Where Does All the Water Go?

Following water's journey through an urban landscape to preconceive a sustainable city

John Daniel Hartzog

Penn Alexander School

Abstract

The human impact on our environment has been devastating but has also changed so much for the better over the past several decades. Living in sustainable and just cities was a fantasy a few generations ago. But due to changes in awareness and education around the environment and social justice, it seems like an attainable goal. That said, the vast amount of work that needs to be done can be overwhelming. Starting with our youngest, and sometimes most just, learners can make this work possible. This unit explores a very concrete element of how our cities work, and should work: wastewater management. By exploring this concrete, physical, and important aspect of our environment, children will be prepared for later, more complex investigations into environmental change and interconnectedness. This unit will walk kindergarteners through the pathways of rainwater through the urban landscape to discover the planned city and the historic waterways underneath. And it will leave them with an interest in ideas of a more sustainable infrastructure that not only keeps water around longer but brightens and cools our cities.

Unit Content

Our city needs to be prepared for the changes that a warmer and wetter climate will bring. There are political, systemic changes that need to happen but the actors in these systems, our city's inhabitants, need a change of mind, a change of awareness, a desire, an ability and need to demand a change in priorities as to how we develop and maintain our shared urban landscape.

The challenge for many people understanding the impacts of climate change is our economic, social, political bent towards individuality, independence, and self-containment. Our society leans towards individuality, lacking an awareness of the interconnectedness of our natural world as well as our social, political, economic world. This understanding needs to be developed from a young age. Students need to see the importance of connection. That learning requires connection. Our brains are NOT a muscle made stronger by repeated practice alone. Our neural system is made of

connections. Our brains, our thinking and understanding and problem-solving brains, become more effective, more useful, more powerful through the creation and strengthening of connections between our facts, ideas, and understanding.

Teaching about cycles through early childhood creates a cognitive template upon which later learning can be built that allows for more equivocal, more interconnected thinking and less polar, right or wrong thinking. Understanding the water cycle, its physical elements and the chemical and physical changes it undergoes provides a concrete, physical, and relatable opportunity for young minds to grasp this great interconnectedness of our world. They can easily understand the interdependence of the oxygen we breathe, the carbon dioxide we expel and the carbon dioxide that plants "breathe" and the oxygen that they expel. The trash cycle, the kindness cycle, etc. all provide children a chance to develop this awareness that as we are individuals, we live in an interconnected and interdependent world.

In this Unit, I want to create an opportunity for our students to engage their innate desire for justice and fairness and their deep curiosity about the hidden parts of our world. I want them to develop an awareness about the built urban environment and finally inspire them to speak up and demand that we, as a people, take care of our end of the water cycle: managing rain runoff and processing water. To be ready to demand change, these actors need to have an awareness about the invisible workings of our urban fabric: water management, development planning choices, trash collection, and land use management.

Water is a tangible, understandable unit in this process of making our lives and cities more sustainable. It can act as metaphor for the larger problems with our global climate problems. As we explore our water use and its movement through our environment we will begin to notice, understand, and care about the interconnectedness of our environment and be better prepared to understand managing other resources (like waste, recycling, and materialism), mitigation (changing from a fossil fuel based economy), and the incredibly intricate impacts of global warming on communities (especially the less privileged and marginalized communities of our world) (Wheeler and Rosan, 2021, pg. 37).

Teaching Strategies

This unit that I am creating will follow a week or two after a 2/3 week unit of lessons about weather. Weather (like sustainability) is an incredibly complex system. Way too complicated for the minds of young children to understand. Many Kindergarten curricula

(see PSD science curricula) will spend a semester studying weather. Usually these students will observe the weather and begin to develop nomenclature around weather and its occurrences. I begin this unit explaining that weather is simply one of the most complicated and difficult natural events that occur in our world. I explain that meteorologists (whose job it is to predict the weather) cannot even predict weather on a small scale (whether it will rain or snow in a city that feels so grand and large scale to us, the inhabitants of that city), with great precision. Instead of studying the weather we study the "characters" in the story of weather (water, air, and the energy from the sun) culminating in a study of the water cycle. This preceding unit to my proposed curriculum consists of a handful of experiments that show the children characteristics of water, air, and sunlight that illuminate the roles these elements play in the functioning of the water cycle. We will eventually make it rain in our classroom with an awareness of the invisible workings of this water cycle.

