Discovering Water

Discovering Water

Student Authors:

Emily Algeo
Bailey Card
Dakota Ennis
Reine Frechette
Julia Rand
Sam Shoberg
Haley Stedt

Student Illustrator:

Bailey Card

Student Graphic Design:

Olivia Verrill

Student Photography:

Austin Verrill

Printed in Maine. Second edition. Portland Water District, 225 Douglass Street, PO Box 3553, Portland, ME 04104-3553

Portland Water District

RSU 14 Windham Raymond Schools Success for All

Baxter State Park, Millinocket, Maine

Little Niagra Falls
Baxter State Park
Millonocket, Maine

Portland Headlight, Fort Williams, Cape Elizabeth, Maine

INTRODUCTION

Discovering Water, a collaborative effort between Windham High School students, the Portland Water District, and other support staff, was written to share information about water in Maine and the world. This book is one tool for you to use to understand some scientific principles about Earth's water, watersheds, and the connection water has to all locations on, in, and around our Earth's surface.

Students from Mr. Riddle's Honors Earth Science class researched information about water in Maine and around the world to publish this book. Those students, Julia Rand, Haley Stedt, Dakota Ennis, Emily Algeo, Sam Shoberg, and Reine (Gareth) Frechette, worked together to make this book beneficial to all. Other contributing student authors, illustrators, designers, and photographers were Bailey Card, Olivia Verrill, and Austin Verrill.

To publish this book, a small group of dedicated 9th, 10th, and 11th graders required a detailed plan and the support of many professionals. This team of professionals, Amy Denecker (WHS Librarian), Sarah Plummer (Environmental Education Coordinator at PWD), Dorothy Hall-Riddle (consulting librarian), Deborah Debiegun (Educator at Cumberland County Soil and Water Conservation District), Stacy Smith (Art Director), and a few others supported Jeff Riddle's (Honors Earth Science teacher) team of students to publish this book that will be used by many. Our special thanks goes to J.S. McCarthy Printing for their generous support of this project and their belief in our mission, which will ensure that this book finds its way into the hands of even more children than it otherwise might have.

By reading this book, we hope you learn about the incredible chemical compound that makes up water and all it does for life on Earth. And, most important, we hope you take the knowledge and put it to use in your daily lives so that Earth's water, which comes around and goes around, stays available, clean, and safe so all may benefit for generations to come.

Jeff Riddle & the Discovering Water
Publishing Team
May 2015

Glen Ellis Falls
Kancamangus Highway
New Hampshire

TABLE OF CONTENTS

Chapter One: Water in the World

Baxter State Park
Millinocket, Maine

Little Niagra Falls
Baxter State Park
Millonocket, Maine

What is Water?

Hydrogen and oxygen are both elements in Earth's atmosphere. When they are apart, they are usually found as gases, but when they are together the two elements create the most important thing on Earth-water! Water is two hydrogen atoms bonded with one oxygen atom. The bond between hydrogen and oxygen is called a **hydrogen bond**. This means that the hydrogen and the oxygen atoms are constantly trading electrons. These two elements are strongly attracted to each other, so when they are together, they usually form water.

Photo by Jeff Riddle

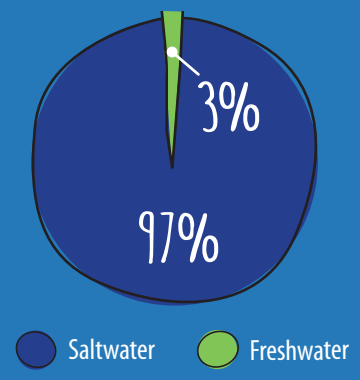
Matanuska Glacier in Alaska is an example of a basin on Earth that holds water in the frozen form.

How is Water Found?

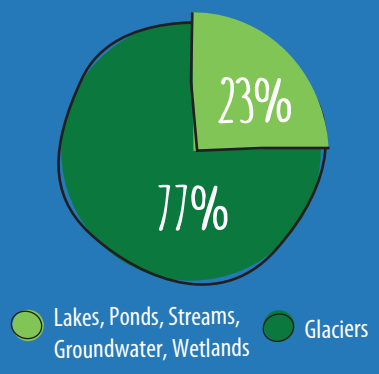
Water comes in three different states of matter: solid, liquid, and gaseous. Water that is solid forms ice crystals, **glaciers**, and snow. Ice crystals could be the icicles hanging from the roof of your house, or an ice cube in your water! **Glaciers** are huge rivers of compacted ice and snow. Gaseous water is what most people recognize as steam, and liquid water is the colorless, tasteless liquid that we drink!

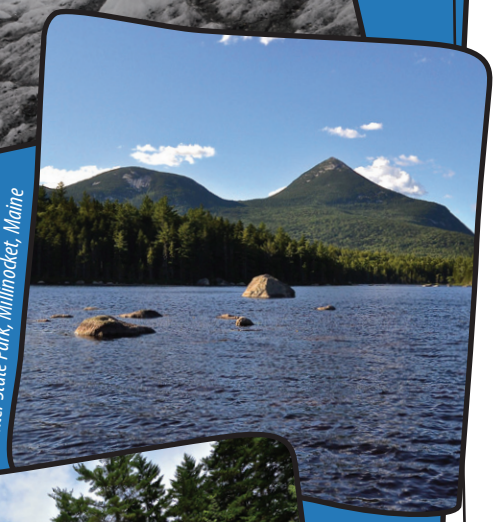
Water can easily change from one state to another. When the snow melts it is going from a solid to a liquid, and when the water for your pasta boils, it is turning from a liquid to a **gas**. Water can also change from a gas to a liquid or from a liquid to a solid. The dew on your lawn is water that has changed from a gas in Earth's atmosphere to a liquid. When you put water in the freezer and it comes out as ice, that's water changing its state of matter from a liquid to a solid. It happens all around us!

Salt water and freshwater distribution in the world

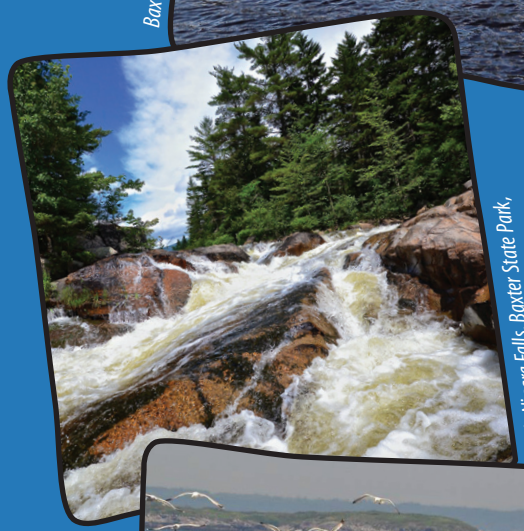


How the three percent of freshwater is distributed





Baxter State Park, Millinocket, Maine



Little Niagra Falls, Baxter State Park, Millinocket, Maine

Boothbay Harbor, Maine

How is Water Distributed?

Water covers approximately 75% of the Earth's surface. Salt water makes up 97% of this water, which leaves only 3% of Earth's water as fresh water, which is not very much. 77% of this fresh water is stored in **glaciers**, so even though the Earth is covered with water, there is not very much that humans can use. The remaining fresh water on Earth is found in **rivers, streams, lakes, ponds, wetlands,** and in the ground. **Rivers** and **streams** are flowing water that come from **groundwater**, which is water contained in the ground, and from surface **runoff**. Surface **runoff** is water that flows over the ground too fast to be absorbed into the ground when it is raining, or cannot absorb into the soil because it is already too full of water (like a sponge that cannot hold any more). Water from **rivers** and **streams** flows into **lakes, ponds, oceans,** and other **streams**. The water in **lakes** and **ponds** does not flow like the water in **rivers** and **streams.**

Both **lakes** and **ponds** are bodies of water that are surrounded by land, but they are not the same. In most circumstances **lakes** are larger and deeper than **ponds** but not always. Sometimes a body of water is very small but it is still called a **lake**. Sometimes a body of water is huge but it is still called a **pond** because there is no clear definition of either. For example, Crescent Lake in Raymond, Maine is 716 acres and Panther Pond, also in Raymond, is 1,439 acres. Their names suggest that Cresent Lake would be larger than Panther Pond, but that is not the case.

