



Thematic Unit 4:

Land and Water: A Delicate Balance

Homes, schools, businesses, parks, and roadways are all part of the essential fabric of our urban life. When our built environment grows, development can overwhelm the natural environment and impact surrounding waterways. Students will learn how this relationship between land and water is a delicate balancing act for humans and nature. Periodically, throughout the last two centuries, human activities have tipped the balance leading to a loss in equilibrium. Finding and maintaining this balance in order to protect public health and sustain ecological well-being is a commitment we must make for our future.



What you should know:

NEW YORK HARBOR

New York City is shaped by water. The waters of New York Harbor set boundaries for the City's boroughs and define our history. Hundreds of years ago, freshwater wetlands, salt marshes, streams, and rivers supported communities, commerce, and wildlife. In earlier times, we depended exclusively on our waterways to transport vital (and luxury) goods. New York's proximity to major waterways in the industrial age propelled it to become America's primary hub for manufacturing and trade, most notably in the garment, sugar refining, publishing, and boat building industries. Eventually, wetlands and marshes were filled in and the resulting tributaries became some of the nation's busiest commercial waterways.

As one of the world's great waterfront cities, the development and rapid urbanization of New York City is intrinsically linked to the waters around it. This growth eventually adversely impacted the environment and our quality of life. Since its settlement, New York's waterways also became the "drain" for our untreated waste, and dumping ground for industrial chemicals with the intent to convey it away from homes and hope that the tides would carry it out to sea. As we learned in the previous unit, the industrial age tipped the balance, as nature could not keep pace with the waste produced by a population in the millions. "Out of sight, out of mind" eventually caught up to us.

More than a century of effort has been dedicated to creating and implementing innovative ways to restore ecological equilibrium. In 1909, the Metropolitan Sewerage Commission was established in an effort to assess and improve water quality in the rivers, bays, and estuaries-- collectively known as the **New York Harbor**. New York Harbor includes the inner harbor of the Hudson River up

to Westchester County, the lower New York and Raritan Bay, Jamaica Bay, the East River, western Long Island Sound, and dozens of tributaries. We continue to monitor harbor water quality today through the Harbor Survey Program, by which scientists have collected more than a century of data on the health of our harbor and helped to identify the need for innovative infrastructure projects. The introduction of wastewater treatment facilities (the first in 1886) to treat our wastewater and the advancements in technology to enhance these processes have had a tremendous impact on improving water quality and restoring the healthy marine ecosystems we experience today.

CHALLENGES TO WATER QUALITY

New York City continues to protect the health of our harbor today by identifying and addressing stormwater pollution. As described in earlier units, New York City's sewer system is comprised of both combined and separate sewer systems. A **combined sewer system** carries sanitary waste (or sewage) from homes, schools, and businesses, plus stormwater runoff from streets, sidewalks, and rooftops, to a wastewater resource recovery facility where it is treated before clean water is released to a nearby waterway. During wet weather, our 14 wastewater resource recovery facilities can treat up to twice as much incoming wastewater as on a typical dry day. However, in times of moderate to heavy rainfall, these facilities may reach capacity. When the system reaches capacity, **combined sewer overflows (CSOs)** can occur, discharging a diluted mixture of untreated wastewater and stormwater runoff directly to the nearest waterway. In New York City, there are over 400 of these permitted combined sewer outfalls, or locations where this overflow can be released. Approximately 60% of the city is part of the combined sewer system, while the remaining areas, including most of Staten Island, south Queens, and south Brooklyn, rely on separate sewers.

These areas of New York City's land are drained by the **municipal separate storm sewer system (MS4)**. This kind of system collects stormwater runoff and wastewater separately into two discrete pipes. Wastewater is collected in a sanitary pipe and sent to a wastewater resource recovery facility for treatment. Stormwater runoff is conveyed through a storm sewer pipe and discharged directly to the nearest waterway. While this discharge is cleaner than a CSO, it can still result in water pollution due to trash or bacteria that gets swept up with stormwater and flows untreated to waterways.



CHANGES TO POLICIES AND INFRASTRUCTURE

Still, the waters surrounding New York City today are cleaner and healthier than they have been since the Civil War. The federal Clean Water Act of 1972, the State Pollutant Discharge Elimination System (SPDES), and other important environmental regulations for industries and public water and sewer departments have been a driving force for setting the standards that help protect the health of our waterways. By the time the United States Congress passed the Clean Water Act in 1972, New York City was well on its way to reversing the effects of neglect.

