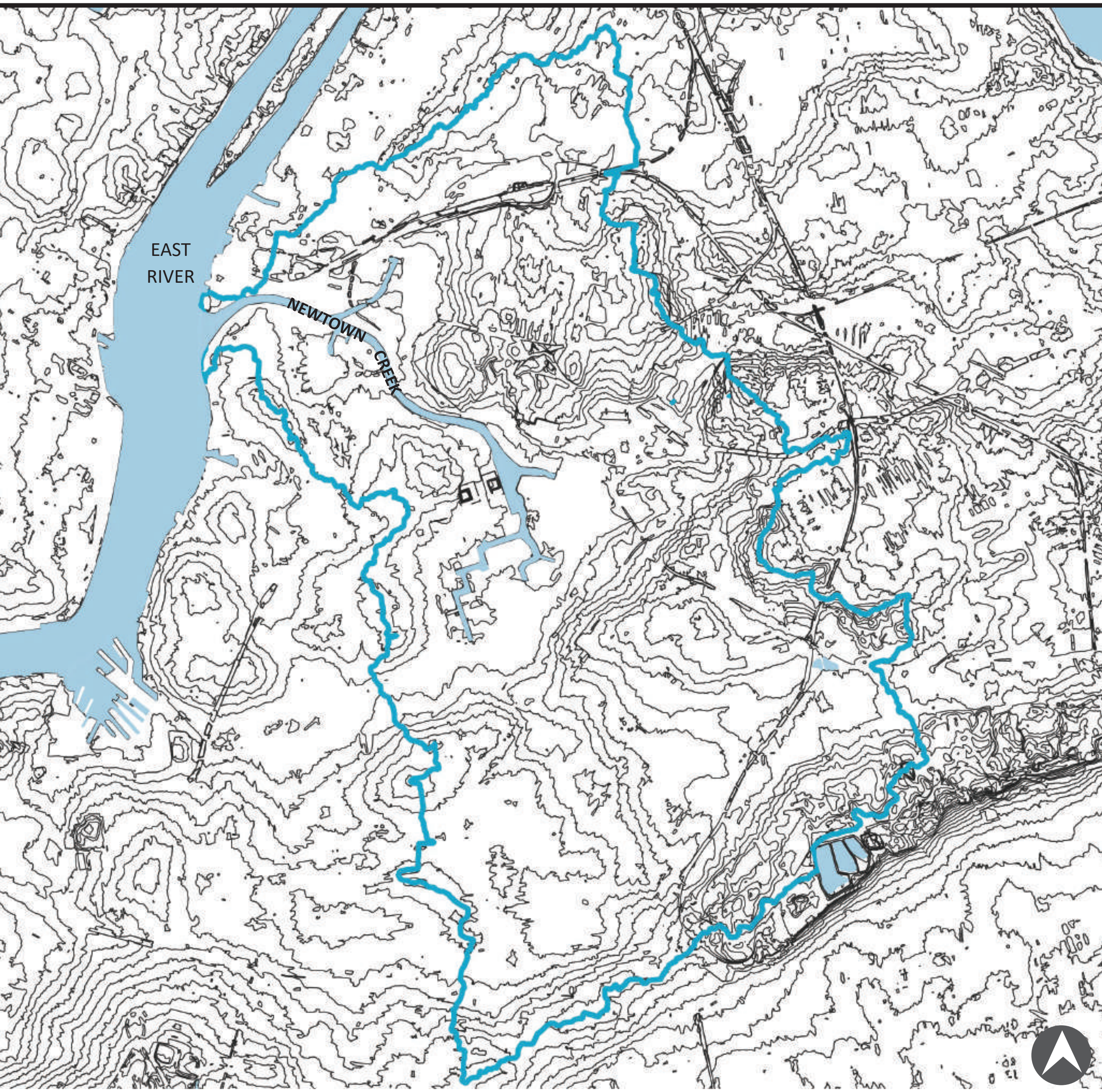
Water

Land contour lines

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Newtown Creek Topographic Map with Watershed Outline

This map shows contour lines which represent a change in elevation. The Newtown Creek Watershed outline represents the highest points in the area of land around Newtown Creek.



Notes:

Map Key:

Water

Land contour lines

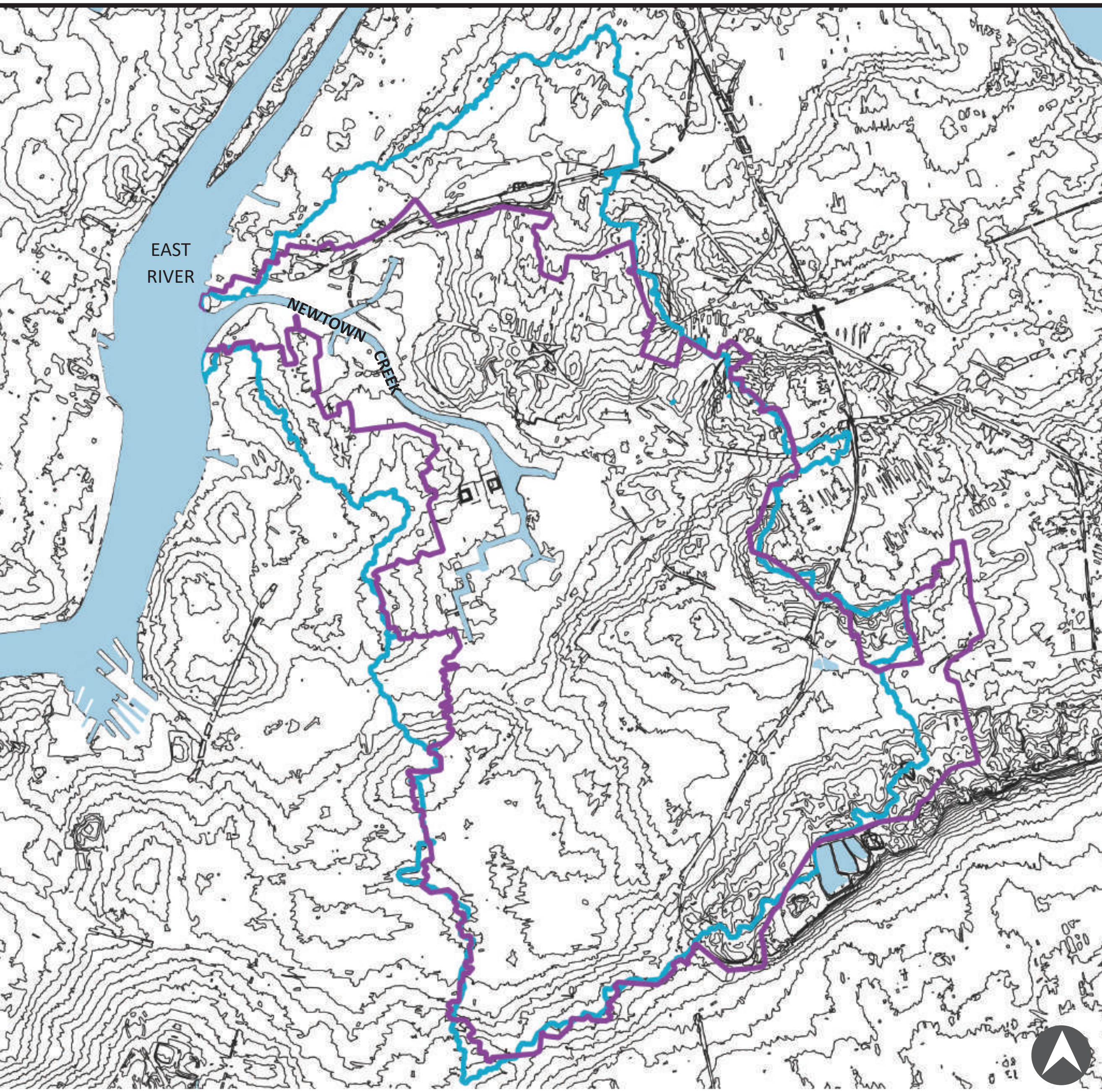
Watershed

NCA
NEWTOWN CREEK ALLIANCE

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Newtown Creek Topographic Map with Watershed and Sewershed Outline

This map shows contour lines which represent a change in elevation. The Newtown Creek Watershed outline represents the highest points in the area of land around Newtown Creek. The Sewershed represents the area of stormwater capture that effects Newtown Creek.



Notes:

Map Key:

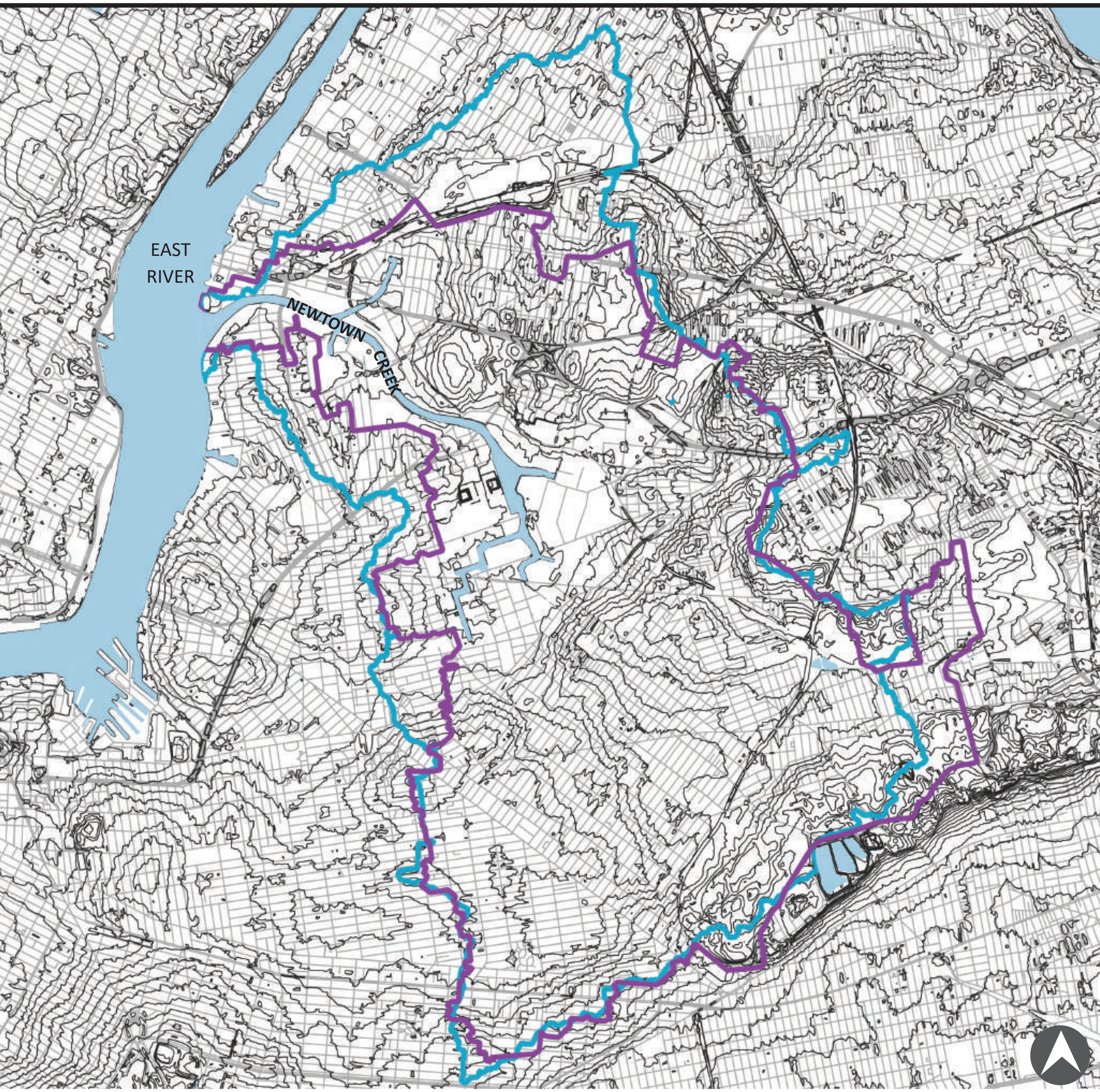
- Water
- Land contour lines
- Watershed
- Sewershed

NCA
NEWTOWN CREEK ALLIANCE

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Newtown Creek Street Map w/ Watershed & Sewershed

This map is a street map showing outlines of the Newtown Creek Watershed and Sewershed with contour lines.