Fresh water is also found in **wetlands**. **Wetlands** are areas of land that are so full of water that the water sits on the surface as well as soaking through the ground. The term **"wetlands"** includes marshes, bogs, fens, swamps, and vernal pools. **Wetlands** are vitally important to many organisms around the world. They are a source of water for people living downstream and a habitat for mammals,

fish, birds, and other organisms. People use **wetlands** for a variety of things. We get blueberries, cranberries, fish, and even some medicines from **wetlands**. **Wetlands** also help control pollution by filtering out some pollution as the water flows through. **Wetlands** are a very important part of keeping the water in our world and us healthy!

Water is Essential for All Life

Biologically, water is a necessity for all life. All living things depend on it to survive! People need water because we are made largely of water. Water makes up about 60% of the human body. Water also makes up a large portion of the fruits and vegetables that humans eat. For example, on average, an apple is about 84% water and lettuce is about 96% water!

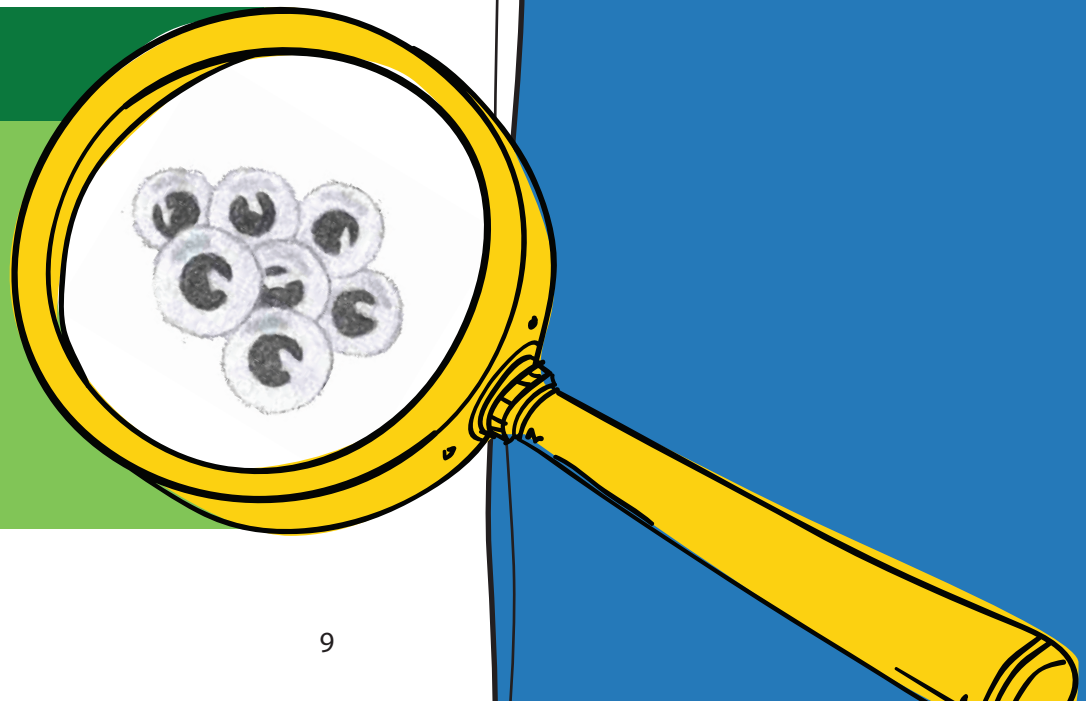
In Maine, most people do not have trouble getting access to clean drinking water. However, less than 1% of all of the water on Earth is clean enough for humans, so some places in the world don't have much, if any, clean water to drink. In Africa there are 345 million people who don't have access to clean water, and that number is for just one continent! A person can live for three weeks without food but only three days without water. Water is the most important thing on Earth because it is essential to supporting life.

Windham, Maine

Water is the most important thing on Earth because it is essential to supporting life. Just ask this green frog!

Stage #1

Well hi there! Can you see me? I'm over here in this tiny egg! Did you know that I am born on the surface of water? How cool is that?! But wait, guess what else? I have almost 20,000 brothers and sisters hanging out here with me too! Talk about a big family!
Can you guess what I am?

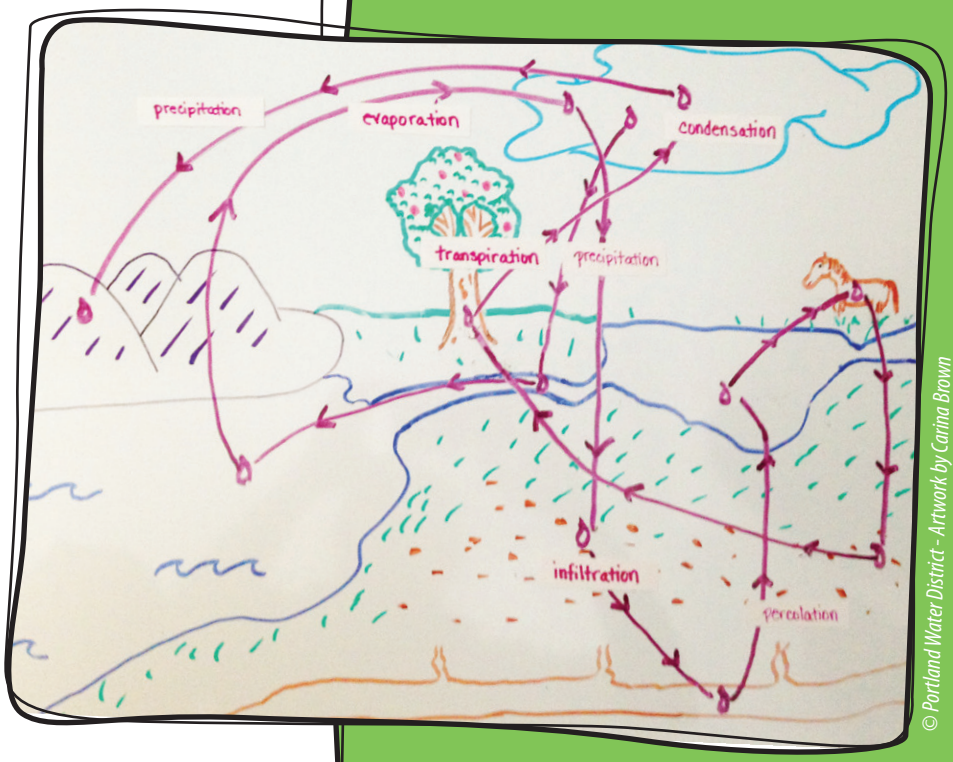


Chapter Two: The Water Cycle

White Mountain National Forest
Kangcamangus Highway
New Hampshire

Windham, Maine

Has it ever occurred to you to ask where water actually comes from? Have you ever thought about how water eventually ends up in lakes, oceans, **rivers**, or even puddles on the streets? The reason for this is the water cycle, also known as the **hydrologic cycle**, which is the movement of water between oceans, atmospheres, and continents. Water is capable of moving throughout the world by changing its form many times. Water can change to a solid, to a liquid, then to a gas, and from there the cycle starts over again. This cycle repeats infinitely; there is no end to it. This means that the water we have on Earth now is the same water that covered the planet when dinosaurs lived!