Introduction to this Unit:

The unit will begin by collecting students' ideas about where runoff from a rainstorm goes. "We already have learned so much about how the water gets to our streets, sidewalks, parks, and heads in a rainstorm. But where do you think all this water goes after it rains?" Students might mention "puddles, water the plants, gutter, drains, holes, dirt, etc. Read Rain by Donald Crews or Come On Rain by Karen Hesse or After the Rain by Rebecca Koehn and Simone Kruger. As you read, notice features in the book that depict elements in our world that show us where the water goes once it has rained.

Classroom Activities

Lesson 1: Landscape Literacy

Reading the Landscape: Urban landscape Literacy - Take a walk around the school noticing and marking and describing and naming features of the landscape that we will need to know about to track where the water goes after it rains. Walking out of the building, begin noticing immediately the concrete of the surfaces we walk on, the overhangs that protect us, the downspouts around the building. Discuss where the water might go as it pours out or falls down. Some kids will wonder why the water doesn't just stay right there? Pull out a few marbles or small bouncy balls. Drop them gently and watch where they move. They will roll in the same general direction- down the "slope." Repeat the word "slope" as you show them where the slope leads is where the water will go. Engineers build our city to keep us dry. The water will flow AWAY from our buildings and down the slope. Continue this exploration down the slope noticing curbs and gutters, cracks and holes, etc. Use the ball to represent the water, explore what might happen to water at each of these features or obstacles. Continue until you reach an "inlet"

a "sewer drain" etc. Sometimes it might even be a green space where you end up. Remind students that water always "wants to go down." Notice that water will puddle, go into watering plants in green spaces or disappearing down these mysterious inlets. Upon returning to class collect observations and invite students to draw a cartoon or picture that can show what we saw and label the parts of the environment.

Lesson 2: It Goes Underground

Re-read *At Last to the Ocean: The Story of the Endless Water Cycle* by Joel Rothman and Bruce Roberts. When we read this book last time we were noticing the way this book shows us the endless nature of our Earth's water cycle. Today we will read it thinking about where the water goes in our city. We cannot see the mountains and brooks and streams of the story here in our city. Does the water cycle stop in our cities?! No. But the streams and brooks have been covered, diverted, and hidden.
Engineers have done this because they get in the way of travel (it is hard to drive or walk across a stream). They have also done this to protect our cities from flooding. Our cities are built over pipes and tunnels that carry the water away as quickly as possible so that people can get home, get to work, and go shopping right after a rain storm.
See historic streams of Philadelphia https://www.hiddenhydrology.org/philly-h20/
Explore books and diagrams about pipes, gutters, and sewers as water run-off management. See *Underground* by David Macaulay. Reference movies or videos like Ratatouile that represent this underground world to help students take an imaginative journey through pipes, and other urban infrastructure systems, etc. Use Mazes, maze games, and Pipe build games for students to explore how this system operates.

Lesson 3: Water Flows Downhill

One of the great things about managing water is that it follows this one rule- Water flows Downhill. Water will always go down if given a slope or incline to follow. Define and illustrate slope, inclines using diagrams, pictures or illustrations. Nature shows this with canyons and streams, waterfalls and rivers. Remember from At Last to the Ocean-- all water flows to the oceans. Use historical images and maps to try and find where there were streams in your neighborhood historically.
https://www.philageohistory.org/tiles/viewer/ Compare years 1808, 1843, and 1855
Do an experiment on a tilted metal or plastic tray spraying water at the top of the slope. Notice how the water collects into larger drops then start to slide, with the slope, down the tray. Water always travels downhill, down a slope.