Notes:

Map Key:

- Water
- Land contour lines
- Street grid
- Watershed
- Sewershed

NCA
NEWTOWN CREEK ALLIANCE

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Newtown Creek Watershed Map with Water Flow

This topographic map shows the direction that water flows in the Newtown Creek Watershed. Contour lines represent a change in elevation.

Notes:

Map Key:

- Water
- Watershed

10 ft contour lines (elevation from sea level)

- 0, 10, 20 ft
- 30, 40 ft
- 50, 60 ft
- 70, 80 ft
- 90, 100 ft
- over 100 ft
- ← Direction of water flow

NEWTOWN CREEK ALLIANCE

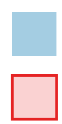
Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

NYC Map with Newtown Creek Sewershed

This map shows where the Newtown Creek Sewershed is relative to the greater New York City.

Notes:

Map Key:

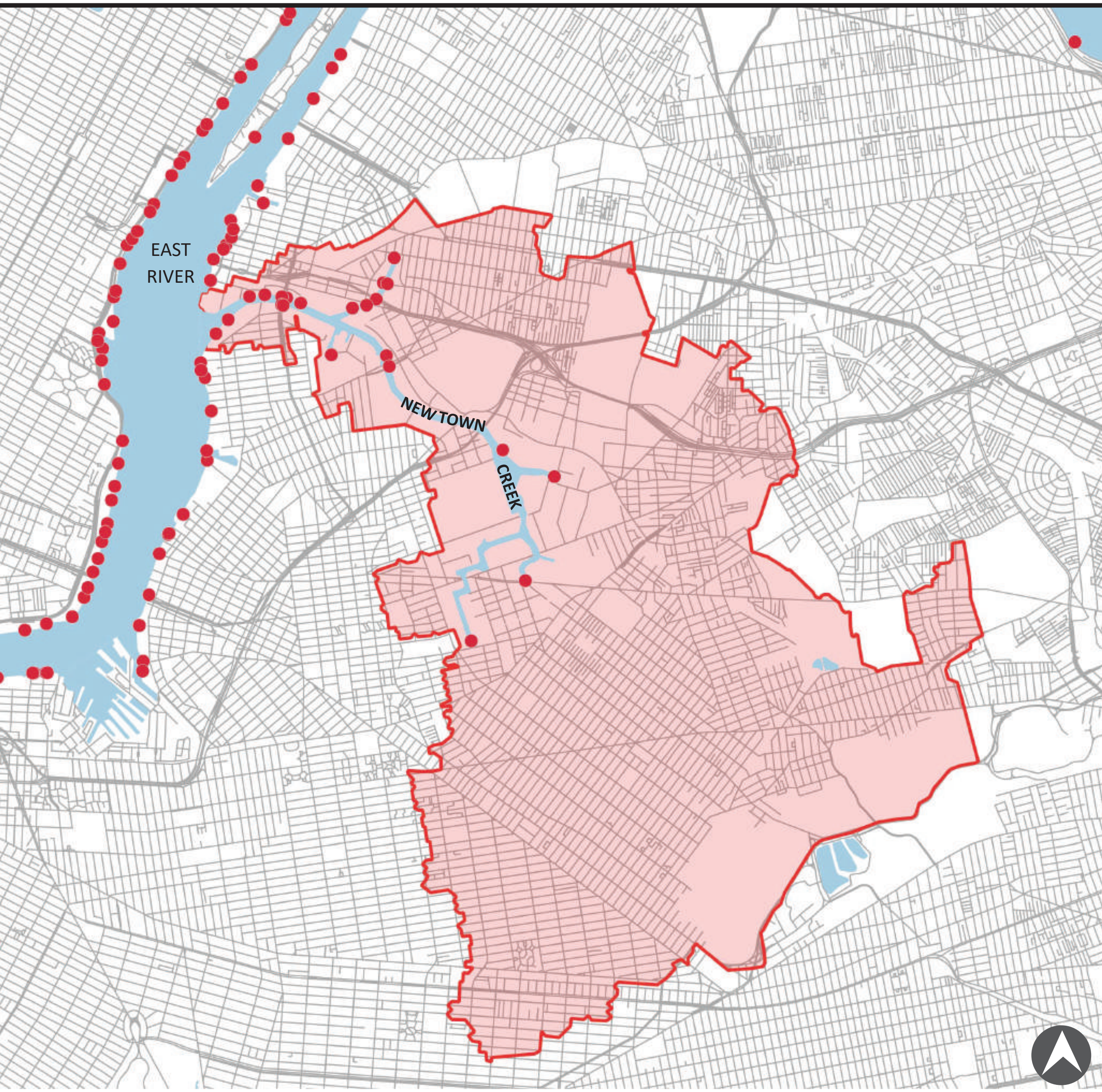


NCA
NEWTOWN CREEK ALLIANCE

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Newtown Creek Sewershed Map

This map shows the area of land that drains to Newtown Creek during a rainstorm and CSO outfall points along the Creek.



Notes:

Map Key:

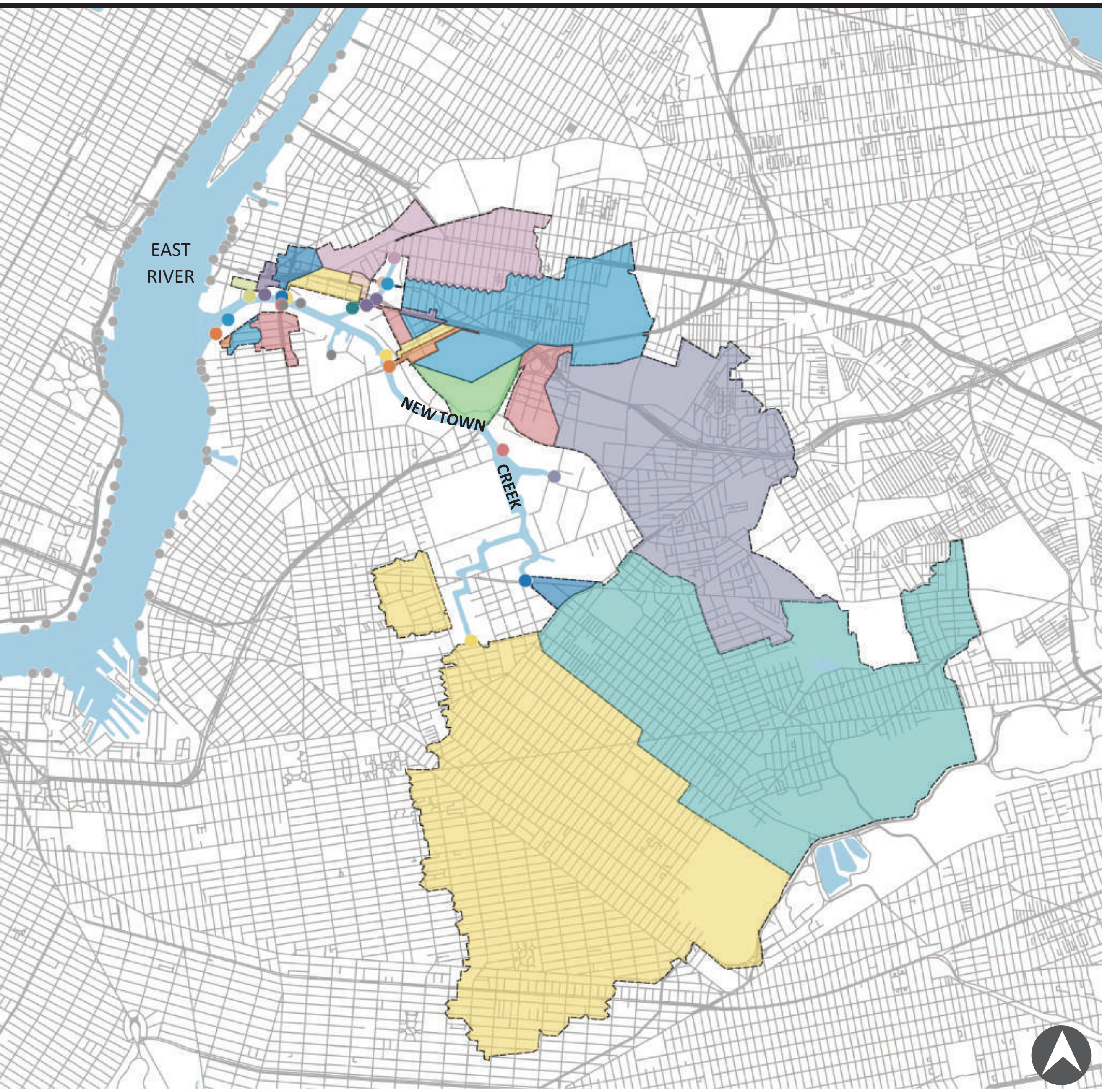
- Water
- CSO outfalls
- Sewershed

NCA
NEWTOWN CREEK ALLIANCE

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Newtown Creek CSO-shed Map

This map shows the areas of land that drain to Newtown Creek during a rainstorm and which CSO outfalls each area drains to, or the CSO-shed.



Notes:

Map Key:

Water

CSO outfalls

CSO-sheds

NCA
NEWTOWN CREEK ALLIANCE

Map developed by Korin Tangtrakul
NYC Soil & Water Conservation District.

Soil Quality

In this Unit:

This Unit has been modified by permission by the Newtown Creek Alliance from the original with assistance from the National Wildlife Federation's Greenpoint Eco-Schools. The original module was developed by the Gowanus Canal Conservancy.

Unit Overview

Essential Questions:

- How is soil important to life?
- How is soil part of an ecosystem?
- How does the diversity of life in the soil contribute to soil health?
- What is the relationship between soil ecosystem and soil health?
- What are some indicators of a healthy soil ecosystem? (What does a healthy ecosystem look like?)
- How does soil ecology change overtime?
- How can we effectively test soil?
- What can soil testing tell us about the Newtown Creek?

Teacher's Introduction: page 4

Lessons & Objectives:

Teacher's Introduction

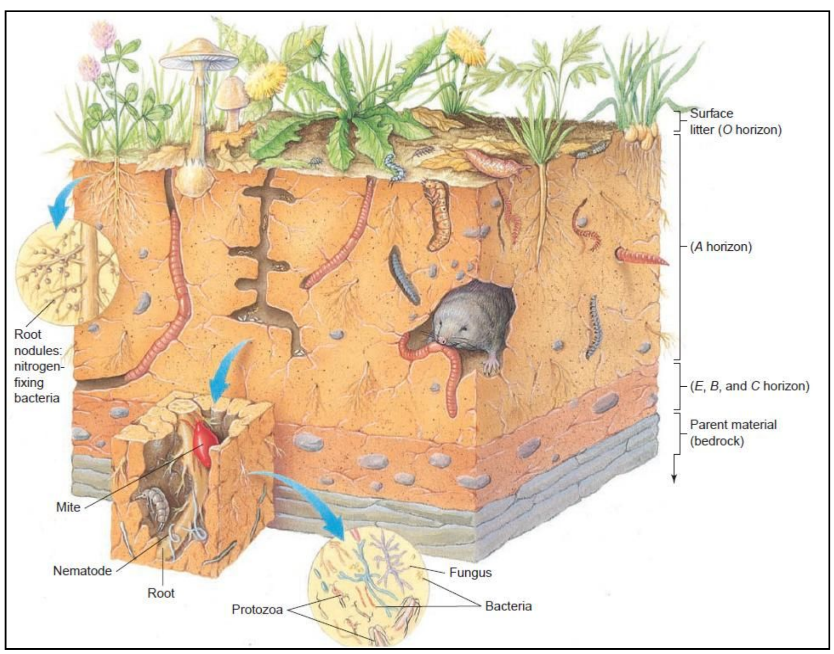
What is Soil Quality?