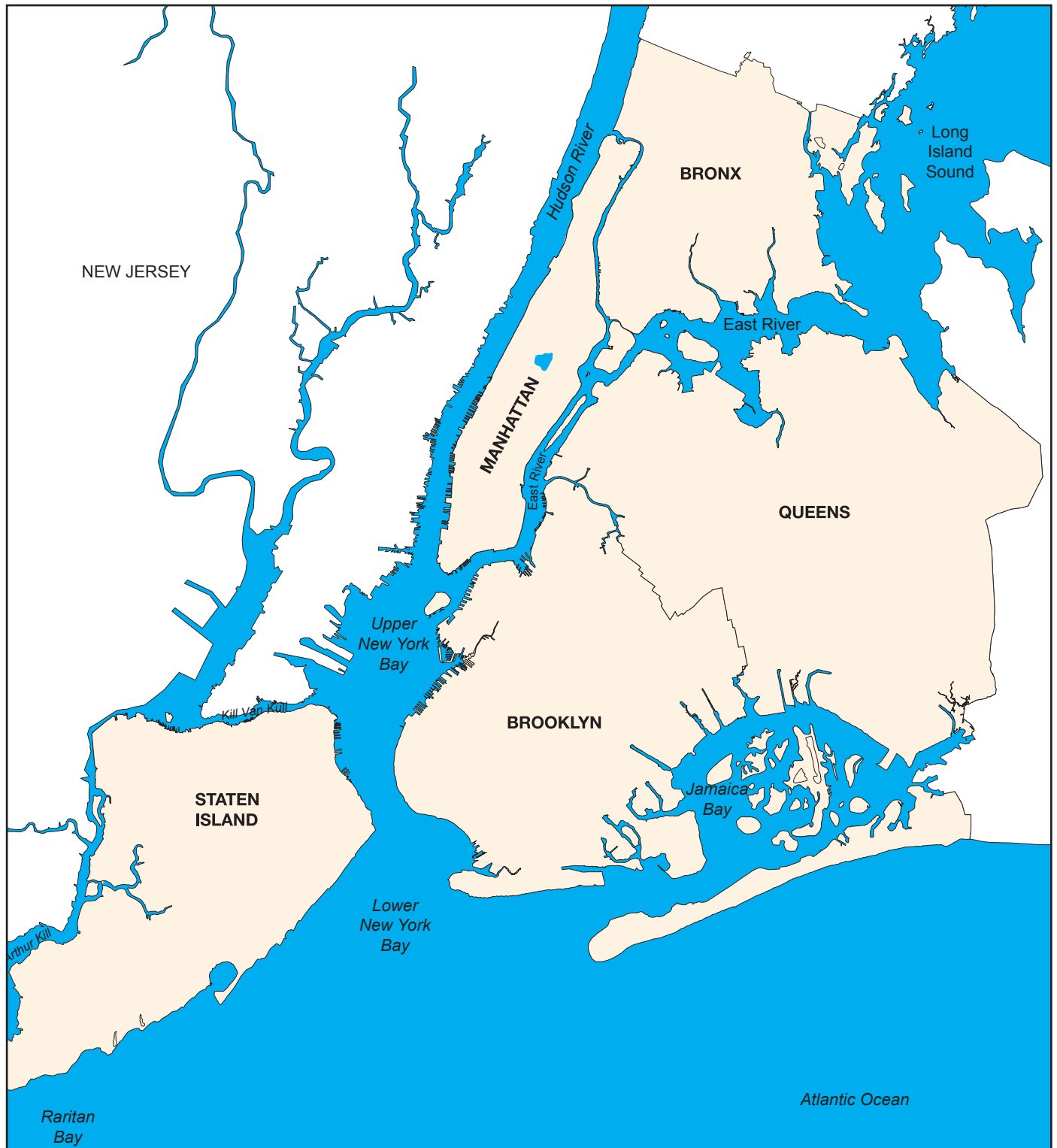
Over the past several decades, we have invested more than \$45 billion in the construction and upgrade of critical infrastructure to improve the health of our vital ecosystems. These essential investments included upgrading wastewater treatment facilities to handle twice as much flow during wet weather, building new storm sewers in low-lying areas, upgrading pumping stations to keep flow moving throughout the system, building out sewers where more capacity was needed, and implementing a wide range of best management practices to reduce potential pollutants in stormwater. These improvements can be seen throughout the five boroughs: seals exploring the Bronx River, whales splashing in the Upper New York Bay, and millions of New Yorkers and tourists flocking to waterways for recreation.