Lesson 4: Permeable and Impermeable Surfaces

Flooding is caused by too much water in the same place at the same time. City engineers have designed the city to take all the water away as fast as they can, all at the same time. Sometimes the pipes and sewers cannot fit all this water. Engineers are experimenting with ways to let the water sink into the ground instead of washing all away to help us prevent flooding. Today we will see what kinds of surfaces take water away to other places and which surfaces can keep the water around for a while. We will be looking at permeable and impermeable surfaces. Collect a few trays and line them with a light colored construction paper. Place on them different materials: wood block, plastic sheet, dirt, sponge, cotton, piece of slate or thin rock, etc. Place each material, one at a time, using a fresh piece of paper each time. Pour an ounce (or more) of water onto each of these materials. Always use the same amount of water in each experiment. Observe where the water goes. Chart it. Take the material off the paper and see if the paper is wet underneath. If the paper is wet, it means that the material is permeable (the water can get through it). If the paper is not wet underneath, the students can see that it is impermeable and that water cannot get through the material. Create a T-chart listing the materials that are permeable and impermeable.

Lesson 5: Walking Audit #1

Explain that a walking audit is a time to look in our neighborhood for a specific thing. It is a lot like a scavenger hunt. Today we are walking and looking at surfaces. We are looking for permeable and impermeable surfaces. Walk around the school in a pre planned route. (This route will be used in later walking audits). Take a clip board with a permeable/impermeable T-chart. Also carry a bucket of water and a turkey baster. Every 20 steps stop and try out a surface with 2 turkey basters full of water in one spot to test for permeability. Record your findings on the T-chart.

Lesson 6: Dissolved Substances

Show students a large clear jar of water. Ask them what they notice. Use a clean eyedropper or a coffee stirrer (plug one end with your finger while in the water then unplug it once it is over the student's tongue) to let each student taste the water. How does it taste? Ask students to hold their responses until all classmates have had a drop. They will report sour, sweet or salty depending on what you prepare the water with.

Explain that things can dissolve into water. Show an example of dissolving a quarter cup of sugar or salt into a jar of water. Give different groups different materials that are soluble or insoluble. Let the small groups add, stir, and observe what happens. Share out as a whole class which materials dissolve in water and which ones do not dissolve in water.

Lesson 7: Dissolved Substances in our Environment

Water is amazing at cleaning things up. When it rains in our city- it cleans up. Lots of things get washed away with the water- wrappers, paper,cans, litter of all sorts. But water also will carry away things we might not even see like gas or oil from cars or spilled coffee or even pee (from dog walks!). When our water flows into our sewers from the streets it is full of trash and leaves and even dissolved materials. These end up in our rivers. Give each student a piece of paper. Have them fold it into zig zags. Color along the top ridges of the zig zag with washable markers using different colors. Walk around the room with a plant sprayer "raining" on each students' papers. They will observe the marker color dissolve in the water and trail down into the valleys of the paper. Next, invite students to help you "build" a city of blocks and plastic strips and tape on a large plastic board. Place drops of food coloring in various spots naming the pollutants as you drop the drops. Place large blocks or books under one end of the board to create a slope to the city. Then again "make it rain" on the board. Notice how the colors (pollutants) travel down the slope with the water as it wishes off the city.

Lesson 8: The City Then and Now

Return to maps and images of your city and neighborhood from the 1800's and 1900's and now. Talk about the changes we can see: more paved surfaces, more dense housing and buildings, less green space, more grid and less slopes following streams and rivers, etc. Generate open ended questions to explore why these decisions were made. Why are there paved roads instead of dirt roads? Why are there more and/or bigger houses? What decisions were being made? Collect images of Green infrastructure. Show students road bumpouts, water catchment areas, street tree plantings, etc. Why are engineers adding more trees? Why are there more plants and shrubs being planted in gutters? What decisions are being made here?
Read The Little House by Virginia Lee Burton.