Soil is critical for life. It provides food for plants, animals and humans; cleans air and water; and beautifies landscape.

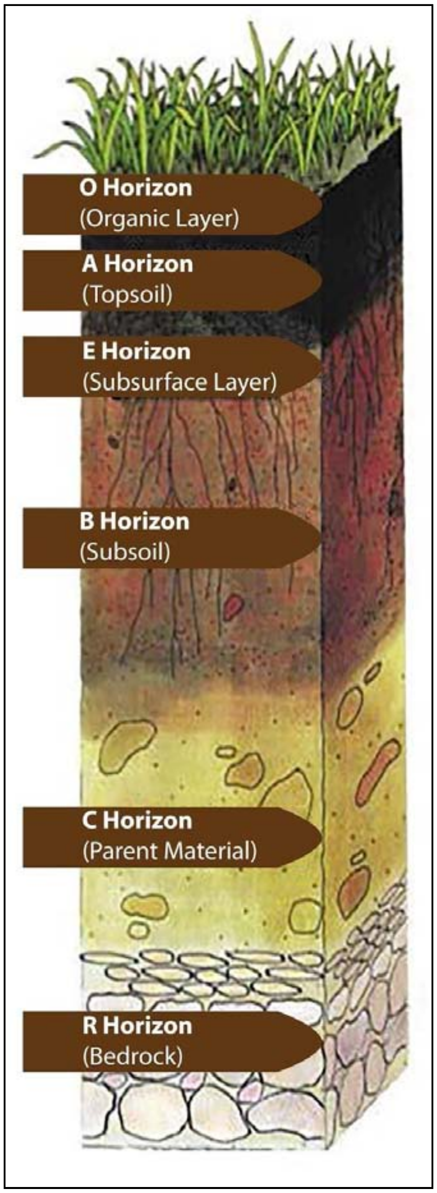
Cotyledon in rich soil.

What makes soil different than dirt? Think of soil as a thin living skin that covers the land. Dirt is misplaced soil. It is what you find under your fingernails or on your clothes; soil is what you find under your feet. It goes down into the ground just a short way. Even the most fertile topsoil is only a foot or so deep. Soil is more than rock particles. It includes all the living things and the materials they make or change.

Soil is a mix of minerals, air, water and countless microorganisms, forming at the surface of the land and coming in many types.



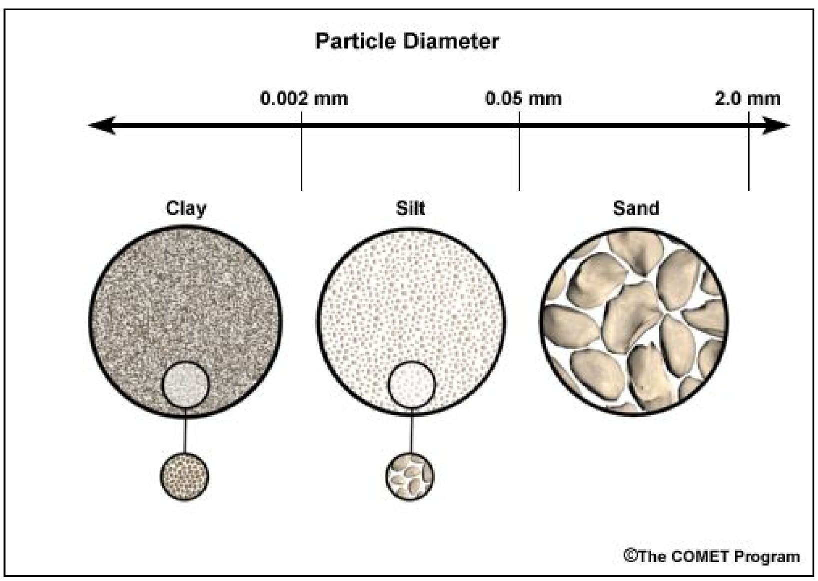
Surface soils can be home to many types of life. (Source: Permaculture Sydney South)



If you were to dig a hole a few feet down, most likely you would be able to see clearly the difference between the topmost layers (O and A layers), teaming with life and rich with organics, down to the mineral and rock based bottom layers (C and R layers) and a few others in between. Soil can take many, many years to form and it's the process of formation that creates those distinct layers. Soils in the desert will look a lot different than the soil you might see in a rainforest or on a mountain slope or in a forest. Even urban soils have their own unique characteristics.

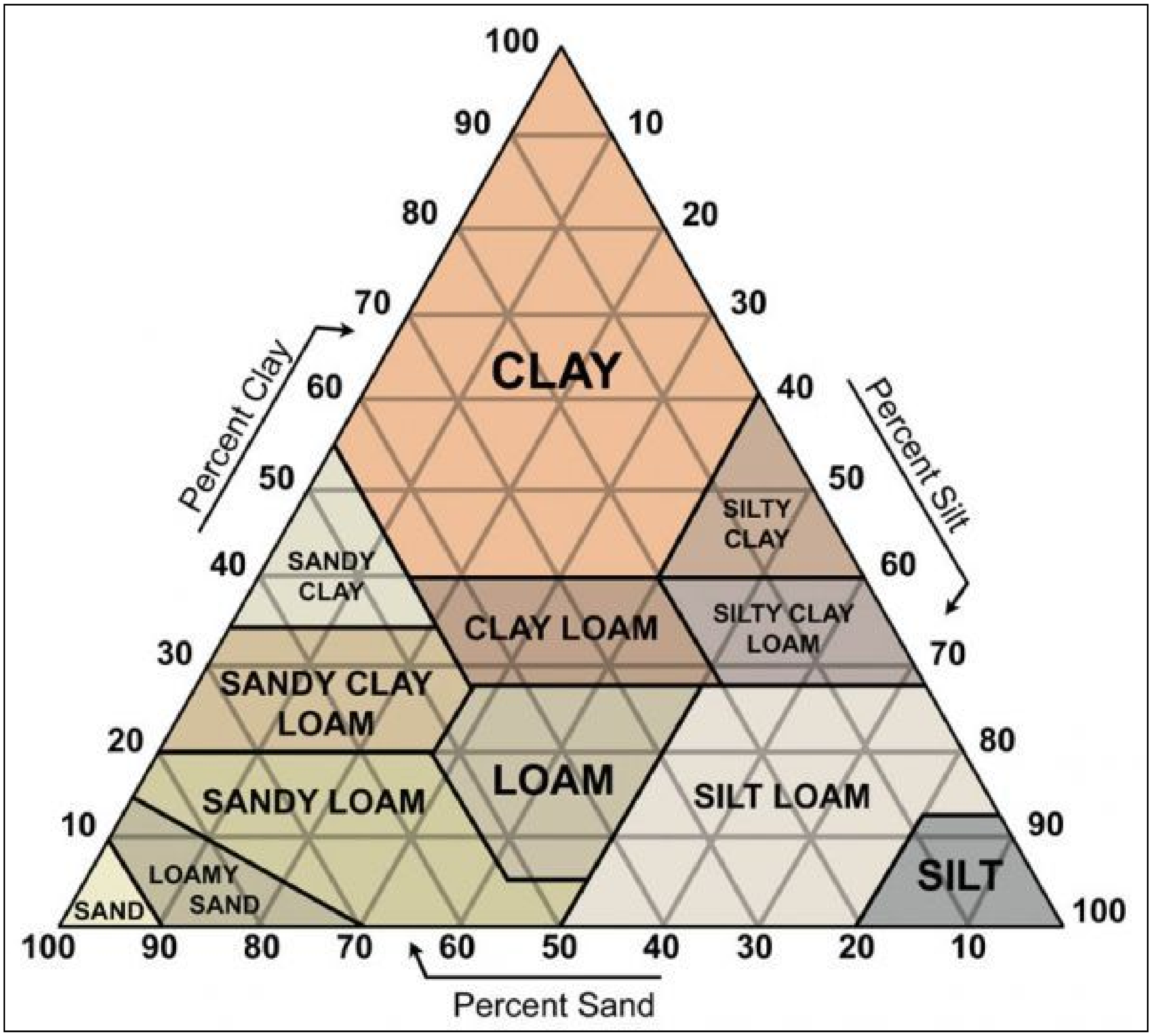
The diversity of life in fertile soil includes plants, root systems, fungi, earthworms, flatworms, roundworms, beetles, ants, spiders, mites, bacteria, algae, burrowing animals such as moles, mice and groundhogs, and much more, all depending on where you look.

In addition to being home to many organisms, soil has distinct textures, structures and colors. Sand, silt and clay describe the particle size of soil, with the largest being sand, and the smallest clay. As parent rocks break down into smaller and smaller pieces these particles are formed.



Constituent particle size determines the soil texture. (Source: COMET Program)

Soil's texture is described as the relative proportions of sand, silt and clay, for example a loamy soil has a balance of the three. Here in NYC, much of our soil can be described as either sandy loam or loamy sand. Soil structure are how these particles clump together. These clumps also have different properties; they filter water, hold nutrients, support life and provide different resources based on how they "clump". Structure can be described as balls, blocks, columns and plates. The structure of the soil is particularly important when considering it's direct impact on how water interacts with it. Sometimes resulting in rapid infiltration, other times the opposite.



Soil Texture Pyramid. (Source: Natural Resource Conservation Service (NRCS)

The spaces in between clumps create pore space for water, air and organisms. Color varies according to mineral content. A darker soil indicates more organic matter; and orangey color indicates higher iron content.

Soil provides many important biotic and abiotic ecological functions including [1]:

• **Nutrient Cycling** - Nutrients are made available to to plants as soil releases them through the water cycle process

• **Water Relations** - Soil regulates water drainage and stores nutrients. It regulates water use for plants and groundwater recharge

• **Biodiversity & Habitat** - Soil provides habitat and nutrients for plants, animals and microorganisms. The healthier the soil, the more biodiversity exists

• **Filtering & Buffering** - Soil filters air and water, buffering or degrading toxic nutrients and making them unavailable to plants and animals

• **Physical Stability and Support** - Soil structure can allow air and water to pass through pores between particles, prevent erosion, and support to hold plant roots. It provides foundation for building structures and other human made infrastructure

• **Soil Quality** - Refers to the the capacity of a soil to function and can include chemical, physical and biological characteristics, usually with respect to the needs of one or more biotic species of plants, animals, and humans. When measuring soil quality, it is important to evaluate these properties of the soil.

It can take up to 500 years to form an inch of soil – is this a renewable resource? Conversely the quality of a soil can be degraded rather quickly by: erosion, contamination, and compaction.

Soil Quality Indicators: Measures of Soil Functional State[2]		
Indicator	**Tests**	**Related Soil Function**
Biological	Respiration, Earthworms, Particulate Organic Matter	Biodiversity of Organisms (decomposers and nutrient cycling), Filtering
Chemical	pH, Electrical Conductivity (EC) and Soil Nitrate Levels	Nutrient Cycling, Water Relations, Buffering, Plant and Soil Organisms Health, Contaminant Levels and availability of uptake
Physical	Bulk Density, Water Content, Infiltration Rate, Aggregate Stability, Slaking, Morphological Estimations	Water Entry and Retention, Nutrient availability, Erosional status

[1] Soil Functions: Services Provided by Soil. Soil Quality for Environmental Health. http://soilquality.org/functions.html

[2] Soil Quality Indicators: Measures of Soil Functional State. Soil Quality for Environmental Health. http://http://soilquality.org/indicators.html

Why teach Soil Quality Testing?

Soil Quality Testing provides a window into the health and vitality of the creek. It can:

- Help to identify pollution and specific sources of pollution
- Determine whether soil is meeting specific standards
- Monitor trends over time
- Monitor impacts of disturbances such as flooding, drought or chemical spill

Exposed sediments during a low tide on Newtown Creek's Queens shoreline. (Source: Newtown Creek Alliance)

Issues related to soil quality in urban soils like that surrounding the creek may include:

- Erosion
- Compaction
- Reduced infiltration and increased runoff
- Salt or other chemical buildup
- Nutrient loss
- Reduced biological activity
- Weed or pathogen infestation

Several of these soil quality issues directly impact the water quality of the creek, including erosion, runoff, infiltration and groundwater recharge.