Despite these regulations and investments, our work is not done. We continue to invest billions of dollars to reduce CSOs, coordinate with state and federal regulators, work with legislators to pass regulations for property owners, and develop innovative solutions to complex challenges. Today we have taken a more green approach to improve this land-water imbalance by investing in green infrastructure to improve our urban landscape's ability to absorb stormwater where it falls (covered more in Unit 5). We recognize that our actions on land affect the health of our waterbodies, and with continued sustainable urban planning, stewardship and education, we, and future generations, can enjoy the benefits of a clean and healthy environment.

Sequence of Lessons

1. The Rain Drain: Stop Trash in its Tracks
2. What's the Point: Exploring Point Source and Non-point Source Pollution
3. Plants and Pavement: Pervious and Impervious Surfaces
4. What is Combined Sewer Overflow?
5. The Clean Water Act: A Policy Movement

New York City Waterways



L1 The Rain Drain: Stop Trash in its Tracks

One of the threats to water quality today is pollution from stormwater runoff. This happens when rain and snowmelt washes away trash, oil, pet waste, and other pollutants from our streets and sidewalks into local waterways. There are more than 144,000 catch basins capturing and draining stormwater runoff from streets and sidewalks in New York City. Stormwater pollution is an ongoing issue in our communities that continues to challenge the health of our rivers and ocean. Learning about this issue through real-world observations, data collection, and action are the best ways to engage your students in helping to protect our waterways.

ESSENTIAL QUESTION

What is the relationship between trash on my street and the waterways that surround the city?

VOCABULARY

Pollution (*noun*)

The introduction of harmful substances, such as oils, chemicals, sediments, and trash that can contaminate or dirty water, air, and land.

Stormwater Runoff (*noun*)

Water from precipitation that lands on rooftops, parking lots, streets, sidewalks, and other impervious surfaces, and flows over the land instead of seeping into the ground.

Catch Basin (*noun*)

A type of drain structure located next to the curb that collects stormwater runoff into the sewer system in order to decrease street flooding.

SUGGESTED IDEAS AND ACTIVITIES

- Take a walk around your school community to identify nearby catch basins. Create a simple checklist for students to gather their observations, including the condition of the catch basin and the different kinds of litter and pollutants they observe near the catch basin.

Discuss next steps for helping to maintain catch basins (e.g., report issues to 311, request another trash bin from New York City's Department of Sanitation, reduce litter and help clean up).

- Have students observe the condition of catch basins in dry weather versus in wet weather. Can you find the message "Dump No Waste, Leads to Waterways"? Do you notice any symbols or other messages on this particular catch basin? What do you think this means? In the classroom, have each student select one item of trash or debris they saw and write a story about it. Consider where it may have come from and what will happen to it after a storm. Research who and what stormwater pollutants can affect (e.g., sea turtles and plastic bags).
- Create a litter survey with students to study the most common types of trash and debris around your school community, as well as their locations. Hypothesize on the sources of these different items. Organize a clean-up and spread awareness to community members and local businesses on how to reduce street litter and protect water quality.
- Have students create an art piece featuring commonly-littered items. Students can use discarded items (upcycling) to create materials or artwork for display. Share students' artwork and related stewardship projects using the interactive [Zero Waste Schools](#) website.
- Discuss and develop a school wide plan to reduce trash, increase recycling, and raise awareness. Conduct a waste audit using examples from [GrowNYC](#) and the Zero Waste Schools program. Using this information, have students make posters, write slogans, and create public service announcements for the school community about reducing litter waste and advocating for solutions.



- f. Visit the [Recycling Education Center](#) at Sims Municipal Recycling in Brooklyn to learn about how the recycling system in New York City works. Where do different types of litter originate? Recall that many items that are littered could have been recycled. What happens to the items we recycle?
- g. Research citywide regulations that ban or restrict the use of some disposable (often littered) items such as plastic bags and Styrofoam. How are other U.S. cities addressing similar issues? Discuss reusable alternatives to use at school and home. Allow students to get creative and design their own reusable canvas bag using compostable or recyclable material (e.g., an old t-shirt). Check out [Materials for the Arts](#) for some inspiring materials or activity ideas ahead of time.