Lesson 9: Green Infrastructure Scavenger Hunt

Do another walk audit but this time focus your walk (it can be virtual on Google Street View) to give students a chance to view projects that are being built now to contain rain runoff and to create more green space and less impermeable surfaces. Compare these projects to similar areas in the neighborhood that have not been improved with plantings, design, and permeable surfaces.

Lesson 10: Philly's Combined Sewers

Explain that Philadelphia has one waste water system in most areas of the city. This means that water from the streets and sidewalks, rain run off, goes into the same pipes as our house, schools, and buildings waste water. We talked about what might be in rain water runoff but what do you think is in house, school or buildings' waste water. Collect ideas from students. What will that do to the water in our sewer system as it runs to the river? Yes it makes it dirty, even filthy. Show a house cutaway image that shows wastewater management in the house. Notice that our sinks and toilets go into the same pipes. These pipes in turn go into the same larger pipes that our rain water goes into.

Lesson 11: Cleaning Water

All cities and towns in our country must have systems that clean our waste water before dumping this water back into our rivers. This is a law that many people fought hard to put into place. Before this no one was responsible for cleaning the dirty water once people were done with it. Water treatment plants use a lot of energy and take a lot of time cleaning our water before we put it back into the river. Our Earth and the water cycle already have ways to do this naturally. We can make a model of how this works with a few simple items from our house and the hardware store. Take a medium sized, terracotta flower pot. Invite the students to help you layer in different materials. First place a coffee file or paper towel in the bottom of the pot and pour in a layer of sand. Then add a layer of charcoal (either for plants or for fish aquariums) and cover it with another layer of sand. Pour in some fine gravel (either pea gravel or aquarium gravel). Then top it off with large gravel or small riverstones. Prepare a batch of "dirty water" by adding some dirt from the playground or nearby park to a large, clear container of water and stirring until the dirt is dissolved and the water is murky or muddy. It helps illustrate the concept if there is some leaf debris or litter in the dirt. Set the flower pot into a large jar or bowl so that it is suspended above the bottom. Pour the dirty water into the "filter" and compare the dirty water to the water that comes out of the filter.

Extra: More in depth experiment to show how plants help clean water.

Lesson 12: Keeping the Water Clean

The rain that lands on our city is clean water. How can we keep it clean as it passes into our sewer system? Collect ideas from students. Take a walk in the area of your school cleaning up litter and debris. Notice the prevalence or lack of trash cans and recycling bins available to the public. Sort the debris into natural and manmade waste as you collect it. Have a few students record information about the trash you collect. Is it from an individual food item? Is it from an industrial source? Is it possible blow out from a city trash can? Is it advertising? Help the students to try and notice the SOURCE of the trash. Upon returning to class, show with a graph, pie chart, or with literal piles of waste, the different sources of the street litter. Begin a conversation about how each of these sources need different solutions to reduce this source of waste littering on the streets. For example an individual person needs both education and access to trash cans while household trash that blew out of a trash can might need to be addressed by an awareness campaign or by different trash cans. During writing time the next day, have students make signs to raise awareness around street litter and have them focus on the persuasive aspects of this writing to speak to one of the various sources that they think might be littering.
Read I Stink by Jim Mcmullen and Kate Mcmullen

Lesson 13: Keeping the Water Around, Helps Us All

Our city is hotter on a summer day than the towns just outside our city. We have the same weather but the city landscape is hotter. Scientists have named this problem- Urban Heat Islands. Present a video to students that explains Urban Heat Islands. If the day is a sunny, warm day, take students outside, again, around the school with an infrared thermometer. Tell them the general, area temperature. Have them measure the temperature in sunny spots and in shady spots. Have them measure the temperature of different kinds of surfaces that are in full sun. Notice with them where they find the highest temperatures. What kinds of surfaces are the hottest? Is there a pattern? Which surfaces are the coolest? Is there a pattern? Return to the classroom and have them put these observations to work. The natural, green spaces help lower the area temperature. The glass and concrete surfaces absorb and reflect and create higher temperatures. The natural green spaces ALSO help hang on to more water after a rainstorm. Ask the

students-- What can we do with this information? Some students may want to write letters or make signs to educate people about this problem. Some students may want to begin solving the problem directly by designing Cityscapes with more green space. Take a few Photographs of several different highly urbanized areas from your walk. Print them out in a large 8 ½" x 11" format. Copy them in black and white on the copier. Invite students to draw directly on these images or to draw on another paper, then cut it and glue it onto the photographs. Invite them to design these spaces in ways that allow for more natural surfaces, to catch rainwater and to support plant growth. And this work will, in turn, help reduce the area temperature.