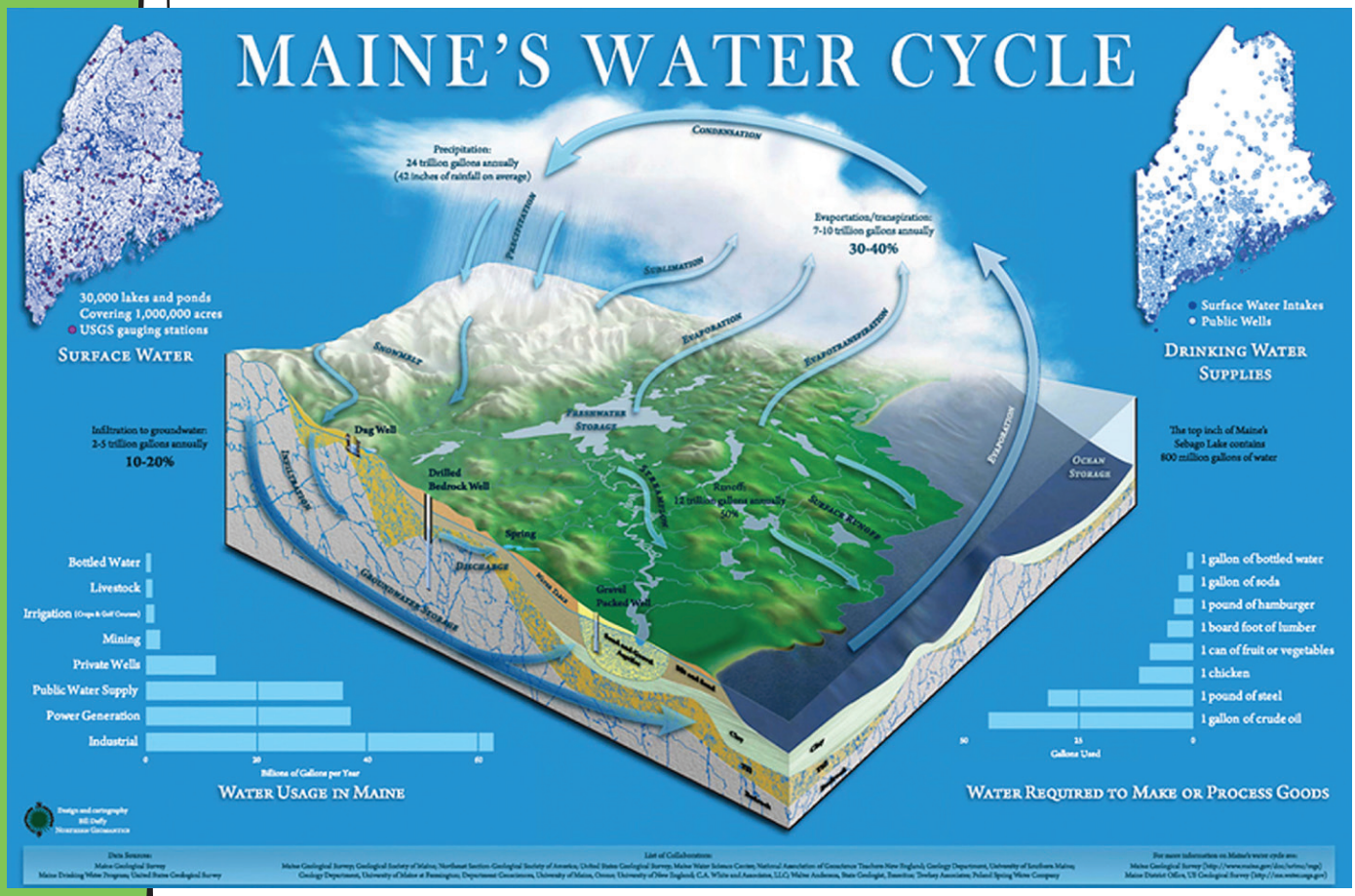
© Portland Water District - Artwork by Carina Brown

When people think of water on Earth, they normally think of the water in oceans, **lakes,** or **rivers**. But people often look past the other states in which water can be found, such as gas and solid. Water becomes a gas when it leaves the Earth's surface and enters the atmosphere as vapor. If you have ever boiled water to cook, or turned the shower faucet to the hottest **temperature** possible, the steam that rises from the pot and the shower head is actually water in a gas form. This

Has it ever occurred to you to ask where water actually comes from? Have you ever thought about how water eventually ends up in lakes, oceans, rivers, or even puddles on the streets? The reason for this is the water cycle, also known as the hydrologic cycle, which is the movement of water between oceans, atmospheres, and continents.

Stage #2

Whoa, check me out! Look at this super cool tail I have grown! Now I can swim all over the place with all my brothers and sisters. I also have grown some awesome gills that help me breathe in water. I eat tiny plants and algae to make me big and strong.
Do you know what I am yet?



© Maine Geological Survey

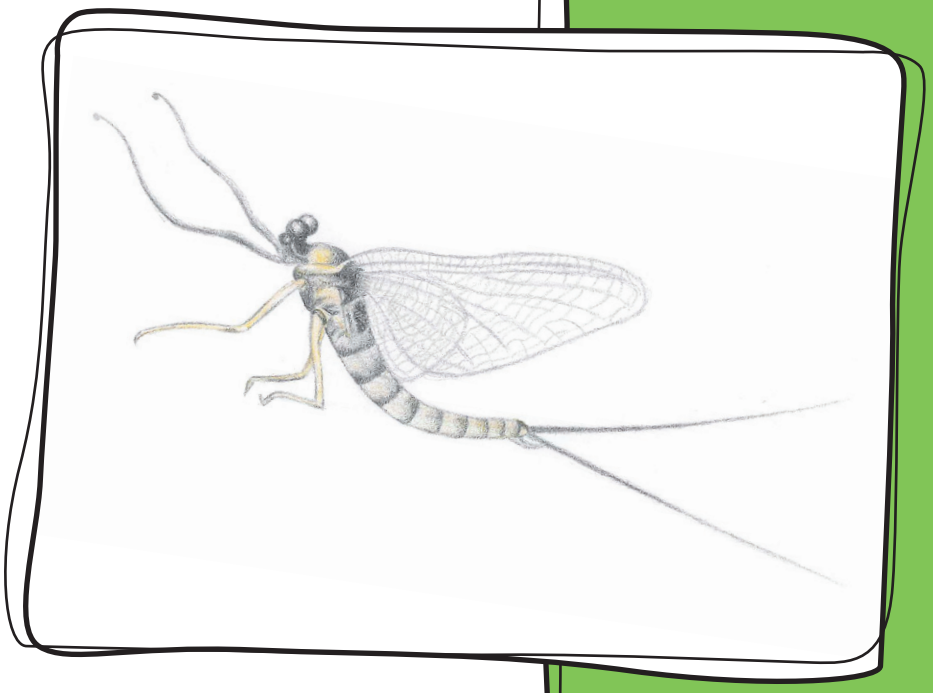
occurs due to a process called **evaporation**, which is when liquid water molecules are heated and form a gas. From there, these gas molecules rise into the atmosphere where they will eventually form clouds. When water vapor rises and enters the colder regions of the atmosphere, the gas returns back to its liquid form and creates clouds, in a process called **condensation**.

Once the liquid that is held in clouds builds up to a point where it is too heavy to remain in the upper atmosphere, the water is released and brought down to Earth as rain. Another name for the process in which water returns to Earth from the atmosphere is called **precipitation**.

Precipitation may fall in a liquid or frozen state. Water exists as a solid when the **temperature** drops below its freezing point of 32 degrees Fahrenheit. Once this happens, water can appear in many forms of solid **precipitation**, such as snow, ice, hail, or sleet.

Once water falls as liquid or solid **precipitation**, it finds its way back into the atmosphere through **evaporation**. From there, the water cycle continues on and on, moving on to a liquid or even solid state.