Since we're interested in the health and changes over time in the Newtown Creek it is important to test the soil. Soil health is directly linked to plant health — for example, if soils are degraded, how will beneficial plants and organisms thrive?

It also impacts Water Quality. Does compacted soil absorb and filter the same volume of water — and how would this affect levels of stormwater runoff? Do different testing locations along the Newtown Creek reveal different results (e.g. in a tree pit, a bioswale, or a brownfield property)?

Through testing, students will see a "snapshot" of the Soil Quality at the Newtown Creek. Most meaningful data sets emerge when the soil is tested over time. Long term monitoring reveals trends over days, months and seasons. It could also uncover the sources of previously unknown sources of pollution.

(An urban tree with heavily compacted soil. Source: Shrub Doctor)

Soil Quality testing addresses additional skills including:

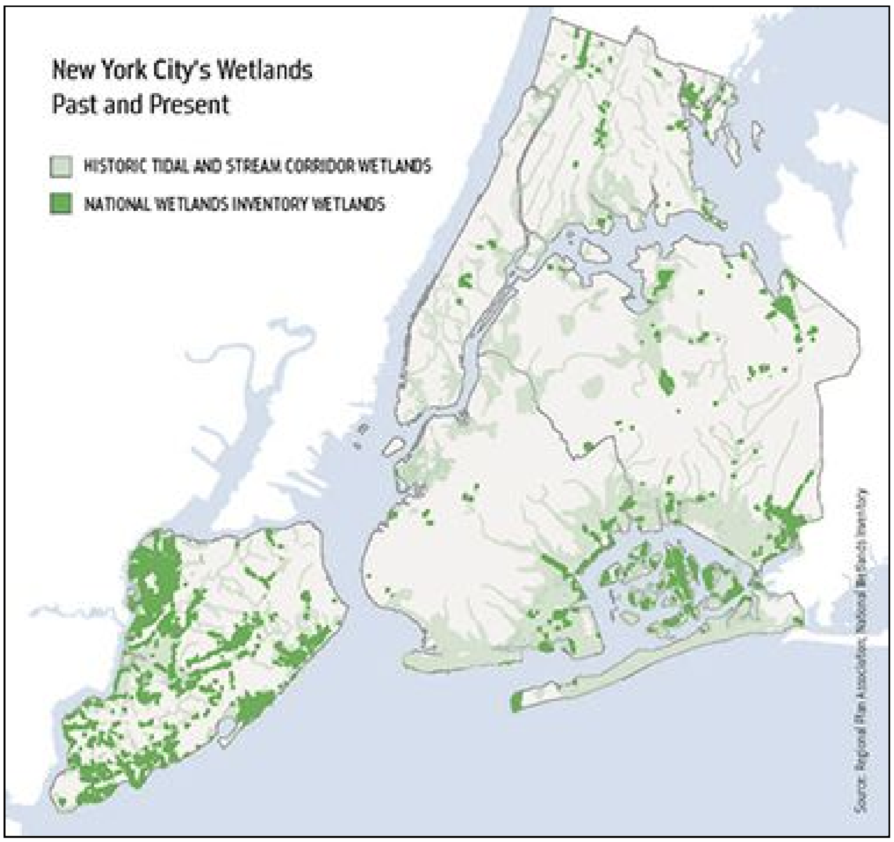
- Following safety procedures
- Making predictions and hypotheses
- Measurement and accuracy
- Data collection and recording
- Analysis and interpretation of data
- Comparison of data

Newtown Creek Soil Quality Background

All of the soil in the land surrounding Newtown Creek is imported. None of it is original to the tidal salt marshes of 400 years ago. But whether it is older landfill or new soil brought in for restoration it is important to understand the health of the soil and how it impacts life — plant, animal, and human — in the Newtown Creek Watershed.

The Phelps Dodge Copper refinery in Queens mid-1900s. (Source: Newtown Creek Alliance)

The primary issue with Soil Quality surrounding Newtown Creek today is the contaminated soil left over from polluting industry that operated along the waterfront from the mid 1800's to the mid 20th century — a period of heavy industry. Dozens of refineries, glue factories and tanneries, metal and chemical processing plants on the Creek supplied the region with goods, economic wealth and industrial power for more than a century and are the major source of poor soil health. Soil Quality suffered as industrial waste leaked or was dumped into the soil around the Creek. In particular, coal tar, the byproduct of converting coal to manufactured gas, and crude oil seeped from holding tanks into the ground from Standard Oil's progeny companies, as well as copper refining byproducts — contamination from the Phelps Dodge Superfund site, are all still present in high quantities in the soil. Coal tar and other oil byproducts mixed in with Creek sediments is often called “black mayonnaise” for its thick, gooey consistency and color, and contains many known carcinogens. It is a highly toxic substance. These contaminants include polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), pesticides, other coal tar wastes and heavy metals such as barium, cadmium, copper, lead, mercury, nickel and silver. These pollutants pose serious health risks and prevent important soil organisms (not to mention plants and animals) from thriving.



Map showing historic wetlands, nearly all of which were filled in. (Source: Regional Plan Association, National Wetlands Inventory)

Urban soils like those surrounding the Newtown Creek have particular issues due to the nature of land use and population density. Urban soils have been disturbed in some way, by cutting out native soil, filling with other material and regrading to construct roads, buildings, and recreational areas such as parks. As a result many urban soils are likely to be compacted and contaminated, depending on previous or current land use. In NYC in particular, 85% of waterfront land and soil that was originally salt marsh was filled in and built on during the 1700 and 1800s.

In the original marsh land around the Newtown Creek, fill materials are associated with canal construction in the 1850s and 60’s and the subsequent industrialization and regrading of the area. The fill consists of silt, sand and gravel mixed with ash and fragments of brick, metal, glass, concrete, wood and other debris.

Four geologic units lie beneath the area surrounding the Newtown Creek:

- Fill (newest and most shallow)
- Alluvial/marsh deposits
- Glacial sands and silts
- Bedrock (oldest and deepest)

Today, other factors affecting Soil Quality health surrounding Newtown Creek include soil compaction and contaminated runoff from road salt, animal feces, oil and other chemicals on the streets that get washed off during precipitation.

Improvements to Newtown Creek Soil Quality

Several coordinated efforts are underway to improve Soil Quality near Newtown Creek. Larger clean ups are being led by government agencies, and volunteer groups are improving Soil Quality through smaller scale interventions.

The Superfund

After years of community advocacy and a series of lawsuits, in 2010 Newtown Creek was designated a Superfund site by the United States Environmental Protection Agency (USEPA)[4]. The Superfund program has the resources to mediate some of the nation's most contaminated areas and responds to environmental emergencies, oil spills and natural disasters. Restoration of Superfund sites are covered under the *Comprehensive Environmental Response, Compensation and Liability Act of 1980*, which forces polluters to clean up the toxic sites they created. To protect public health and the environment, the Superfund program focuses on making a visible and lasting difference in communities, ensuring that people can live and work in healthy, vibrant places. The Superfund process promises to be a lengthy investment of time and resources in achieving a thorough cleanup of toxic contaminants that pose risk to human health and ecological systems. Advocates and community volunteers play a large role in making sure Superfund is carried out correctly and they are on the ground making incremental positive steps to improve the environment around the Creek every day.

[4] *https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0206282*

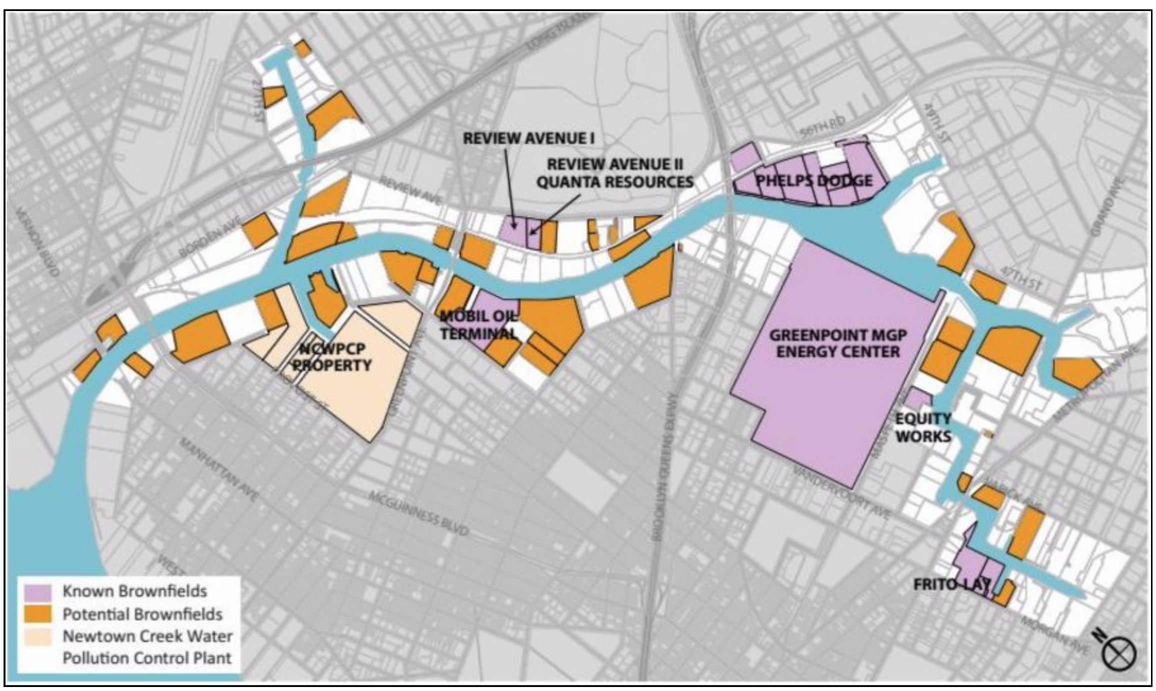
New York State Brownfield Program

The soils in properties adjacent to the Creek can be cleaned up through the New York State Brownfield Program. A site is a brownfield if the contamination levels exceed health or environmental standards.[5]

The contamination in these soils can also be attributed to toxic wastes from petroleum refining and other chemical production and storage on the Creek. Today, any time a property is redeveloped along the Creek the law requires property owners to remediate the soil, which usually involves large excavations of the most contaminated layer. Developers are provided tax incentives to do this work.

Redevelopment of Creekside properties is unlikely to take place without a larger rezoning -- or change of use -- of the area. In 2012, in a joint initiative of the Greenpoint Manufacturing and Design Center (GMDC), Riverkeeper and the Newtown Creek Alliance, the Newtown Creek Brownfield Opportunity Area (BOA) Nomination Study was initiated. The objective of the BOA was to create a 21st Century approach to enhancing and reutilizing sites within one of New York City's most important maritime industrial areas without using the tool of rezoning.

Like the Superfund cleanup process, citizens are invited to participate in the Brownfield program by providing comments on the proposed cleanup plans.



The 2012 BOA identified dozens of known and potential Brownfields around the Creek. (Source: Brownfield Opportunity Area Nomination Report)

[5] *NYSDEC Brownfield Cleanup Program http://www.dec.ny.gov/chemical/8450.html*

NYC Green Infrastructure Plan

The thousands of bioswales (Right of Way Rain Gardens) are being constructed across NYC as part of the NYC Green Infrastructure Plan. The sandy soil mix used in these street side gardens is engineered to slow down and filter stormwater runoff. Bioswales are designed with a significantly deeper soil bed than most gardens and tree beds, increasing water holding capacity. The soil elevation is lowest in the center of the swale, which allows water to pause and infiltrate.

Right of Way Rain Garden in action. (Source: NYC DEP)

Compost!