Lesson 14: Summarize and Action

Review the lessons you have covered over the last few weeks by inviting students to reread and discuss the materials collected from this study of water in our city environment. You can collect and bind them together or the students can keep these materials in a folder for future reference. Invite the students to relocate in the room based on their interests from this past study. What is the most interesting studies or activities we did? Or which are the most important lessons to learn? In these small groupings have the students take turns talking about why this learning is important. Does it help us to solve a problem? What IS the problem that needs being solved? Why is it a problem? How can we solve that problem? This Socratic seminar moment will help the children to practice expressing their ideas about the learning. After they verbally practice they will then be ready to write about it. The students can make signs, create petitions, write letters, or write narratives about ways to solve one of the problems that they would like to address.

Lesson 15: Headlines From the Future

Share a few of the problems and solutions that the children wrote about the previous day. Ask the students to imagine that they are now in 12th grade, leaving high school and the problems that they wrote about have been solved. The solutions that they proposed are now in place. Using your imagination draw pictures and create posters or write letters about what the world looks like now. Help us to see what the world would look like if we take care of some of these problems now.

Lesson 16: Culminating Celebration

Plan a day that either families can join us or another grade or grades from the school can join. Set up stations with several of the experiments and teaching models we have used and prepared to make visible this world of water that is usually invisible. Create groups of students at each station to present, run,and explain the experiments. Diagrams and posters can be displayed. Students can be prepared with questions to ask and activities for the audience to explore. This Water Fair can consist of water play- pipes, cleaning water experiments, saturation experiments, downhill flow, runoff takes our trash with it, etc.

Resources

Books to Read with Students:

At Last to the Ocean: The Story of the Endless Water Cycle by Joel Rothman and Bruce Roberts
The Boy who didn't believe in Spring by Lucile Clifton
I Stink by Jim Mcmullen and Kate Mcmullen
The Little House by Virginia Lee Burton
The Lorax by Dr. Seuss
Underground by David Macaulay
Wangari's Trees of Peace by Jeanette Winter
The Works by Kate Asher

Books for Research:
Wheeler, S. and Rosan, C. (2021) *Reimagining Sustainable Cities Strategies for Designing Greener, Healthier, More Equitable Communities.* University of California Press

Sites to Reference

https://atlas.phila.gov/

https://water.phila.gov/history/

https://www.philageohistory.org/geohistory/

https://www.hiddenhydrology.org/philly-h20/

https://fairmountwaterworks.org/

https://pathstosustainability.com/2017/05/26/landscape-literacy-and-design-for-ecological-democracy-anne-whitson-spirn/

https://www.phila.gov/2019-07-23-beat-the-heat-community-heat-relief-toolkit/#:~:text=Created%20in%20collaboration%20with%20City,term%2C%20resident%2Ddriven%20solutions.

https://www.pwdraincheck.org/en/

https://www.jjtiziou.net/

https://www.epa.gov/ejscreen

Appendix

Next Generation Science Standards

K-LS1-1.	Use observations to describe patterns of what plants and animals (including humans) need to survive.
K-ESS2-1.	Use and share observations of local weather conditions to describe patterns over time.
K-ESS2-2.	Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
K-ESS3-1.	Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.
K-ESS3-3.	Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. *

2-PS1-1.	Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
K-PS3-2.	Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.*
K-2-ETS1-1.	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
K-2-ETS1-2.	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3.	Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Common Core Writing Standards

CCSS.ELA-LITERACY.W.K.2

Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.

CCSS.ELA-LITERACY.W.K.8

With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.