When people think of the water cycle, they often think of it as always following a specific pattern, but it doesn't! The water cycle is never-ending and its movements are sporadic and inconsistent, ***meaning no single water molecule will spend a fixed amount of time in one state of matter.***



The nymphs of these flies are studied for their choice in freshwater homes. Mayfly nymphs live in very high quality water. Scientists study them to know if the water is clean and oxygen rich.

All water molecules may be doing the same thing, but each in its own time. If you were to track a single water droplet for one hundred years, it is possible for that single molecule of water to stay trapped in a certain state of matter for ninety-eight of those years! The entire process for a single water molecule to travel from the ground to the atmosphere could take only eleven days. The concept of water being anywhere in the world and remaining in specific states and stages of the water cycle is called **residence time**.

Water is also capable of traveling all over the world. Sure, it takes a lot of time to travel across the planet, but it does ***happen eventually***. Try to imagine two water drops, both that fall from the same cloud. One falls onto a mountain top, where it flows into a **stream** and then into a **lake**, where an animal drinks it. The other water drop falls on the soil where it filters down into the **groundwater**, then moves between rocks and grains of sand, infiltrates the ocean, and from there the possibilities are endless. In this way, one drop of water's journey is always completely different from another's. They are unpredictable and are capable of traveling more than an average human in the same span of life.

As stated in the previous chapter, water covers a huge part of Earth's surface - about 75%. It is incredibly important that we take care of the small amount of fresh water we have on Earth. Water is an important resource that is necessary to sustain all life on Earth. Without water, we wouldn't be here today to talk about how important it is! So, in order to keep all organisms alive, we must protect our water and keep it clean. If you take care of your environment, your environment will take care of you.

CHAPTER THREE: WATERSHEDS

Windham, Maine

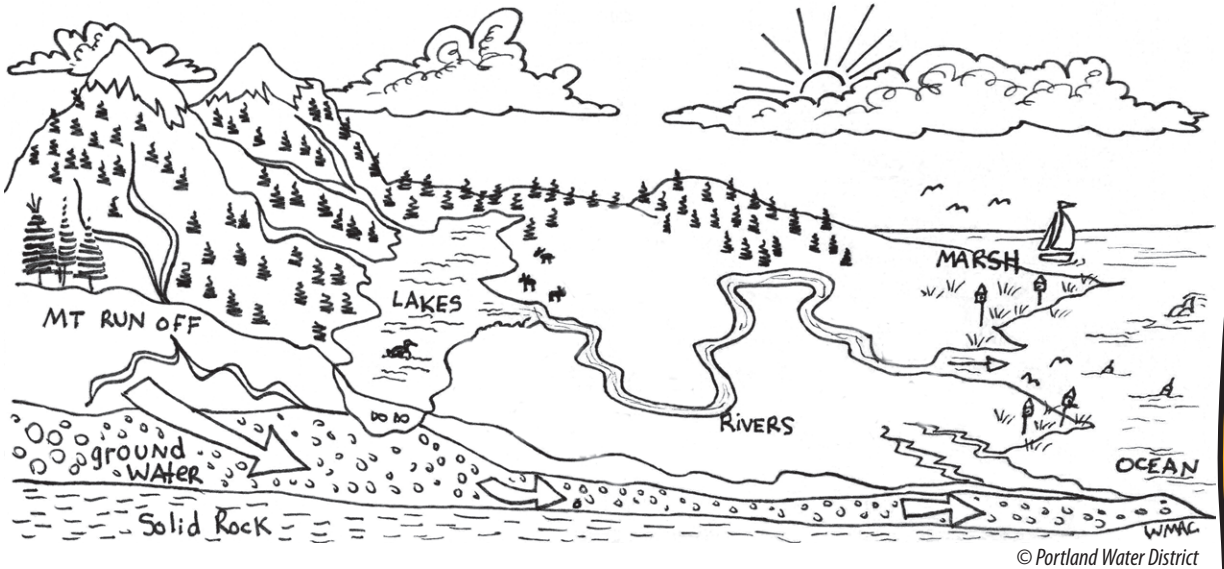
Baxter State Park
Millinocket, Maine

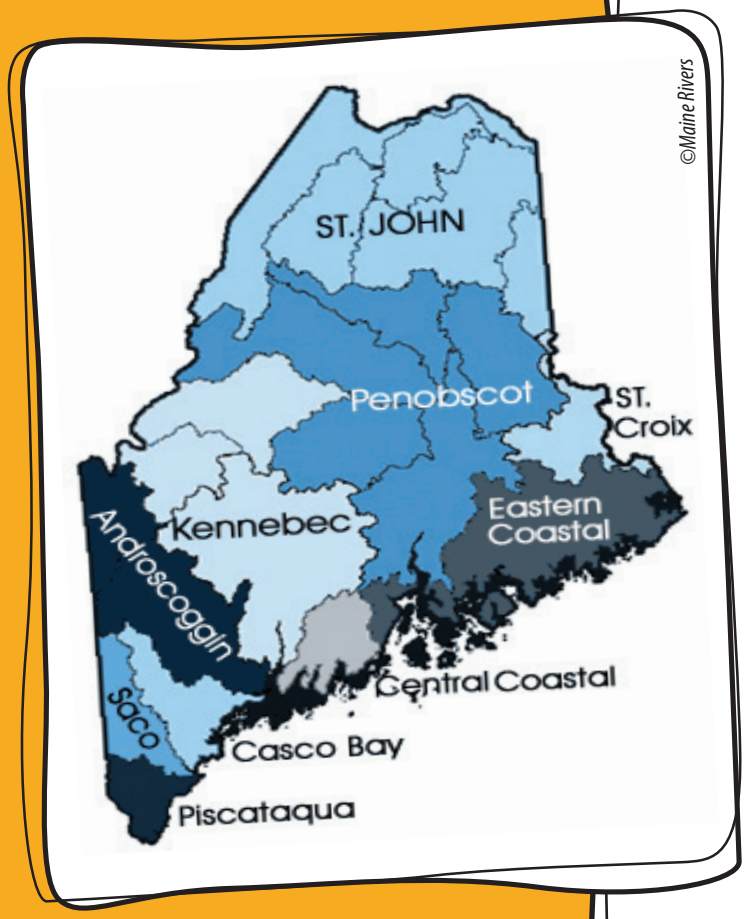
What is a Watershed?

A **watershed** is a specific area of land that drains to any body of water, such as **streams, rivers, ponds, lakes,** or the ocean. **Watersheds** are named for the water bodies that they flow into. The **topography**, or the shape of the land, defines the highest points surrounding a body of water. These high points also define the boundaries of a **watershed**. Any water falling within the land of the **watershed** will drain to a smaller water body and then that water body could flow into a larger water body, which has a larger **watershed**.

Imagine a group of bowls fitting into each other where the smallest bowl is on the very top and then fits into a bowl a little bit larger and then that one sits inside one a little bigger and so on. If someone were to pour water into the bowls, and there were holes in the bottom of all the bowls except the bottom one, the water would start in the smallest bowl and flow to the next bowl and then to the next bowl until all the water is collected in the biggest bowl. The top edge of the bowls is like the top of mountains, and water flows down the bowl into the bottom of the bowl, like rain would flow down a mountainside into a **lake**. That is how **watersheds** work.

For example, if a person lives in Windham, Maine, he may be in the smaller Pleasant River **watershed**, but he is also in the larger Presumpscot River Watershed, and if he is in the Presumpscot River Watershed, then he is also in the Casco Bay, Gulf of Maine and the Atlantic Ocean watersheds. Just like the bowls, the largest **watershed** collects all the water from the smaller **watersheds**. No matter where we are on the planet, we all live in a **watershed** because we all live on land that drains to a certain water body.





This map shows the 10 major watersheds in Maine. In which one do you live?

Streams and **rivers** create branching patterns in our **watersheds**. This branching system within the land of a **watershed** is very important because the **streams, rivers, lakes**, and oceans are all connected in a system that flows together.