One way volunteers improve Newtown Creek Soil Quality is by promoting the production and use of compost within the Newtown Creek Watershed. Compost adds important nutrients and organisms to replenish depleted urban soil. Volunteers create healthy compost with a 1:1 mix of nitrogen-based material (mostly food scraps) and carbon material (“browns” such as dead leaves and mulch). The material should be regularly turned to aerate the pile, providing oxygen for microorganisms that break down material. The mixture cures until it becomes a rich, dark material ready to add to gardens and street tree pits. Compost can be distributed to local schools, community gardens, street trees and parks.

Compost provides these benefits to soil health[7]:

- Increases water filtration rates, reducing runoff and erosion
- Improves soil structure and porosity
- Improves water holding capacity
- Absorbs and binds contaminants, such as heavy metals
- Increases biodiversity of micro and macro organisms
- Adds nutrients to soil and stabilizes pH
- Helps prevent weed growth and some pathogens

7: Compost and Its Benefits; US Composting Council (2008)
http://compostingcouncil.org/admin/wp-content/uploads/2010/09/Compost-and-Its- Benefits.pdf

How to Test Soil Quality in Newtown Creek

Determining the soil quality in Newtown Creek requires completing a battery of tests. There are many different tests that are used by organizations and government agencies that monitor Soil Quality.

This unit will focus on the several of the most fundamental Soil Quality tests:

- **NPK (Nitrogen, Phosphorus, Potassium)**
- **pH**
- **Temperature**
- **Filtration Rate**
- **Stratification**
- **Organism Population**

Use test kits to determine these soil quality parameters. Filtration, Stratification, and Organism Population can be determined by additional tests that are explained in the field lesson.

NPK (Nitrogen, Phosphorus, Potassium)

All plants need these three basic elements to grow. Nitrogen helps plants grow leaves and shoots. Phosphorus facilitates strong root growth, and potassium promotes flower and root development. A deficiency in any of these nutrients stunts plant growth and production, also making the plant more vulnerable to insect attack. Indicators of deficiency may include discoloration of leaves. A balanced level of these nutrients allows for healthy growth and increases the plants ability to ward off pests and disease.

pH

A pH test will show whether a soil is acidic or alkaline. Plant nutrients, like Nitrogen, Phosphorus and Potassium are best absorbed from the soil when a pH is in the neutral range (6.2 to 7.2). Soil becomes acidic by erosion from rain water (which leaches away basic ions), carbon dioxide from decomposing organic matter and some strong plant fertilizers.

Temperature

Use a soil thermometer to measure the warmth of soil at specific depths. Temperature is important when planting new plants and germinating seeds, which require specific temperature ranges for different species and planting zones. Temperature will vary during the day, night and season. Taking the temperature of compost can also indicate when the pile has heated up by decomposition activity and when it has cooled down enough to be applied to the soil as fertilizer.

Vocabulary

Vocabulary Note: Some of this vocabulary is referenced in other parts of this curriculum. All vocabulary and definitions appear in the glossary of the curriculum.

Background Vocabulary:

biology
biodiversity
ecology
ecosystem
environment
food chain
food web
organism

Essential Vocabulary:

absorption
bulk density
clay
compaction
contaminate
decompose
decomposer
dirt
fertilizer
filter
fill (or urban fill)
landfill
leech
loam
humus
microorganism
mineral
matter
nitrate
nutrient
organic matter
parent material
pH
phosphate
porosity
potassium
runoff
sand
sediment
silt
soil
soil horizon
soil profile
structure
subsoil
texture
topsoil

Extension Vocabulary:

abiotic
alluvial
aquifer
bacteria
bedrock
benthic zone
biotic
blocky
buffer
brownfield
compost
disturbance
drought
friable
fungi
glacial till
massive
nematodes
platy
protozoa
permeable
photosynthesis
remediation
respiration
rhizosphere
stormwater

Lesson I - Observing Sand, Silt and Clay

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Soil is important for supporting life, filtering and storing water, growth of all plants and animals (humans included!), is a foundation and anchor for our buildings and the city we live in. In this lesson, students will work in small groups to observe samples of sand, silt and clay. The teacher will then lead students in a discussion in order for them to learn more about these particle sizes. The students will understand the importance of soils in our lives and the value of knowing it's component parts.

Learning Objectives

• Students will observe samples of soil using different senses
• Students will differentiate between different sizes of soil particles (sand, silt and clay)
• Students will explain why soil is important
• Students will determine how the soil type impacts the plants that live in the soil

Time

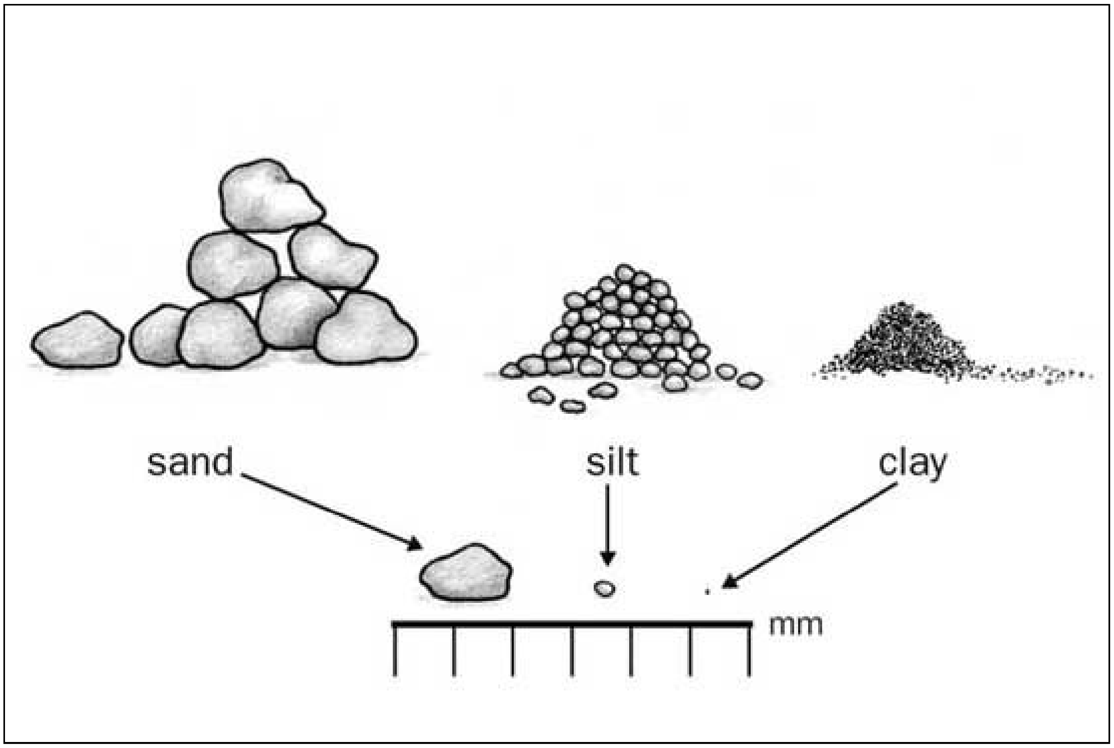
45-60 minutes

Vocabulary

See Soil Quality Introduction for a list of vocabulary words from which to choose

Tips for Teachers

- Consider using and/or modifying portions of the **Soil Quality** in Teacher's Introduction as a text for your students.
- Consider if and how you want to review the definitions of soil, sand, silt and clay before the students have an opportunity to observe the samples.
- **Sand** - feels gritty, has lots of air space, and does not hold water well.
- **Silt** - feels smooth, has some air, and holds water well. When silt soil is wet, it gets slippery.
- **Clay** - feels sticky because it is made of very small particles. It does not have much air space and does not have much room for water.
- Remember to leave sufficient time to have the students clean up at the end of class.



Texture scale.
(Source: Nelson, M. Rae. "Soil." *Experiment Central*: *Understanding Scientific Principles Through Projects)*

Materials

- "Know, Want to Learn, Learned" (KWL) Worksheet
- Soil Observation Activity Worksheet
- Sand, silt and clay (can be purchased from Ward's Science or Home Depot)
- Containers for soil
- White paper
- Cleaning supplies

Procedure 1 - Introduction

1. Give students the **KWL Worksheet.**
2. Facilitate a discussion assessing students' knowledge of soil. Students write in the "K - Know" section of the worksheet during the discussion.
    a. What is soil? (Soil is a complex mix of materials: minerals, air, water, and organic matter.)
    b. What is the difference between soil and dirt, and where in your

neighborhood do you see either? (Dirt is just soil that has gotten lost. When it's on our living room floor we call it dirt. When it's in the park we call it soil.)

   c. What are some of the functions and purpose of soil? (Food, clothing, building materials, etc.)
   d. Why might soil be called "the foundation of life"? (Because nearly everything we eat, drink, use, etc. comes from soil, grows in soil, is filtered by soil, is built on soil, etc.)
   e. Are there different types of soil? (Yes: different combinations of sand, silt, and clay.)
3. Tell students that they will be observing (looking, smelling and touching) the soil.
4. Students individually fill out the "W - Want to Know" section of their worksheet based on what they want to find out during their observation/exploration of the soil. (This can be thought of as the student learning how to develop a hypothesis)

Procedure 2 - Observing Soil Textures (Sand, Silt and Clay)

1. Separate students into pairs or small groups.
2. Give each pair/group a copy of the **Soil Observation Activity Worksheet** to record their results.
3. Post or review a word bank for students to reference when making specific observations:
   a. **Look:** *sparkly, dull, shiny, multi-colored, speckled, grainy, marbled*
   b. **Smell:** *musty, earthy, pungent, odorless, sour, fragrant, grassy, sweet, moldy, rotten*
   c. **Feel:** *grainy, smooth, bumpy, soft, dry, wet, hard, malleable, moist*
   d. **Structure:** *friable, loose, crumbly, firm, clumpy, massive*
   e. **Smear color:** *feel free to combine colors (e.g. greenish-gray, reddish-brown)*
4. Give each group soil samples of sand, silt and clay OR have students rotate around to a station for each soil sample.
5. Students observe and write down all observations on the Soil Observation Activity Worksheet.each soil sample.
   - Look closely at it
   - Smell it
   - Feel it between your fingers
   - Smear on paper (color is important with soil!)
   - Grain size - space between particle sizes
   - Structure - how it holds together
6. Students draw a picture of the soil particles and include labels that indicate size

(refer to "Texture scale" graphic,) shape and color of particles.

7. Students hypothesize or predict whether each soil sample is sand, silt or clay based on the following definitions:
    a. **Sand:** *feels gritty, has lots of air space, and does not hold water well.*
    b. **Silt:** *feels smooth, has some air, and holds water well. When silt soil is wet, it gets slippery.*
    c. **Clay:** *feels sticky because it is made of very small particles. It does not have much air space and does not have much room for water.*

Discussion Questions

1. Why do we find different-sized particles in soil? Soil composition and particle size depend on the materials (rocks, plants, minerals, etc.) and processes (surf, wind, moisture, etc.) in the area.
2. How do we describe soils with different percentages of sand, silt and clay in them? (Reference "Texture Pyramid" in Teacher's Introduction)
3. How can particle size affect filtration (water moving through the soil)? Water will flow more quickly through sand, get absorbed by silt and have a difficult time penetrating clay.
4. How might this particle size and filtration rate be important? Different amounts of water, or moisture levels, exist in soil depending on amount and regularity of rainfall and precipitation and rates of filtration through the soil. Different plants require different amounts of water and have adapted different root systems etc.
5. Why soil is important to human beings? Prompt students to think about what comes out of soil: plants make food, clothing materials, and so forth. We build our houses and schools on soil. Soil filters our water...
6. How might different soil types affect human lifestyle in that area? The soil composition determines what kind of plants and crops grow best in each area and therefore which resources are available.
7. During or after this discussion, have students fill out the "L - Learned" section of their KWL worksheet.
8. Have students write an "extended response" to the question: Why is soil important?

Extension Lesson - Porosity of Soil

To demonstrate the size of soil particles, display three jars: golf balls (sand), marbles (silt), and small beads (clay). You can use large mason jars for this activity. Pour the same amount of water into each container and observe how long it takes the water to fill the bottom of the jar. The water will filter to the bottom of the jar fastest in the golf balls (sand) container and slowest in the beads (clay) container.