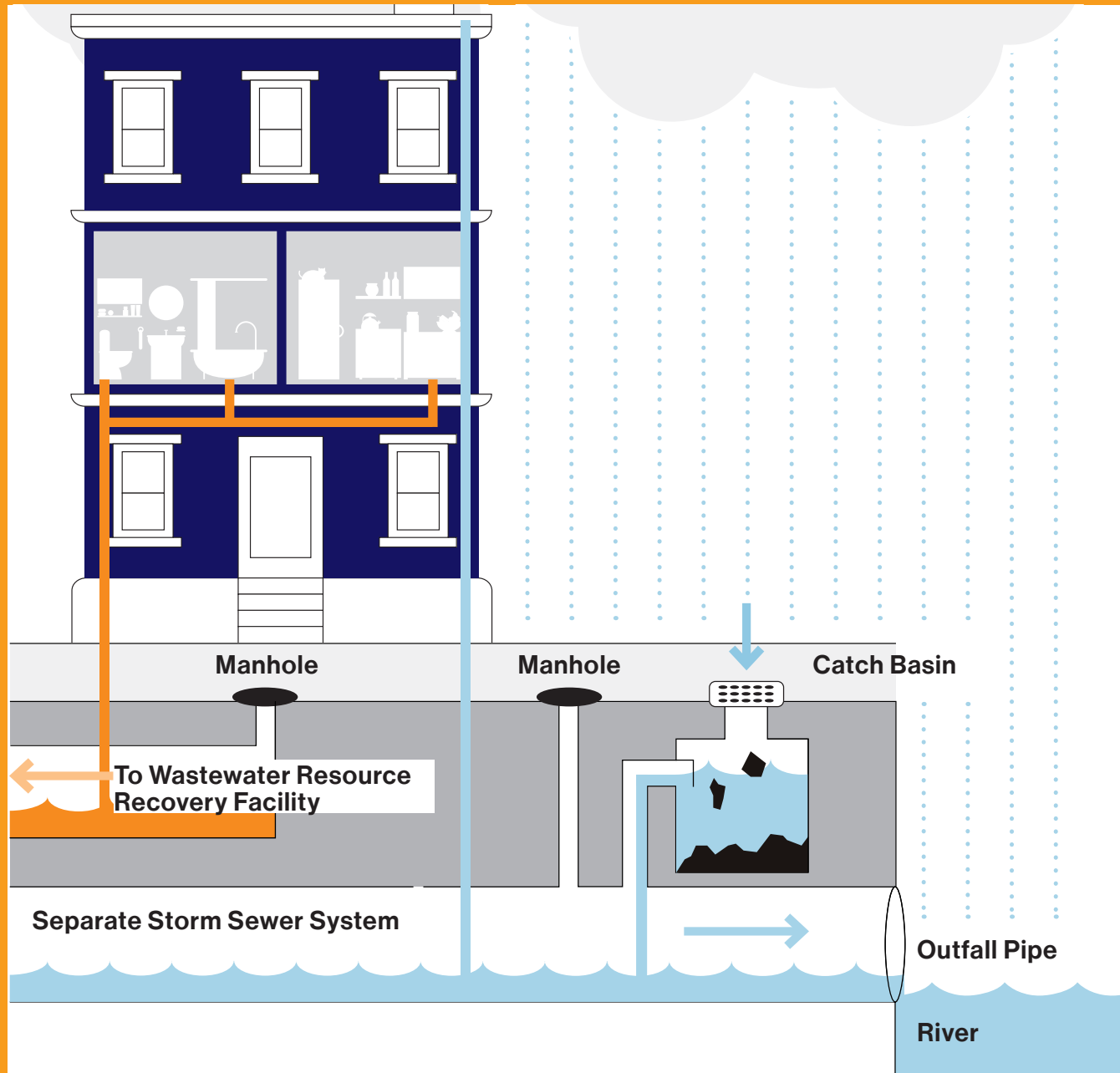
CONSIDER AND DISCUSS

- Do we all live *in* a watershed? Revisit what a watershed is. Consider how many watersheds exist in New York State (about 70,000!); in New York City? (Hint: Water draining off the land into pipes is still part of a watershed)
- Explore DEP's [Sewer System Virtual Tour](#) for video interviews, maps, and more activities on stormwater and the sewers. What happens to stormwater runoff that drains into catch basins?
- How does trash move through your local watershed? Where are the different places it can end up?

ASK THE EXPERT

Now students are becoming the experts! Students should ask friends and family what they think happens to street litter. Remind them why it's so important to dispose of waste and recycling properly.

Separate Sewer System



While most areas of New York City rely on a combined sewer system, nearly 40% of the sewer system is separated. A separate sewer system consists of two pipes: a sanitary sewer pipe that carries wastewater to a wastewater resource recovery facility for treatment and a storm sewer that conveys stormwater runoff directly to a nearby waterway. During wet weather, stormwater runs off city sidewalks and streets, picking up pollutants, such as litter, car oil, and pet waste, and flows directly out to waterways untreated. This runoff is

harmful to water quality and can negatively impact the local ecology or limit recreational uses of waterways. The City of New York received its first Municipal Separate Storm Sewer System (MS4) Permit, issued by the New York State Department of Environmental Conservation in 2015, to further manage urban sources of stormwater runoff and reduce pollution to our vital rivers, creeks, and bays. What individual and collective actions can we take to help reduce stormwater pollution from entering our waterways?