Have you ever thought that maybe our bodies and **watersheds** could have something in common? Well, if you compare the system of **rivers** and **streams** to the human body, you would see similarities by looking at arteries and veins. Our veins and arteries are the **streams** and **rivers** of the human body! All the blood in our bodies is transported by the veins and arteries, like how water is transported by all the **streams** and **rivers**. The **streams** and **rivers** all flow to one main source too, the ocean, which is like the heart of all **watersheds**.

How do you know if a Watershed is healthy?

The health of a **watershed** is very important and many factors contribute to it. Ground cover is one extremely important factor. The surface of the ground will either let water infiltrate, or absorb into, it or not. A **pervious surface** allows water to be absorbed into it, and this is good for the health of **watersheds** because it means there will be less **runoff**. Examples of **pervious surfaces** are soil and vegetation. The opposite of a **pervious surface** is an **impervious surface**.

An **impervious surface** is any surface that does not allow water to soak through it. Examples of **impervious surfaces** are asphalt, tar, concrete, and buildings. Typically the more impervious cover, the poorer the health of the **watershed**. Since **impervious surfaces** do not allow water to soak through, they can result in an excess amount of **runoff**.

Runoff occurs when the water from the melting snow or falling rain is too much for the ground to absorb. The **runoff** flows over the ground and can pick up soil, nutrients, and **pollutants** from the ground as it flows over. To learn more about the pollution of our water, read Chapter 5.

Urban vs. Rural

If you lived in the city, what kind of surfaces would surround you? Impervious or pervious? What if you lived in the country or in the mountains? The city is more urbanized and covered by more **impervious surfaces**. The concrete on the sidewalks and the asphalt on the roads will not allow water to soak through, and this can cause flooding and more polluted water. If you lived in the country or in the mountains, then you would be surrounded by **pervious surfaces**, like soil and a lot of vegetation, which absorb the water and keep our **watersheds** clean and healthy. Since **pervious surfaces** absorb so much water, there is less **runoff** and there are fewer **pollutants** being carried by the **runoff** into the water. We all can take part in keeping our **watersheds** clean and healthy. To find ways that you can help, see Chapter 7 about Stewardship.

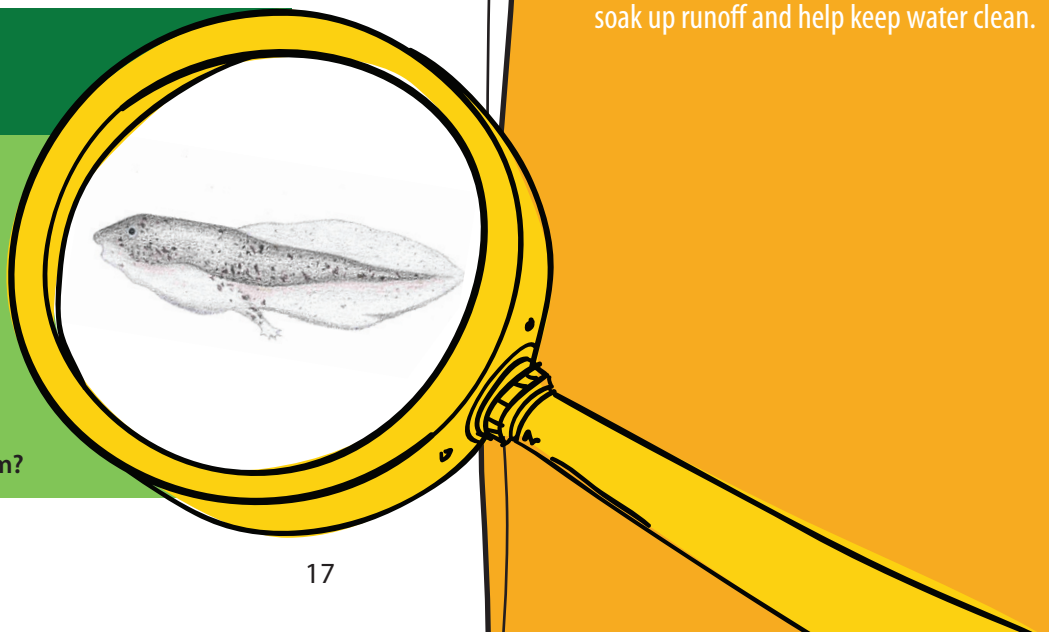
Sebago Lake, Maine
© Portland Water District - Photo by Kendra Raymond

© Windham High School

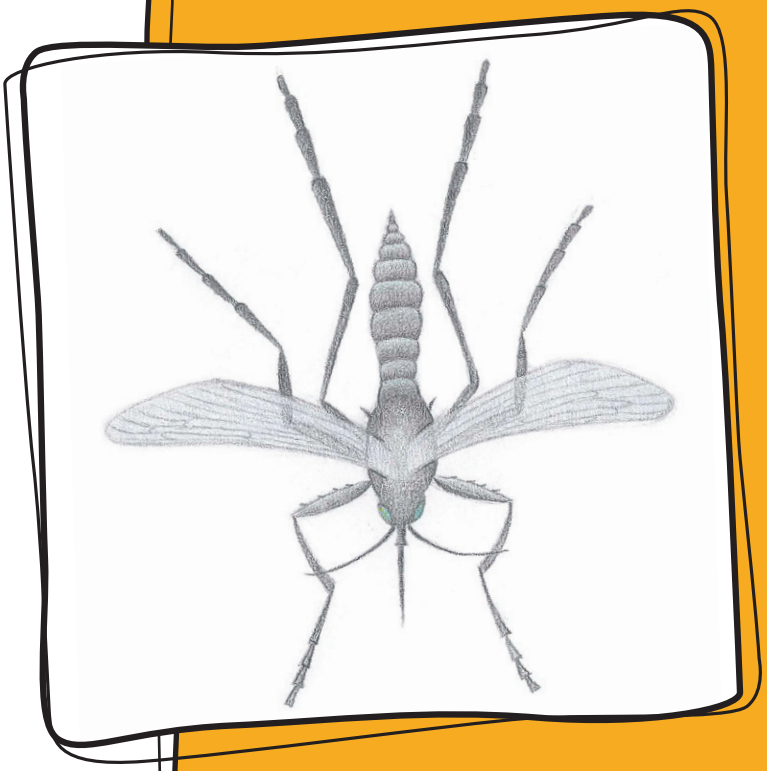
Urban areas contain more impervious surfaces, like the parking lot, that do not allow water to soak through. Pervious sufaces, like this shoreline with many trees, soak up runoff and help keep water clean.

Stage #3

Wow! Do you see that?! I've started growing some hind legs! Thanks to this clean water I'm living in, and all the food sources it contains, I will be able to grow big and strong just like my mom and dad.
So, any ideas about what I am?



Natural History



Mosquito

Scientific Name: Culicidae

There are about one hundred and fifty species of mosquitoes in North America. Mosquitoes have two pairs of wings, thin, long bodies, and three pairs of legs. The scales along their wings and the proboscis, or a sharp sucking mouth, distinguish them from other insects. They tend to feed on nectar and fruits. The female mosquito feeds on blood, which is needed for the eggs to develop. Not only do female mosquitoes feed on humans, but also mammals, birds, bats, and fish. The mosquito enters four stages of the life cycle once the female mosquito has deposited her eggs. The larvae stage comes after the egg stage, where they live in water and feed on plankton. The next stage is called the pupa. Transformation to this stage happens within a matter of minutes. The pupa continues into adulthood by swallowing air to expand its abdomen and wings.