Extension Lesson - Blind Test

After the above lesson, have students work in pairs and do a “blind feel” test to see if they can determine whether the sample is sand, silt or clay. Students can use all their observation skills other than sight.

Extension Lesson - Building Soil

Collect a sample of soil from the McCarren Park Demonstration Garden or another raised bed in your neighborhood. Using 1) the raised bed soil as a model, 2) the sand, silt, and clay from the Observing Soil Textures activity, 3) some compost and decomposing leaf litter (also known as humus), and 4) the Texture Pyramid, try to recreate the soil found in the garden. This is nutrient rich soil, perfect for growing food - how much sand, silt or clay, compost or other organic matter is required to achieve this type of soil quality?

Extension Lesson - Explore the soil around your school

Students will collect soil samples on and near their school. These samples will be Jar Tested and compared to the Soil Pyramid to identify different soil compositions. How to Jar Test soil: place collected sample in a jar (just a few tablespoons works well). Fill the rest of the jar with water. Shake. Leave jar overnight to settle. The next day observe how the soil has settled in the jar. The sand will settle on the bottom; the silt will settle in the middle; and the cay will settle on the top (if there is lots of clay it may take more than 24 hours to settle!). Using a marker, indicate on the jar with a line where each soil type ends. Compare ratios to Soil Pyramid to determine soil type.

Lesson II - Soil as a Filter

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Soil acts as an important filter, removing pollutants and other contaminants. Different types of soils work differently as a filter, some types doing a better job than others. Reduced filtration increases runoff; increased runoff means increased contamination. Students will work in small groups and experiment with how sand and fine soil (a combination of silt and clay) filter different ingredients mixed with water (floatables, colored water, soap, oil).

Learning Objectives

- Students will see how soil acts as a filter
- Students will explain the concept of “filtering capacity”
- Students will discuss how the filtering capacity of soil affects pollution and contaminants
- Students will explain the benefits of soil acting as a filter

Time

45-60 minutes

Vocabulary

See Soil Quality Introduction for a list of vocabulary words from which to choose

Tips for Teachers

- Consider using and/or modifying portions of the **Soil Quality** in Teacher’s Introduction as a text for your students.
- You can model one of the experiments to save time.
- You can do many varieties of this activity with different soils. You could collect soil from the places you will visit during the field lesson or purchase soils with different make-up and sediment sizes.
- Remember: always try these experiment first, so you have an idea of what to expect before you try it with students.

Materials

- Soil as a Filter Activity worksheet
- Toothpicks or pencil
- Liquid soap or detergent
- Extra cups

- Aluminum tray
- Paper towels
- Sand - *clean with large, rough particles (stream table sand from Ward's Science or Home Depot)*
- Fine soil - *mixture of particle sizes (silt and clay)*
- "Floatables" *(like styrofoam pieces or other small pieces of plastic trash)*
- Colored liquid *(mix red and blue food coloring to make purple water)*
- Paper cups of two different sizes. *(The bigger size should be able to sit in the smaller size - 5oz and 3oz work well).*
- Cooking oil

Procedure 1 - Introduction

1. Review Lesson I and the different types of soil particles: sand, silt and clay.
2. Briefly discuss soil as a filter with the class
    a. What is a filter? (show a coffee filter to aid discussion)
    b. How can soil work as a filter?
    c. How do different soils filter differently?
3. Split students into small groups.

Procedure 2 - Cup & Sand Set-up - Soil Filter Test Preparation

1. Poke holes in the bottom of a bigger cup using the toothpick or sharpened pencil.
2. Place the bigger cup in the smaller cup.
3. Put a toothpick or pencil vertically in between the two cups so air can escape from the bottom cup.
4. Place the two cups into the aluminum tray.
5. Fill the bigger cup 1⁄2 way with sand.

Testing with Floatables, Colored Liquid, Detergent, and Oil

Procedure 3 - Filtering Water With Floatables (Trash)

1. Make **Cup & Sand Set-up**.
2. Give each group a copy of the **Soil as a Filter Activity** Worksheet.
3. Students hypothesize or predict what will happen to the sand, water and floatables when poured through the sand.
4. Pour water with floatables added to it into the bigger (top) cup.
5. Students observe and record what happened to the floatables.
6. Remove bottom cup and observe and record the results of the experiment on the water and soil.
7. Draw conclusions from the experiment.
8. Repeat experiment with fine soil.

Procedure 4 - Filtering Water With Colored Liquid (Chemicals)

1. Make a new **Cup & Sand Set-up**.
2. Hypothesize or predict what will happen to the sand and the colored liquid.
3. Pour colored liquid into the bigger (top) cup.
4. Observe, record and draw conclusions based on what happened to the colored liquid and the sand.
5. Make another **Cup & Sand Set-up**. This time fill bigger cup with 1⁄2 inch of sand and <u>add fine soil</u> until the cup is 1⁄2 full.
6. Predict and hypothesize what will happen to the fine soil and the colored liquid.
7. Pour colored liquid into bigger cup.
8. Observe, record and draw conclusions based on what happened to the colored liquid and the soil.

Procedure 5 - Filtering Water With Detergents

1. Make a new **Cup & Sand Set-up**.
2. Hypothesize or predict what will happen to the sand, water and the detergent.
3. Mix up the water and detergent so there are suds.
4. Pour sudsy water into the top cup.
5. Observe, record and draw conclusions based on what happens to the sudsy water and the sand.
6. Make another **Cup & Sand Set-up**. This time fill bigger cup with 1⁄2 inch of sand and <u>add fine soil</u> until the cup is 1⁄2 full.
7. Hypothesize or predict what will happen to the fine soil and the sudsy water.
8. Pour sudsy water into bigger cup.
9. Observe, record and draw conclusions based on what happens to the sudsy water and the soil.

Procedure 6 - Filtering Water With Oil

1. Make a new **Cup & Sand Set-up**.
2. Hypothesize or predict what will happen to the sand, water and the oil.
3. Pour oil & water into the top cup.
4. Observe, record and draw conclusions based on what happens to the oil & water and the sand.
5. Make another **Cup & Sand Set-up**. This time fill bigger cup with 1⁄2 inch of sand and <u>add fine soil</u> until the cup is 1⁄2 full.
6. Hypothesize or predict what will happen to the fine soil, oil & water.
7. Pour oil & water into bigger cup.
8. Observe, record and draw conclusions based on what happens to the oil & water and the soil.

Discussion Questions

1. What types of pollution/contamination could each ingredient above represent?
2. What happened with the floatables (trash)?
3. What happened with the colored liquid (chemical)? (Clay has a charge and can hold onto certain nutrients and chemicals that are oppositely charged)
4. What happened with the detergent?
5. What happened with the oil?
6. How would you describe the difference between the different types of pollutants you experimented with?
7. How would you describe the difference between the different types of filtering you experimented with?
8. What other factors in a soil ecosystem (worms, other insects, roots, organic materials, etc) could contribute to filtering?
9. How does planting plants along the shoreline of the Newtown Creek help with the issues of runoff?
10. Based on this experiment, what type of soil used in these experiments should we use along Newtown Creek? Why?
11. How could the filtering ability of soil be used in the wastewater treatment process?

Extension Lesson:

Soil Horizons - draw a Soil Profile poster or have each student represent one of the layers in the profile. The layers can be described as a lasagna, where each layer plays an important role.

Field Lesson - Soil Quality

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Soil quality in and around Newtown Creek varies depending on its current or historical use, its natural history, its location and what its made out of. This field lesson is an opportunity to bring your students outdoors and have them interact with Newtown Creek by making observations and inferences and testing the quality of the soil using several different parameters.

Learning Objectives

- Students will observe different types of land surfaces in the Newtown Creek watershed
- Students will accurately measure soil quality parameters (filtering rate, Nitrogen, Phosphorus, Potassium [NPK], stratification, organism observation)
- Students will interpret the results of each test and discuss possible factors impacting each test result
- Students will draw preliminary conclusions about the health of the soil based on the data
- Students will compare soil quality data if tested at more than one time or location

Time

Can vary from 60 minutes to several hours

Vocabulary

See Soil Quality Introduction for a list of vocabulary words from which to choose.

Tips for Teachers

- Choose one or more of the sites listed in the Newtown Creek Field Sites Information section of the Curriculum Introduction. (recommended sites: McCarren Park Demonstration Garden and Manhattan Ave Street End Park)
- Always visit the Field Site prior to bringing your students there.
- Consider using and/or modifying portions of the Soil Quality Introduction as a text for your students.
- Each student group will collect a soil sample and conduct one or more tests.

Working in small groups will help these tests go smoothly and help guard against error.

- For each discussion point, decide which teaching method works best for you and your students.

Discussion Points

- Built vs. "Natural" environment
- Importance of testing procedure/protocols
- Importance of metadata (location, date, time, tide, etc.)
- Testing once vs. testing multiple times and taking an average
- Factors influencing nitrate, phosphorus, and potassium
- Bioswale (Rain Garden) soil vs. tree bed soil
- Pollutants that may influence test results (e.g. chemicals dumped at curb)
- Other factors that may influence test results
- Other observations about the site
- Human activity at the site
- Stewardship of the Creek

Journal Prompts

We recommend having students write in their journals at the end of the field experience and consider some or all of the following questions. Also refer to the "Journal Writing" section of the Introduction & Methodology for more suggestions about journaling.

1. What observations do you think are important to note on your **Soil Quality Data Sheet**? What observations did you make?
2. What are some common features of healthy soil?
3. Why do we need healthy soil for our ecosystem?
4. What factors contribute to unhealthy plant and soil life?
5. How does the diversity of life in the soil contribute to soil fertility?
6. What is a human's relationship to the soil?
7. How is soil important to life?
8. What are the components of soil? What are some abiotic and biotic factors of soil?
9. What are the different soil types?
10. How does soil change as depth increases?
11. What are nutrients that plants need to maintain health? Explain how each nutrient is responsible for a specific plant function.
12. How does the quote, "one man's trash, is another man's treasure" relate to the compost ecosystem?

13. What are the benefits of composting?
14. Choose one soil quality result that you think should be improved in Newtown Creek. What could you design/propose/build within the Newtown Creek Watershed that could have a positive impact on this soil quality parameter?
15. Alternatively, what other kind(s) of stewardship could you participate in that could improve the health of the soil in the Newtown Creek Watershed? Explain.

Main Activity - Testing the Soil Quality of Newtown Creek

Materials

- Clipboards
- Journals
- Soil Quality Data Sheet
- Site Map (for your chosen Field Site)
- Soil quality test kit tools (depending on which tests you choose to do)

Procedure

1. Separate students into small groups.
2. Give each group a copy of the **Site Map** and a **Soil Quality Data Sheet**.
3. Stand in a central area on the site with the whole class and compare the boundaries on the Site Map to where those boundaries are on the actual site.
4. Students make observations and inferences on the Site Map, based on elements they notice that are degraded (e.g. litter, floatables, oil, compacted soil, dilapidated bulkheads) and other things that may impact soil quality.
5. Students collect metadata and record on Soil Quality Data Sheet; Metadata Section. You may want to collect the metadata with the whole class, or you may assign this as a task to one or more small groups. It is important to collect this information first because it sets the stage for the soil quality tests.
6. Student groups test the soil and record results on the Soil Quality Data Sheet.
7. Facilitate students sharing test results so that their data sheets are complete as possible.
8. Students calculate averages.
9. Students complete the soil quality analysis at the end of the data sheet.
10. Students clean their equipment and hands.
11. Bring all data back to the classroom for the Applied Learning Lesson.

Extension Lessons - Soil Drainage Test

To test drainage (infiltration capacity):

1. Dig a hole about 1 foot deep.
2. Fill with water and allow it to drain completely.
3. Immediately refill the pit and measure the depth of the water with a ruler.
4. 15 minutes later, measure the drop in water in inches, and multiply by 4 to calculate how much water drains in an hour.

Less than 1 inch per hour is poor drainage, indicating the site may stay wet for periods during the year. Plants that don't tolerate poor drainage will suffer. 1 to 6 inches of drainage per hour is desirable. Soils that drain faster than 6 inches per hour have excessive drainage.