What's the Point: Exploring Point Source and Non-point Source Pollution

Before we can work on reducing pollution in our waterways, we need to identify its source. When something harmful is dumped directly into the water, this is considered point source pollution. When waste from numerous sources is deposited on the land and makes its way into the water indirectly, that is considered non-point source pollution. Both sources of pollution are quite common in an urban environment like New York City.

ESSENTIAL QUESTION

What is the difference between point and non-point sources of pollution?

VOCABULARY

Point Source Pollution (*noun*)

Any single source of pollutants dumped or discharged directly into a waterway from a pipe or outfall.

Non-point Source Pollution (*noun*)

Pollutants that originate from multiple sources over a relatively large area, rather than from a single source.

SUGGESTED IDEAS AND ACTIVITIES

- Brainstorm a list of activities and things that can cause pollution in our waterways. Ask students to separate this list into point source and non-point source pollutants. Ask them to describe the difference. Illustrate a comic strip about a specific pollutant's travels. Is it point or non-point source pollution?
- Create an I-Spy game for students to conduct neighborhood observations of all the different types of non-point source pollution they notice. Make a display of drawings or photographs collected from their observations. Record by type and create a graph to display results.
- Research a nearby waterway, its history in the community and to New York City, types of local industry and development, and its current water quality conditions and uses (e.g., boating, fishing, swimming). Using their observations and litter surveys from activities in Lesson 1, create an inventory of any potential (or proven) point and non-

point source pollutants they can identify from their neighborhood research. Discuss the issues and plan strategies for solutions.

- Build off of your school wide campaign activity in Lesson 1 by developing a community wide campaign. Research ongoing citywide litter campaigns; for example, the Bring It. campaign to remind New Yorkers to use reusable bags, water bottles, and more. In small groups, come up with a catchy slogan and actions everyone can do to reduce pollution in New York City. Discuss different types of media for reaching a wider audience and local community leaders (e.g., video, PSA, artwork, poetry). Have students write a letter (to family, school administrators, or local council members) to accompany their announcement.
- Refer back to watershed modeling activities in Unit 1, this time create a watershed model of our urban environment (e.g., more low-lying, less forested, more developed) to investigate the relationship between the local landscape and surrounding waterways. Compare potential pollutant sources in an urban environment versus a suburban or rural environment like New York City's upstate watersheds. Summarize how land use management and water protection impact each other.

CONSIDER AND DISCUSS

- Research New York City's [Green Infrastructure Program](#) to understand what the city is doing to reduce stormwater runoff and manage potential pollutants from runoff. What are other cities doing to reduce pollution and protect water quality?
- Research the history of your community or borough and its relationship to environmental pollution in New York City. What types of pollutants affected your community in the past (and presently)?

ASK THE EXPERT

Environmental Engineer – an engineer who designs, plans, and implements measures to prevent, control, or remediate environmental pollution.



Plants and Pavement: Pervious and Impervious Surfaces

Changing an urban *streetscape* to an urban *landscape* is one of the long-term goals of water quality protection.

The transformation of streets, rooftops, and parking lots (or impervious surfaces) to green roofs, rain gardens, and porous pavement (or permeable surfaces) requires some understanding of the key components of success: soil and plants.

ESSENTIAL QUESTION

How does our urban landscape affect water quality?

VOCABULARY

Pervious/Permeable (*adjective*)

Allowing water to pass through.

Impervious/Impermeable (*adjective*)

Preventing or slowing water from passing through.