Caddisfly

Scientific Name: Trichoptera

The caddisfly is found near North America's streams, rivers, and lakes. There are over 1,200 different species of the caddisfly. The larvae stage are the best known stage since they build tubular cases to shelter themselves. The unique cases are built from stems of grasses, fragments of rock and bark, and any materials available for access. Their cases protect them from flowing water. The larvae can be found attached to rocks. The immature caddisflies obtain their oxygen from the water. Caddisflies undergo metamorphosis, and the adult caddisfly breaks free from the tubular casing. The adult caddisfly feeds on plant nectar but often does not live more than a month. During adulthood, they remain inactive throughout the day and active during the night hours.

Dragonfly

Scientific Name: Anisoptera

Dragonflies are usually found along streams and ponds. Their large eyes, short thorax, and long abdomen make them very distinctive insects. They are found feeding, mating, and laying their eggs by their water homes. The male dragonfly tends to patrol a part of a stream or pond for most of the day. When a female dragonfly enters this territory, they will begin to mate. The female lays her eggs in the water, and the aquatic larval stage of the dragonfly soon hatch from the eggs after being laid. During the winter, the larvae will grow and live in the water. When spring comes around, they climb from the water, and the adult stage of the dragonfly emerges and spreads its wings.

CHAPTER FOUR: WATER QUALITY

Presumpscot River
Gorham, Maine

Pleasant River
Windham, Maine

What is water quality?

Water quality is the "health" of water based on its chemical composition and its biological makeup. The chemical composition of water relates to the materials dissolved or found within water. The biological make up of water relates to the organisms that live in water.

How do you test for water quality?

To determine water quality, evaluate two things: one, what is found living in the water, and two, the chemical makeup of the water. Studying life in water is called a **macroinvertebrate** study, or taking a biotic index of the water. You can discover and record what organisms are living in the water and depending on what species you find, you can learn a lot about how clean that water is. Generally speaking, finding species with lots of legs and tails is a good sign the water is probably clean. An example is a stonefly larvae. This is a simple and fun test you can try by observing a body of water.

Testing the chemistry and physical traits of water is a bit different and requires test kits and/or electronic meters. Below you will learn about these physical, biological, and chemical tests and what they tell us about the water we are studying.

© Portland Water District

A Windham High School student looks closely at living macroinvertebrate samples from the Pleasant River.

Physical and Chemical Water Tests:

There are many different physical and chemical tests that determine water quality, and the results of these tests can teach us many things about water. Here are descriptions of some common tests performed on water:

Temperature:

Measuring **temperature**, the amount of warmth or coldness, is a common test. In Maine, we measure

Windham, Maine

Windham, Maine

temperature in degrees Fahrenheit (°F is the symbol for degrees Fahrenheit). The **temperature** of water is an important measurement as it can influence which **macroinvertebrates** and other life forms can live in that environment. Specifically, the **temperature** of water is one characteristic that determines how much oxygen can be dissolved in that body of water. **Dissolved oxygen** is another test we can perform on water.

Turbidity:

Turbidity is a measure of how cloudy a liquid is. Sediment floating in the water causes this cloudiness. Sediment that hasn't sunk to the bottom is suspended in water and results in an increased turbidity. Have you ever seen pictures of the Colorado River at the bottom of the Grand Canyon? It looks like chocolate milk because there is so much sediment suspended in the water that it doesn't even look like water. It makes sense that the Colorado River has high **turbidity** because it cuts through rock to form the canyon, and the rock it cuts off ends up suspended in the water, making it brown.

We can use an electronic meter, secchi disks, or test kits to measure the **turbidity** of a water body. Most animals need very clear water to survive, like the brook trout. Think of it like dirty air: same idea but in a different medium. Nobody wants to breathe in dirty air full of sediment, so we need to keep **turbidity** low in Maine waters to support clean water.

Bacteria in Water (E. coli):

Bacteria are a group of single-celled, microscopic organisms that inhabit all environments on Earth. They are found in soil, water, organic matter, and in the bodies of animals, including humans. Some forms of bacteria found in water can be very dangerous for humans and other animals if ingested. One dangerous kind that lives in water and can make us sick is E. coli bacteria.

E. coli bacteria is a particular species of **coliform bacteria**, one of several types of bacteria found on Earth. E. coli is present in animal feces (poop). Human or animal feces infected with E. coli sometimes ends up in **lakes**, pools, and water supplies because we don't clean up after our pets or we don't correctly treat our waste water. If we accidentally swallow contaminated water while swimming in a **lake**, or even in an untreated pool, people can become infected and get sick.

We test for E. coli bacteria with special chemical test kits that we process by incubating the samples in an oven and then shining a black light onto the sample to see if bacteria are present.

Presumpscot River, Gorham, Maine

Testing for Fertilizers:

People sometimes use fertilizers to help plants grow. Fertilizers contain nutrients that the plants "eat" but these same fertilizers can impact our water bodies by increasing plant and algae growth in them too. The rapid growth of plants and algae in a water body can potentially "steal" the **dissolved oxygen** found in that system from other species that share the ecosystem and rely on the **dissolved oxygen** to live.

Phosphates, nitrates, and nitrites usually get into a water body through soil erosion and **runoff.** If chemicals and fertilizers are added to lawns or to a farmer's field and they aren't absorbed, they may **runoff** into a storm drain, a **stream**, or a **river**. We test for these fertilizers with chemical test kits and electronic meters, and they tell us how much of each chemical is found in the water.

Presumpscot River, Gorham, Maine

Biological Water Quality Test

Macroinvertebrates are small organisms without a backbone that can be discovered living within aquatic ecosystems. These animals live all or part of their life cycle in water. They include organisms such as leeches, midges, stoneflies, caddisflies, mayflies, dragonflies, and mosquitos. Many aquatic ecosystems are full of them, but not all species require the same level of water quality. For example, leeches are tolerant of water pollution; they can thrive in almost any aquatic water environment.

On the other hand, mayflies and dragonflies living the first stages of their lives do require high quality water. Therefore, if you test and find a **river** with dragonflies and mayflies, you know that water must be clean and high quality or they would not have been able to survive.

Presumpscot River, Gorham, Maine

Presumpscot River, Gorham, Maine

Pleasant River, Windham, Maine © Portland Water District

Presumpscot River, Gorham, Maine

Macroinvertebrate tests are done by safely getting into aquatic environments and respectfully looking for and collecting samples to identify species. Once you have gathered the data, it is crucial to return the **macroinvertebrates** to their environments.

When you want to learn about the quality of water in a **stream, river, pond,** or **lake**, it is best to get the holistic picture by testing the water's physical, chemical, and biological traits. The data from these tests will then paint a detailed picture of the quality of water in that environment. ***Ideally water should be cold with a high dissolved oxygen content, low turbidity, and void of E coli. bacteria and other unnatural compounds.***

Many plants and animals depend on oxygen that is dissolved in water, so they would prefer living in water with a lot of **dissolved oxygen**. On land, we need to live in an atmosphere full of oxygen to be healthy. Animals and plants can pull **dissolved oxygen** from the water to "breathe," much like our lungs help us breathe air. If the water **temperature** is warm, there is less room for **dissolved oxygen**; therefore, most animals and plants like to live in colder water that can hold more **dissolved oxygen**.

Dissolved Oxygen Test:

Dissolved oxygen is oxygen that has been dissolved in a body of water. Think of putting sugar into a drink: you can only dissolve so much of it before there is no more room between molecules for the sugar to disappear, or dissolve. If you keep adding sugar, you will see it pile up on the bottom of the glass. As you already learned, some organisms need high **dissolved oxygen** levels and cold water to live, like trout, so in Maine trout are an excellent **indicator species.** If you find trout in water, most likely that water is cold and full of **dissolved oxygen**. If **dissolved oxygen** levels are not high enough, certain

animals will not be able to survive in the water. Water like that would have a low **dissolved oxygen** level and is considered low quality water. We use an electronic meter or a chemical test kit to determine the amount of **dissolved oxygen** in water. We record the results of those tests in parts per million (PPM) or as grams per milliliter (g/ml).