Simplified Test Option: Another option is to get a coffee can and open it on both sides. Place coffee can 1 inch into soil. Pour measured amount of water and see how long it takes to absorb. Repeat this same process in different types of soil areas (e.g. tree pit, rain garden, garden, unmanaged area, etc.) and compare and contrast the results.

Extension Lesson - Soil Stratification (Jar Test)

Take soil samples from various sources, including tree beds. Stratify soil by putting each type in a mason jar with water. It will stratify into layers of sand, silt and clay. Bring back samples and compare to "pure" sand, silt and clay samples from Lesson I.

Extension Lesson - Identify Soil Organisms

Collect soil samples to look at under a microscope. Identify various microorganism that you may find (millipedes, centipedes, worms, microbes, roots)

You could purchase and bring field microscopes with you for this lesson or you could collect samples and bring them back if you have microscopes at school. (Newtown Creek Alliance has two student microscopes that can be borrowed for this activity.)

Applied Learning - Designing Soil Quality Improvements

PLEASE NOTE: These lessons were purposefully written with built-in flexibility. You are encouraged to adapt the time, materials, procedures and handouts to fit your students, your teaching and your school.

Activity Overview

Coming up with practical solutions to problems of degraded or impaired soil is a good way to demonstrate students knowledge and critical thinking. It also helps students problem solve using systems thinking. In this activity, students will either recommend a strategy for working towards improvement of the health of the Newtown Creek Watershed or design an improvement to a specific parameter of soil quality in the Newtown Creek Watershed based on the data they gathered during the Field Lesson.

Learning Objectives

- Students will review soil quality data from Field Lesson
- Students will discuss validity of results – what should be repeated or done differently next time
- Students will draw further conclusions about the health of the soil based on the data
- Students will create a plan to build something that would help improve one or more of the soil quality indicators tests at the field site

Time

45-60 minutes

Vocabulary

See Soil Quality Introduction for a list of vocabulary words from which to choose.

Tips for Teachers

- Remind students that they do not need to be proficient artists when doing sketches. Simple line drawings will suffice.
- Consider using and/or modifying portions of the Soil Quality Introduction as a text for your students.
- Make copies of Discussion Questions sheet for small group discussions.

Materials

Materials from Field Lesson (completed)

- Site Map
- Site Map - clean copy
- Soil Quality Data Sheet
- Field Site Metadata
- Journal entries
- Other student work (e.g. photos)
- Google image of Newtown Creek Neighborhood

Design Procedure

1. Separate students into the small groups. You may choose to use the same groups they were in during the Field Lesson or new groups. Consider whether you want the students in the group to have worked on the same area in the field or different ones.
2. Give a copy of the Neighborhood Map (depending on the scale needed) and a copy of Discussion Questions and a clean Site Map to each small group.
3. Review the Field Site(s) visited during the Field Lesson as a whole class.
4. Mark on the Neighborhood Map the location of the Field Site(s) visited.
5. Each student in the group shares some observations or thoughts about their site based on their worksheets and/or journal entries.
6. If you visited more than one site during the Field Lesson, choose one Field Site on which to focus.
7. Review the Discussion Questions in small groups, referring to the information from Field Lesson (Site Map, Soil Quality Data Sheet, journal entries, etc).
8. Each student in small groups choose one soil quality parameter they would like to see improved.
9. Students revisit their observations from the field and discuss what observations might be impacting the soil quality.
10. Using clean copy of the Site Map, each student brainstorm ideas that will improve soil quality at your field site.
11. Each student uses the brainstorm ideas to sketch the design for soil quality improvements on the clean Site Map.
12. Each students share and explain his/her design to their small group.
13. The group members critique each others' designs and write down the best elements from each sketch.
14. The group gets a final clean copy of the Site Map for group design.
15. The group works together to create ONE final design incorporating the best elements from each individual's design.
16. The group works together to write an explanation and defend each element of

their design.

17. Each group presents their completed design to the class, with individuals talking about a particular element of the design.

Designing Soil Quality Improvements

Discussion Questions

1. Describe your Field Site, its location and what surrounds it.
2. What types of pollutants did you observe on the Field Site?
3. What other observation did you make at your Field Site?
4. How do the results compare to the soil quality ranges we would expect to see in the Newtown Creek? Refer to information in the Soil Quality Introduction.
5. Are there any results that are surprising? Explain why.
6. Are there any results that are questionable? (e.g. a group knows they made a mistake while performing the test.) Explain why.
7. How might one or more of the observations you made be impacting the soil quality results?
8. Which of your test results do you find most concerning? Is soil compaction an issue? Why?
9. What role do plants and animals play in the health of the soil?
10. Which of your test results do you feel you should focus on improving? Why?
11. Consider the following remediation options:
    - Excavate it
    - Cap it
    - Aerate it
    - Add mulch
    - Add compost
    - Add plants

Common Core Standards

Lesson I

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure Grades 6-8

CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects

Research to Build and Present Knowledge Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Next Generation Science Standards

MS.Human Impacts

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Lesson II

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8

- CCSS.ELA-LITERACY.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
- CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure Grades 6-8

- CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards Writing: History/Social Studies, Science, & Technical

Subjects

Texts Types and Purposes Grades 6-8

▪ CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.

▪ CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Research to Build and Present Knowledge Grades 6-8

▪ CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English Language Arts Standards Speaking & Listening

Comprehension and Collaboration Grades 6-8

▪ CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

▪ CCSS.ELA-LITERACY.SL.6-8.1.B Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

Next Generation Science Standards MS.Matter and Energy in Organisms and Ecosystems

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological

Field Lesson

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8

▪ CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure Grades 6-8

▪ CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects

Texts Types and Purposes Grades 6-8

▪ CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.

▪ CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Production and Distribution of Writing Grades 6-8

▪ CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge Grades 6-8

▪ CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English Language Arts Standards Speaking & Listening

Comprehension and Collaboration Grades 6-8

▪ CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Next Generation Science Standards

MS.Matter and Energy in Organisms and Ecosystems

▪ MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Applied Learning

English Language Arts Standards Science and Technical Subjects

Key Ideas and Details Grades 6-8

▪ CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure Grades 6-8

▪ CCSS.ELA-LITERACY.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

English Language Arts Standards Writing: History/Social Studies, Science, & Technical Subjects

Texts Types and Purposes Grades 6-8

▪ CCSS.ELA-LITERACY.WHST.6-8.1 Write arguments focused on discipline-specific content.

▪ CCSS.ELA-LITERACY.WHST.6-8.1.B Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Production and Distribution of Writing Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge Grades 6-8

CCSS.ELA-LITERACY.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

English Language Arts Standards Speaking & Listening

Comprehension and Collaboration Grades 6-8

CCSS.ELA-LITERACY.SL.6-8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.6-8.1.B Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

CCSS.ELA-LITERACY.CCRA.SL.1 Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

Grade 6

CCSS.ELA-LITERACY.SL.6.1.C Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. Grade 7

CCSS.ELA-LITERACY.SL.7.1.C Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.

Grade 8

CCSS.ELA-LITERACY.SL.8.1.C Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.

Next Generation Science Standards

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Additional Resources:

Texts:

- ***Life in a Bucket of Soil* by Alvin Silverstein**

https://www.amazon.com/Bucket-Dover-Childrens-Science-Books/dp/0486410579

- ***You Wouldn't Want to Live Without Dirt* by Ian Graham**

https://borrow.bklynlibrary.org/r1s/iii/encore/record/C__Rb11917426?lang=eng

- **The Science of Soil From the Ground Up (teacher resource) Download Lesson 2:**

http://www.thescienceofsoil.com/teacher-resources

- **Soil Quotations; USDA's Natural Resources Conservation Service**

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/college/?cid=nrcs142p2_054312

- **A Deeper Dive into Soil; The Science of Soil: From the Ground Up (teacher resource)**

https://drive.google.com/open?id=1Q4VnVzu2ipLeRHEe2mhwYYNWhL7LAlxl

- **Incredible Journey Into the Soil**

https://www.blm.gov/nstc/soil/Kids/incred.html

Videos:

- **Starting with Soil**

https://www.wholekidsfoundation.org/starting-with-soil/

- **How is soil formed?** (Scroll down to select video).

http://www.thescienceofsoil.com/teacher-resources

- **The Soil Song**

https://www.youtube.com/watch?v=GCLvZ3pffpc

- **Topsoil Dance**

https://www.youtube.com/watch?v=J6l2dMdAx5M

Lesson Powerpoints/ Teaching Guide

Lesson I Observing Sand, Silt, and Clay**:**
https://docs.google.com/presentation/d/1QLKg5YTCz33M3RnjP7IhPWlgopYsxQEdzV9DCIpjc_Y/edit#slide=id.g25a452cca0_0_122

Handouts

KWL Worksheet

Student Name: Date:

Know	Want to Know	Learned

Soil Observation Activity

Student Name: Date:

Feature	Sample 1	Sample 2	Sample 3
Look			
Smell			
Feel			
Smear Color			
Size of Grains			
Other			

Soil as a Filter Activity

Student Name: Date:

Water with Floatables (trash)

Filter	**Sand**		**Fine Soil**	
	Prediction:	**Results/Conclusion**	**Prediction:**	**Results/Conclusion**
Soil				
Water				
Floatables				

Water with Oil

Soil				
Water				
Oil				

Student Name: Date:

Water with Chemicals (colored liquid)

Filter	**Sand**		**Fine Soil**	
	Prediction:	**Results/Conclusion**	**Prediction:**	**Results/Conclusion**
Soil				
Water				
Floatables				

Water with Detergents

Soil				
Water				
Oil				

Soil Observation Activity

Student Name: Date:

Sample #1 Sketch (include labels)

Hypothesis

Prediction:

Explanation:

Sample #2 Sketch (include labels)

Hypothesis

Prediction:

Explanation:

Sample #3 Sketch (include labels)

Hypothesis

Prediction:

Explanation:

Field Site Metadata

Fill in the following information about the Field Site you are visiting

Student Name:

Location:

Site Name____

Time_______________ Day________________

Year_______________ Month______________

Weather Temperature:__________

Describe the weather:

Cloud Type:

Cloud Cover:

- ☐ No Clouds
- ☐ Some Clouds (Partly Cloudy)
- ☐ Lots of Clouds

Description of Site & Conditions:

Soil Quality Data Sheet

Student Name:

Name of Site:

Description of Site (including vegetation, contaminants, and land use)

Time

Year: __________ Month: __________ Day: __________ Local Time: __________ am/pm

Weather

Precipitation in last 48 hours? YES/NO Current Weather: ________

Description of Sample

Depth of Sample:

Smell of Sample:

Color of Sample:

Soil Structure:

Temperature

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Nutrients: Nitrogen

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Nutrients: Phosphorus

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Nutrients: Potassium

Observer Name:	Results:
1)	
2)	
3)	
	Average:

Soil Quality Data Sheet

Student Name:

Name of Site:

pH

Observer Name:	Results
1)	
2)	
3)	
Average:	

Optional Description of Sample

Drainage Test Results:

Stratification Test Results:

Organisms Observed:

Water Quality Analysis

What do these results tell us about Newtown Creek?