SUGGESTED IDEAS AND ACTIVITIES

- a. Grow simple vascular plants (bean plants work well) in your classroom in small test tubes by the window or with a grow light and observe and record the emerging root and leaf systems. Learn about the parts of the plant and the purpose of each. Have students sketch plant growth each week, and compile their sketches in a field journal.
- b. Have students observe their growing plants once a week and write poetry from their observations. Connect with your school or local library, or [Poets House](#) to find sample poems to share with students that capture the richness and value of nature.
- c. Build a terrarium in the classroom (or small individual terrariums), make daily observations, and measure temperature. Observe and discuss the cycle of water throughout this ecosystem.
- d. Students can explore how soil affects the rate of water infiltration by creating some simple soil compositions and timing water flow through these soil types (sand, silt, and clay). Use a funnel, coffee filter, and conical tube or clear measured container to catch the water (an empty liter bottle cut in half with the top inverted works well). Add compost or grow grass in your soil and compare what happens.
- e. Have students conduct a survey of your schoolyard or surrounding community to measure surface area and percent land coverage that is impervious versus permeable. Compare results to annual rainfall data and hypothesize trends for stormwater runoff. (Refer to DEP's [Green Infrastructure Education Module](#)).
- f. Take a walk around your school community or to a nearby park. Bring field journals for writing and sketching observations, along with tree and bird identification guides for determining common street trees and bird species. Connect with the [Urban Park Rangers](#) for a guided program. What do your findings tell you about our urban ecosystem? Why are parks important?
- g. Sign your class up to care for a local street tree. Determine ways to monitor the tree pit daily or weekly for infiltration, growth, and pollutant control. Contact [Trees New York](#) to learn about a tree care and maintenance program for your students.
- h. Visit the botanical garden in your borough to learn about local and native plant species that make up New York City's landscape. Connect with garden educators for a guided program. Learn how some botanical gardens have redesigned their spaces to be more sustainable (and LEED-certified!) with a focus on stormwater management and conservation.
- i. Research the Wildlife Conservation Society's Mannahatta and Welikia projects, which depict the original natural landscapes of New York City. Consider how the landscape naturally handled stormwater in the past. Further explore [Visionmaker NYC's](#) online data and mapping tools to experiment with land use management practices (past, present, and future) by creating climate-resilient and sustainable designs.

CONSIDER AND DISCUSS

- What are our perceptions of nature in the urban environment?
- In addition to protecting water quality, what other community benefits are there to increasing green space and building green infrastructure?

ASK THE EXPERT

City Park Landscape Architect – an architect who designs attractive and functional public parks, including the gardens, playgrounds, athletic fields, as well as roads, walkways, plants and trees.





L4 What is Combined Sewer Overflow?

In Thematic Unit 3, students learned about the New York City sewer system engineered to convey waste, both stormwater and wastewater, away from where we live, work, and play. During dry weather, the city's combined sewer system and wastewater resource recovery facilities have the capacity to transport and treat all the wastewater from homes, schools, and businesses. However, when flow increases as a result of heavy rainfall or snowmelt, the facilities can reach their capacity. When system capacity is reached, a diluted mix of untreated wastewater and stormwater runoff can be released to nearby waterways from combined sewer outfalls to prevent neighborhoods and the facilities from flooding. This discharge is called a Combined Sewer Overflow (CSO).

ESSENTIAL QUESTION

How can I play a part in reducing water pollution in and around my neighborhood?

VOCABULARY

Outfall (*noun*)

The outlet of a pipe that discharges into a body of water.

Convey (*verb*)

To move or transport in a continuous stream or mass.

SUGGESTED IDEAS AND ACTIVITIES

- a. Ask students to share examples of something overflowing (e.g., the bathtub, the sink, a glass of milk or juice). Demonstrate an example in the classroom. What were the consequences? How did they deal with the clean up? Relate this to combined sewers and waterways during a heavy rainstorm.
- b. Set up a demonstration (or have students work in teams to create models) of a combined sewer overflow. Start with two separate plastic tubes each outfitted with a funnel on top. These two tubes are connected to another larger tube. Pour water dyed with food coloring—blue for rainwater and red for wastewater—into the separate tubes and see the water turn purple and spill out the bottom. Then divert some of the water from the larger tube (simulating the journey to the wastewater resource recovery facility). Next, pour larger quantities of water down the stormwater tube and simulate overflow.
- c. Learn more about CSOs using the Center for Urban Pedagogy's (CUP) [Sewer in a Suitcase](#) model. Watch as stormwater runoff picks up debris and contaminants from streets and get diverted into a nearby waterway when a CSO occurs. Try out different scenarios using the model and discuss water quality concerns.
- d. Research when CSOs occur using New York City's [Waterbody Advisory System](#). Look up the weather forecast for the upcoming week and ask students to hypothesize on which days CSOs may occur. Track, monitor, and graph data. What could be in a CSO that can affect water quality and the species living in and around the waterway?
- e. Refer back to activities in Unit 2 that had students calculate how much water they use on a daily or weekly basis. Consider how their water use habits can impact the sewer system on a rainy day. Ask students to create a weekly water use schedule while studying the weather forecast for the upcoming week. Read more about DEP's [WAIT](#) program, and study how water conservation during wet weather can play a role in reducing CSOs.