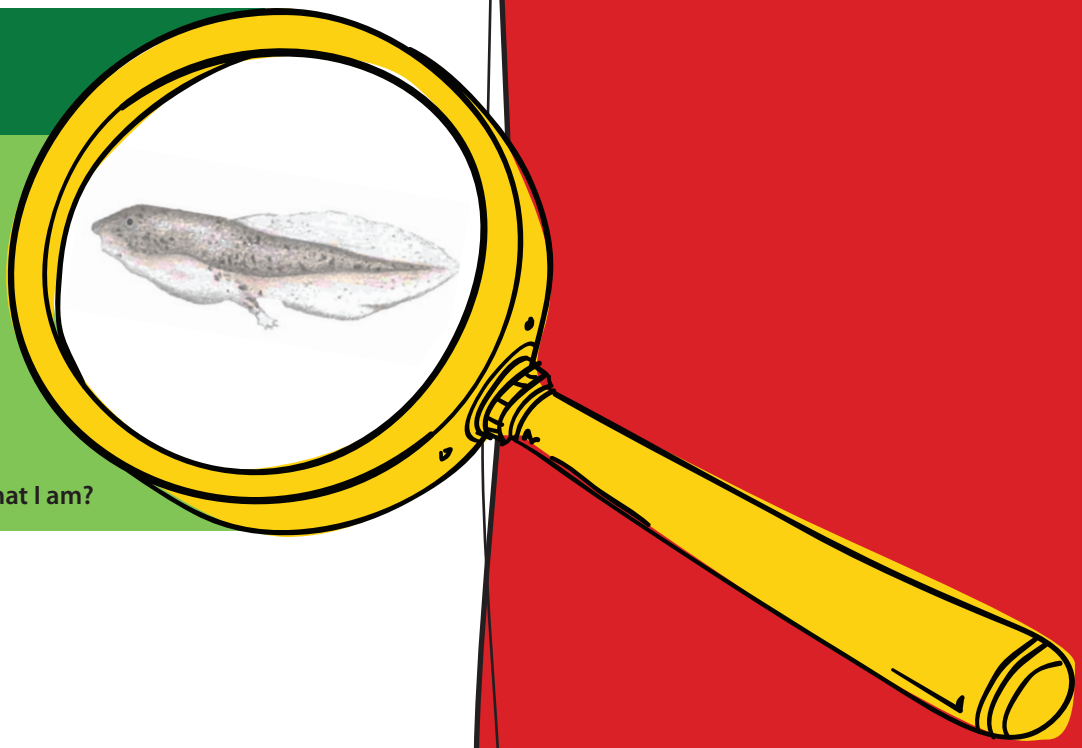
pH (Acid vs Base):

Testing **pH** is important to learning about the quality of water. **pH** is a measurement of how acidic or how basic a substance is. The **pH** scale goes from 0 to 14, with 0 being the most acidic, and 14 being the most basic. Examples of acidic substances are lemon juice or battery acid. Examples of bases are bleach or soap. The **pH** of pure high quality water is 7, which is right in the middle of the scale. If water is too acidic or basic, it limits the variety of species able to live in the water. To find **pH**, we use electronic instruments, chemical test kits, or litmus paper and a **pH** scale.

pH paper is used to test the pH of substances like water.

Stage #4

Does this tail make my butt look big? Of course it doesn't, I look fantastic! I've been growing bigger and bigger each day, and I now have tiny teeth that help me eat small insects in the water instead of those plants and algae. Psht, that stuff is baby food. **Now have you figured out what I am?**



CHAPTER FIVE: WATER POLLUTION

White Moutain National Forest
Kacamangus Highway
New Hampshire

Rocky Gorge
Kancamangus Highway
New Hampshire

What is water pollution?

Water pollution is the contamination of water bodies that reduces water quality. More specifically, water pollution is when the quality of water directly affects the living organisms within the water and makes it unhealthy to use and consume. Although water pollution has decreased over the years, it is still a problem. Since the 1970s, legislation has been created to protect our nation's water, resulting in dramatic improvements in the cleanliness of water over the years.

At one time, some water sources were unusable, such as the Cuyahoga River in Ohio, which caught on fire in 1969 from all of the pollution in it! Situations such as this contributed to the creation of the Clean Water Act in 1972, which reduced pollution and even restored some water sources. The Clean Water Act first appeared as the Federal Water Pollution Control Act in 1948 before being revised and renamed in 1972. Maine had two influential Senators, Edmund Muskie in 1972 and George Mitchell in 1987, who have helped craft and continue the commitment to the Clean Water Act. The act now regulates the amount and kind of **pollutants** allowed in water sources. Without these water protection laws, water sources would be contaminated and water would not be as clean as it is today.

Water pollution can be divided into two general categories: **point** and **nonpoint source pollution**. These types of pollution are classified by where they come from. **Point source pollution** comes directly from one source. Industries and wastewater plants that release discharges that go directly into the water are examples of **point source pollution**. **Point source pollution** is the most commonly known and easiest to prevent since there is one source rather than several, and that source is easier to identify.

Nonpoint source pollution has no known source; it's hard to determine where this type of pollution originates. Pesticides from barns and homes, household waste, feedlots, leaking

Baxter State Park
Millinocket, Maine

Although most bodies of water are protected under the Clean Water Act, water pollution is still a major problem.

Courtesy of Morgue File

Storm drains capture storm water that usually drains into the nearest brook, river, or stream.

auto fluids, and animal and human waste are all examples of **nonpoint source pollution**. Areas such as a parking lot or your own backyard may contain several kinds of **nonpoint pollution**. In a parking lot, leaking fluids from cars and salt used to make the roads less slippery are both sources of **nonpoint pollution**.

Nonpoint source pollution can travel in **runoff. Runoff** is vital to keeping **watersheds** full of water; without it, there would be no water cycle, and the water would stay all in one place. **Runoff** can also be harmful to local water bodies, as it may carry pollution from one place to another, like manure from a farm that washes into a **river** down the hill. A type of **runoff** is **stormwater**, which is rainwater and melted snow that runs off streets and lawns. After a storm, **pollutants** are absorbed into the water and flow into nearby **streams, rivers**, and other bodies of water.

Nonpoint source pollution *can be considered the most dangerous and difficult type of pollution to prevent because the pollution comes from various locations and consists of many contaminants.* A major contributor to pollution in water is contamination from storm drains. Some people are unaware that what flows into storm drains usually goes untreated and directly to a water source. So make sure you never pour anything down a storm drain!

Pollution can come from a variety of places. Nonpoint source pollution is so hard to control, so make sure to stay informed!

Courtesy of Morgue File

Water pollution has a drastic impact on the environment. Pollution can be toxic or fatal to aquatic life and animals living in and around the water. Pollution can cause food sources found in the water to be scarce, and it changes the organisms' environment. Some **pollutants** reduce the sunlight that supports the growth of plants and microorganisms living below the water. ***Pollution does not only affect plants and animals, but humans as well. It creates unhealthy drinking water and an unhealthy environment for animals, which can be toxic to humans.*** It could be dangerous to humans if they were to consume polluted water or an animal that was living in unhealthy water. On the bright side, there are ways everyone can help reduce pollution, keep water clean, and demonstrate **stewardship**, which you will learn more about in Chapter 7.