Other Observations or Notes:

Glossary

These words are chosen to support topics in each unit. Some words appear in more than one unit.

abiotic non living factors, substances or objects

absorption the process by which one substance, such as a solid or liquid, takes up another substance, such as a liquid or gas, through pores or spaces between its molecules

adaptation an inherited characteristic that is passed down from generation to generation, increasing an organism's chance of survival

aerate to allow air to enter into a substance

algae a group of photosynthetic and rootless producers that range from one-cell to multicellular organisms that tend to grow in water

algal bloom the sudden and massive growth of aquatic photosynthetic producers

alluvial deposits of sediment left behind by flowing streams or river that are typically able to sustain plant life

analyze to closely and carefully examine an object or circumstance

aquifer an underground layer of rocks that is permeable and acts as a reservoir for groundwater

attenuate to reduce, weaken or lessen

average the general value found by adding a set of numbers and dividing its sum by the amount of numbers within that set

bacteria microscopic prokaryotic organisms that are able to live in a variety of environments and break down organic materials

bedrock a deposit of solid rock that is typically buried beneath soil or alluvium

bioassessment an evaluation of a waterbody's condition using surveys and other direct measurements of resident biological organisms

biodiversity the variety of organisms found in an ecosystem

biological indicator an organism whose presence or absence indicates a high, low or change in quality of the environment.

biology study of organisms, their physiologic systems and how they interact with each other

bioswale vegetated green spaces typically installed in large sidewalks specifically for stormwater management

biotic living or once living organisms

bivalve a group of mollusks characterized by having two-part hinged shell containing a soft-bodied invertebrate

blocky a rock that has already been broken into lots of blocks, containing many cracks and joints, or the tendency to break into blocks when placed under stress

blue roof a stormwater management system that uses non-plant sources to retain stormwater and provide rooftop cooling

brackish a characteristic that describes a water body as a mixture of fresh and saltwater

brownfield land areas containing large amounts of a hazardous substance, pollutant or contaminant

bulk density the dry weight of soil per unit of its volume

bulkhead a wall used to stabilize waterway systems

buoyancy the act of one item to float in another substance

camouflage an organism's ability to hide or disguise itself by blending into its surroundings

canal an artificial waterway for the purpose of transportation or irrigation

catch basin a small stormwater retention container used in municipal sewer systems

clay fine sediment particles that are smaller than sand and silt, are easily shaped when molded and harden when dried

cloudy a characteristic that describes either the amount cloud cover in the sky or the amount of turbidity in a liquid

combined sewer a type of sewer system that captures and reroutes wastewater and stormwater within the same pipes

compaction describes the reduction in sediment porosity

compost a type of fertilizer that consists of decomposed organic nitrogen and carbon based materials and is used to maintain plant health and soil quality

conservation the act of limiting natural resource usage to a sustainable level

conservation buffer small areas of land with permanent vegetation that are designed to slow water runoff, provide shelter and stabilize riparian areas

contamination the presence of an unwanted pollutant or impurity

control the group within a scientific research study that does not contain the independent variables

countershading describing an organism's darker coloring on areas exposed to light and lighter coloring on areas that are normally shaded for protection from predators

Combined Sewer Overflow (CSO) an event that occurs when the sewer system is overwhelmed by the influx of stormwater which causing excess sewage to overflow into the nearest waterbody

data quantitative (numbers) or qualitative (descriptions) information that is measured, organized, and analyzed in order to test a hypothesis

debris scattered fragments or broken pieces, typically from an object that has been damaged and/or destroyed

decompose to break down, separate, or decay from its original form

decomposition the act of decaying or separating

decrease to make something smaller in size or quantity

density the amount of mass per volume of a substance

dependent variable the variable affected or changed by the independent variable

detris waste or debris of any kind;also, organic matter produced by the decomposition of organisms

dirt misplaced or removed soil that has lost the characteristics that give it the ability to support life

discharge to release or unload a substance or material

dissolved oxygen the amount of oxygen that is dissolved in water and available to aquatic organisms for respiration

diving birds birds that plunge into the water to catch fish or other food and typically have lobed or webbed feet

drainage the natural or artificial removal of surface or subsurface water from an area

drought reduced precipitation over an extended period of time that results in the shortage of water normally used by the community and/or local environment

ecology the science concerned with the interactions of living organisms with each other and with their environment

ecosystem the collection of organisms, their connections, resources and habitats within their abiotic environment

environment the external surroundings including all of the biotic and abiotic factors that surround and affect the survival and development of an organism or population

erosion the removal and transport of soil and rock by natural agents such as wind and flowing water

estuary a body of water where fresh water from a river meets salt water from an ocean

eutrophication the enrichment of an ecosystem with chemical nutrients, typically compounds containing nitrogen, phosphorus, or both. Eutrophication can be a natural process in lakes, occurring as they age through geological time

extinct the status of an organism whose species no longer exists

fauna all of the animal life of any particular region, time or environment

fecal coliform the most common microbiological contaminants of natural waters that normally live in the digestive tracks of warm-blooded animals, and are excreted in the feces

fertilizer any substance, natural or synthetic, applied to soils or plant tissues to supply one or more nutrients essential for plant growth

filter to separate an undissolved substance from its liquid

floatables litter or particles that floats in the water

flood zone a zone that is prone to flooding based on the topography of the land

flora all of the plant life of any particular region, time or environment

food chain a hierarchy of organisms that are grouped based on eating habits within an ecosystem

food web a set of connected food chains within an ecosystem

friable easily broken into small pieces

fungi a group of eukaryotic protists that are characterized by the absence of chlorophyll and the presence of a rigid cell wall

glacial till unsorted material deposited directly by glacial ice and showing no layering of rocks; also known as boulder clay

green infrastructure an approach to water management mimics the natural water cycle by planting vegetation, including trees, plants and wetlands

green roof a roof that is covered in plants, which reduces stormwater run-off and lowers cooling costs

groundwater water found underground in the cracks, pores and spaces in soil, sand and rock

habitat the natural home of an organism (plant or animal) where it can obtain food, water and shelter

herbivore animals that feed on plants

heterotroph an organism that acquires its nutrients by consuming other organisms

humus the layer of organic matter in soil derived from decay of plants and animals

hypothesis an idea or theory that is not proven but leads to further study or discussion

impermeable a surface that does not allow liquids to pass through

increase to make higher in amount

independent variable the variable that is changed by the researcher within an experiment

infiltration the process by which water on the ground surface enters the soil

introduced species organisms, plants or animals, that have entered a new environment by human activity and have not historically existed in that area

invasive species an introduced organism that creates an imbalance in the ecosystem by outcompeting native species

keystone species a species that has an enormously large effect on its environment relative to its abundance

fill (also urban fill) non-native disturbed material in urban areas that may be mixed with demolition debris, asphalt, coal, garbage or other materials

leach loss or extraction from a carrier into a liquid or loss of plant nutrients from soil

loam good quality soil consisting of sand, clay and decayed plants

mean the summation of elements that are then divided by the number of elements

measure to investigate the size, amount, or degree of an object using an instrument with standard units

median the middle value in a list of numbers

metadata descriptive information about a data set, object or resource

microorganism living organisms that can only be viewed by the human eye using a microscope i.e. bacteria

mineral matter a naturally occurring inorganic substance with a definite chemical composition and a regular internal structure

mode the value that occurs most often within a set of numbers

native species organisms, plants or animals, that are found naturally in a local area and are integrated into the ecosystem

nematodes a roundworms found in the Nematoda phylum, are microscopic and found in soil

niche an organism's role or job in an ecosystem. Example: bacteria are decomposers

nitrate a nitrogen and oxygen compound typically found in animal feces and measure used to help determine water body health

non-point source a water pollution source that generally results from land runoff, precipitation, pollution drainage, seepage; i.e. excess fertilizers, oil, and other human-made pollutants

nutrient a substance that enters a waterway from fecal coliform and other contaminants i.e. nitrogen and ammonia

nutrients essential chemicals needed by plants for growth

omnivore organisms that are able to consume both plants and animals

organic matter once living material that has decomposed over time

organism a living thing classified in one of the following groups; animals, plants, fungi, bacteria and protists

outfall a sewer outlet for CSOs that empties into a body of water

parent material the material from which soil is derived from, including weathered bedrock, alluvium and sand

pathogen a bacterium, microorganism or virus that causes disease

permeable a surface that allows liquids to pass through

pH a measurement system that describes the acidity or alkalinity of a solution; a measure used to help determine water and soil quality

phosphate a phosphorus and oxygen compound found in human and animal waste

photic zone sunlight zone; the depth of water the sunlight is able to penetrate

photosynthesis a process where plants use sunlight to make plant nutrients

phytoremediation direct use of living green plants for in situ, removal, degradation or containment of contaminants in soils, sludges, sediments surface water and groundwater

pioneer species a hardy species which are the first to colonize previously disrupted or damaged ecosystems, beginning a chain of ecological succession that ultimately leads to a more biodiverse steady-state ecosystem

plankton an organism (plant or animal) that floats in the water and cannot swim against the current

platy broad, flat; referring to soil structure

plume a slick or sheen of oil sheen on water

point source pollution water pollution that comes from a single place, usually a sewage-outflow pipe

pollutants a waste material introduced to the environment that has undesirable effects on the ecosystem

pollution introduction of harmful substances into an environment that causes harm to the ecosystem

pore space spaces within soil that can be filled with air, water or both

porosity measure of pore space

potassium an essential nutrient for plant growth

precipitation water released from clouds in the form of rain, freezing rain, sleet, snow, or hail

primary producer organisms that make their food through photosynthesis

protozoa group of one-celled organisms that live in the water or as parasites

remediation cleaning or fixing a source of pollution

respiration the reversed process of photosynthesis; converts sugars into energy for plant growth and health maintenance

restoration process of renewing and restoring degraded, damaged, or destroyed ecosystems and habitat by human intervention

retain the act of holding or containing an item or characteristic

retention tanks a tank specifically designed to capture and hold stormwater to reduce the number of CSO events

rhizosphere the area within a layer of soil that is directly impacted by the plants roots and flora of bacteria within that layer

riparian an area of land adjacent to a body of water, i.e. wetlands

runoff flow of water that occurs when excess stormwater, meltwater, or other sources flows over earth’s surface

salinity the amount of dissolved salt in the water; measure used to help determine water body health

salt marsh a coastal wetland that is flooded or drained by salt water brought in from the tide

sand a type of sediment that has the largest grain size, coming from eroding rocks and typically found on beaches and in deserts

sanitary sewer an underground piping system that directs wastewater from buildings to the nearest waste water treatment plant or into the nearest waterbody

saturate the state of an object that is holding the maximum amount of liquid

scavenger a type of feeding behavior of an animal that feeds on dead animal and/or plant material

sediment particles or material formed by the weathering and erosion of rocks or organic matter

separate sewer a type of sewer system that is designed to collect or transport stormwater only

sewage wastewater and excrement conveyed in sewers

sewer a pipe that carries wastewater/stormwater runoff from the source to a treatment plant or receiving stream

sewershed an area of land containing sewage line connections that carry wastewater and/or stormwater

silt a type of sediment whose grain size is smaller than sand and larger than clay

soil upper layer of sediment that contains the organic materials to support plant life

soil horizon layers of the soil that contain different material at different depths

soil profile a column of sediment from the surface down to its underlying rock

soil structure how individual soil granules clump or bind together

species a set of living organisms that share similar physical, genetic, feeding and mating characteristics

stagnant the act of remaining unchanged or having no movement

stewardship cooperative planning and management of environmental resources with communities/industry to prevent habitat loss in the interest of long-term sustainability

storm drain openings, usually a pipe or grated opening that allows stormwater to enter the sewer system

storm water rainfall that ends up in the sewer system

stormwater catchment a set of systems that captures and directs stormwater to either wastewater management treatment plants, retention infrastructures and/or to the nearest water body

subsoil the layer of soil beneath the topsoil and above the bedrock

Superfund the federal government's program to clean up the nation's uncontrolled hazardous waste sites

taxonomy the study of the classification of living things. Each of the 5 Kingdoms is broken down into subgroups (smaller groups): Kingdom, Phylum, Class, Order, Family, Genus, Species

temperature the comparative objective measure of hot and cold

texture the feel, appearance, or consistency of a surface or substance

tide the daily rise and fall of the oceans' water level due to the gravitational pull of the moon

topographic map representations of a three dimensional land surface on a flat piece of paper

topography the study of elevation changes of the Earth's surface which are typically mapped

topsoil the upper layer of soil that contains the root structure of most plants

toxic a harmful or poisonous substance

trend a general direction in which something is developing or changing

turbidity a measurement of the amount of suspended solids in the water. How "cloudy" the water is

urban related to or characteristic of a densely populated environment

urban ecology the study of living organisms, their relationships between each other and their habitat within a densely populated area

variable a factor, trait or condition that can vary in its amount

vertebrate animals with backbones