- f. Consider what types of waste go down our drains from our water use activities at home (e.g., feces, toilet paper, toothpaste, food scraps, oil) that could pollute waterways during a CSO. Create a list and ask students to determine which items can be flushed and which should be thrown out (remember, only flush the 4 Ps -- pee, poop, puke, and toilet paper!). Refer back to Lesson 3 to learn more about DEP's [Trash It. Don't Flush It.](#) campaign and the importance of properly disposing of household waste to reduce fatbergs from forming in the sewers.
- g. Research local waterways using DEP's [Long Term Control Plans \(LTCPs\)](#). Choose a waterway of interest, and refer to DEP's simplified fact sheets and the graphs and data found in the City's [recommended plan summary](#) to learn more. Discuss the different Best Management Practices (BMPs) that we can use to improve local waterways and reduce CSOs. What plans would you suggest including to improve water quality? Write a proposal and create design sketches.

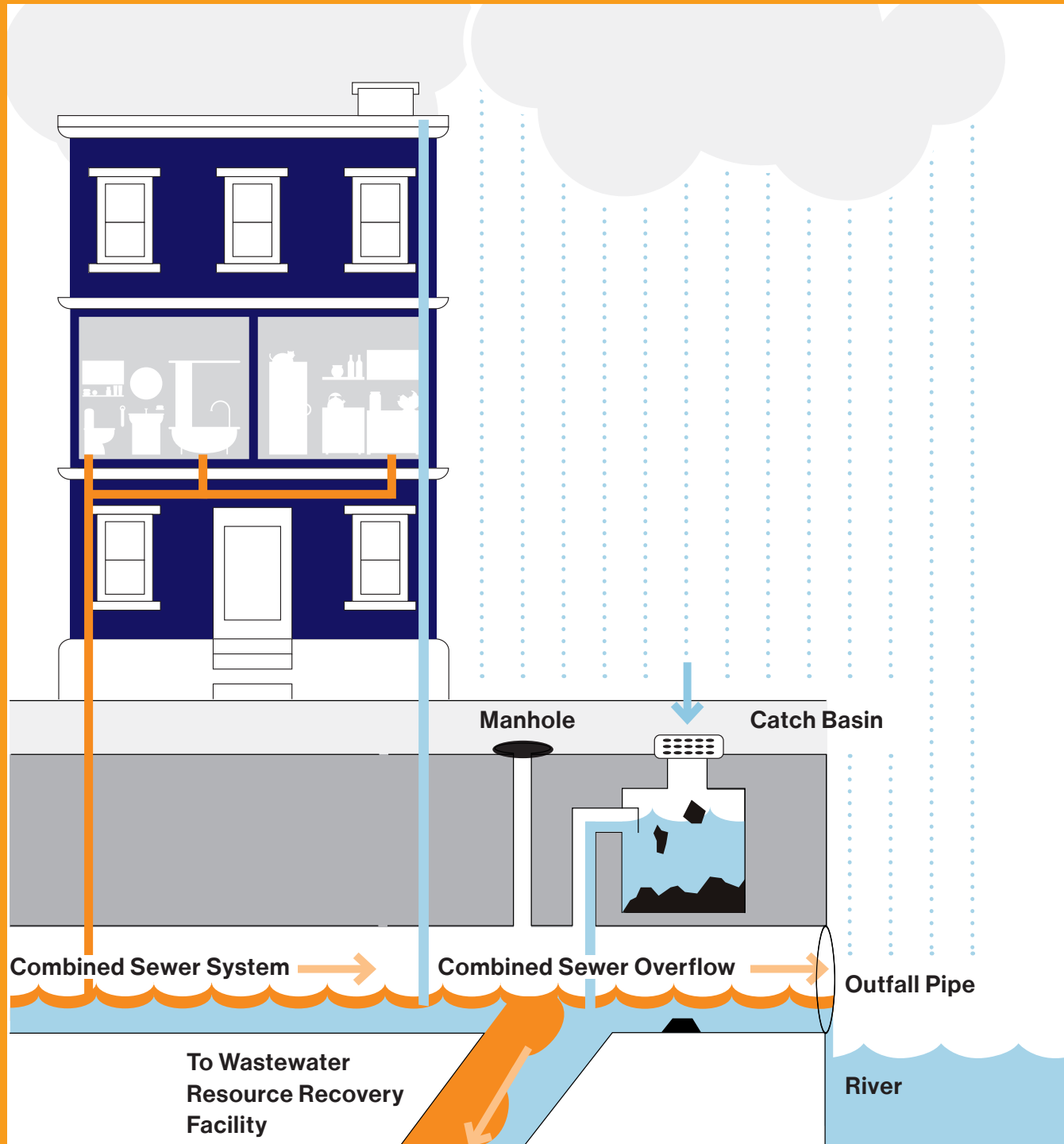
CONSIDER AND DISCUSS

- Speculate as to why the combined sewer infrastructure exists in older neighborhoods. What was the initial objective of New York City's early sewers?
- Explore DEP's [Harbor Water Quality Virtual Tour](#) for video interviews, maps, and more activities on water protection and stewardship. How do you think we can play a role in reducing overflow events? What can individuals do? What can we do as a community?
- Connect stormwater management to climate change. Research and consider climate change trends for New York City. Why is stormwater management important? Refer to DEP's [Climate Change Education Module](#) for more information.

ASK THE EXPERT

Environmental Planner – a professional that plans and designs land use in an environmentally, socially, and economically responsible way.

Combined Sewer System



Similar to many older cities around the United States, New York City relies primarily on a combined sewer system. A combined sewer system is a single sewer system that carries both sewage and stormwater in one pipe, to a wastewater resource recovery facility for treatment before being released to a waterway. During

moderate to heavy rainfall events, the system will reach capacity, leading to an overflow of a diluted mixture of wastewater and stormwater runoff directly to our waterways from more than 400 permitted Combined Sewer Overflow outfalls around New York City. Approximately 60% of New York City's sewers make up the combined sewer system.



L5 The Clean Water Act: A Policy Movement

Enacted in 1972, the federal Clean Water Act began a movement for monumental environmental change in the U.S. The Clean Water Act and numerous subsequent regulations set standards for controlling pollution and maintaining water quality in America's waterways. The U.S. Environmental Protection Agency has put into place federal regulations that make it unlawful to discharge any pollutant directly (point source) into navigable waters without a permit. This generally applies to industrial, municipal, and other facilities that dump wastewater directly into surface waters. Within New York, the State Department of Environmental Conservation enforces all environmental regulations, and is a critical partner involved in our efforts to reduce water pollution and introduce a new generation of New Yorkers to the Harbor.

ESSENTIAL QUESTION

How are significant environmental laws established?

VOCABULARY

Regulation (*noun*)

A rule, order, or code issued by an executive authority or regulatory agency of a government.

SUGGESTED IDEAS AND ACTIVITIES

- Have students brainstorm, develop, and “enact” a regulation for the classroom that benefits the entire group. Determine how and who will enforce the regulation, and what, if any consequences there will be for violations.
- Add to the activity above with role-play as citizens and lawmakers. Review how a bill becomes a law. Have students perform the song, “I’m Just a Bill” from Disney’s Schoolhouse Rock.
- Why was the Clean Water Act so successful? What else was happening during the 1970s that impacted positive change for the environment? Research the first Earth Day and plan an Earth Day event for your school. What topics would you like to educate classmates and community members on?
- Make a timeline of important changes and regulations enacted throughout the environmental movement. Who were the leaders of this movement? Introduce the topic of environmental

justice and discuss the importance of grassroots community activism. Discuss the movement today; who are the leaders now?

- Research the U.S. Environmental Protection Agency and other regulatory agencies that oversee and protect public health and the environment. What else do they protect besides water? Research Superfund sites in New York City, such as the Newtown Creek and Gowanus Canal. Meet with a community-based organization like the [Newtown Creek Alliance](#) or [Gowanus Canal Conservancy](#) for a guided walking tour to learn about the history and natural landscape of these waterways.
- Connect the role of the Clean Water Act to the advancement of wastewater resource recovery facilities and decisions on how to manage byproducts like sludge. Use DEP archival images and maps to document the system upgrades that took place. Refer back to the wastewater timeline activity in Unit 3.
- Research regulations that were influenced by and implemented following the Clean Water Act of 1972. Have students play the role of environmental lawyers and draft an environmental bill (either original or one that was previously introduced) for which to argue in a mock Congress.

CONSIDER AND DISCUSS

- What other laws help protect public health? How are these laws enforced? Are there any rules in your school or classroom that are made to help protect all students?
- Research other environmental protection policies, including for our drinking water supply. Looking at our history, what occurred that influenced significant policies and who influenced these decisions? (e.g., Three Mile Island, Rachel Carson’s Silent Spring, New York City’s Watershed Memorandum of Agreement)
- Consider how our city life would be different if these policies were never passed. Consider how the results might have been different if there were not important laws to support our stance or decisions today.

ASK THE EXPERT

Environmental Law Attorney – a lawyer with an intimate knowledge of environmental laws, regulations, and policies.