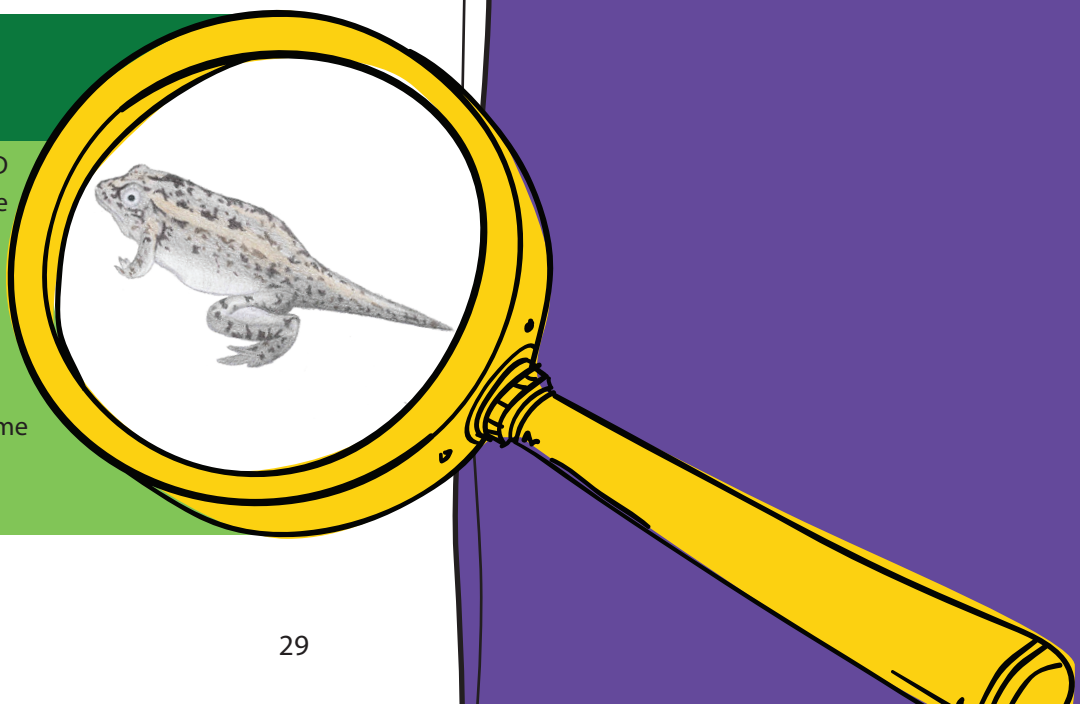
Windham, Maine

Courtesy of Morgue File

Animals that live in bodies of water can die from their homes being polluted.

Stage #5

Oh my goodness! I'm huge! AND I have four legs now; what in the world?! I have grown so big, and guess what? I can breathe outside of water now too! How crazy is that?! I still have my tail, so I'm not completely done growing yet. So you still have time to think about what I could be. **Do you think you know yet?**



Chapter Six: Maine's Trout

Presumpscot River, Windham, Maine
©Michael Heiko www.michaelheiko.com

Baxter State Park
Millinocket, Maine

Brookies

Brook trout, also called "brookies" are an important native fish species in Maine. Also known as the Eastern brook trout, they are a close member of the Salmon family. Their scientific name is Salvelinus fontinalis. The Latin word "fontinalis" actually means "of or from a spring or fountain." This is accurate for this species of fish because brook trout rely on freshwater **streams, rivers,** or springs to survive.

Brook trout are native to eastern North American freshwater systems such as **rivers, ponds**, and **lakes**. They feed primarily on immature stages of aquatic insects; however, the diet of a brook trout can range from food as small as mayflies to prey as large as salamanders. Brook trout will eat basically any animal they can fit into their mouths and therefore are considered carnivorous creatures.

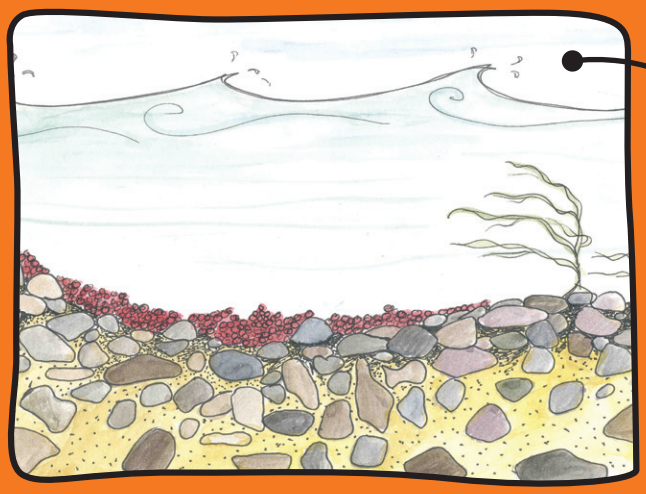
Trout life cycle

The life cycle of the brook trout occurs in seven stages. The beginning of a brook trout's life consists of an incubation period that can last from 44 to 144 days, depending on the **temperature**. During this period of time, the brook trout begin as a group of pea-sized eggs that are in a **redd**, which is the depression a female brook trout prepares in the gravel of a **stream** using her **caudal fin**. This part of the trout's life cycle normally begins in the fall, from October to November.

The second step in the life cycle of the trout begins in March and April, when food becomes abundant. This next stage of life is where the newly hatched trout are referred to as alevin. Alevin will remain protected within the gravel of the **redd** until they use up all the stored nutrients in the yolk sacs that protrude from their bellies, which makes the young brook trout appear much like tadpoles. Alevin do not yet have **fins** or mouths – they won't develop those until they need to swim and eat!

Once the alevin have absorbed all the nutrients within their yolk sacs, they leave the protective cover of the gravel to begin their new stage of life as a fry. Without a yolk sac, they now need to find food! Their mouths and **fins** have developed so they are ready for swimming and eating. They become fry in the spring, when food is available, and they move from the **redd** area to shallow water where they are better protected from predators.

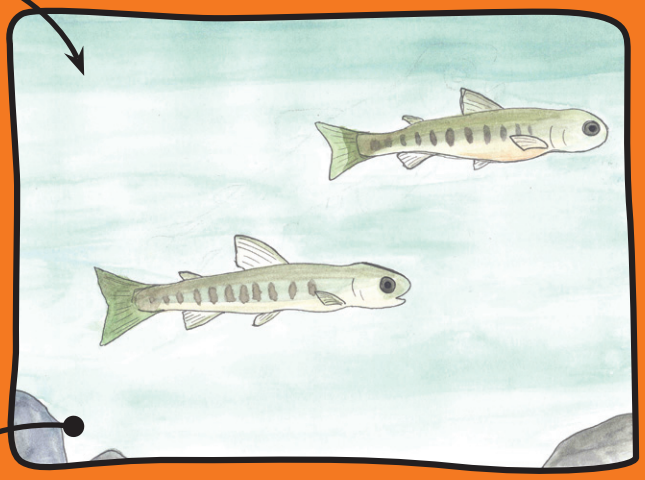
After several weeks, the fry develop a series of dark vertical stripes along their sides called parr marks and because of this, they are now referred to as parr, the fourth stage of a trout's life cycle. As brook trout grow, they eventually lose these marks and become juveniles. After some time and some maturing, these juveniles become adults. The life cycle of the brook trout is completed once the adult fish return upstream to reproduce by spawning.



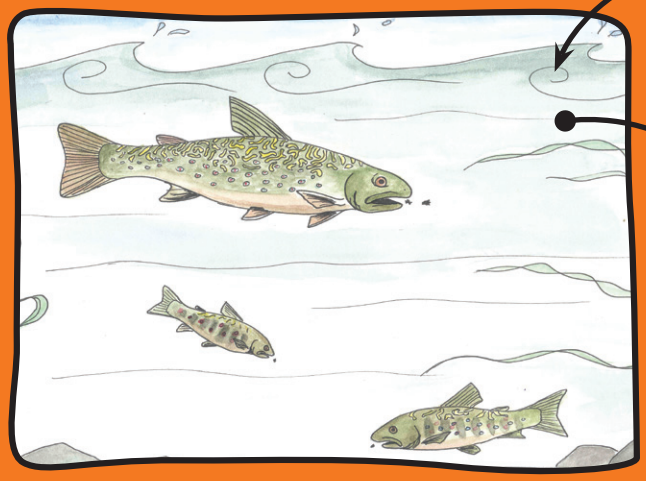
Brook trout eggs in the redd.

Brook trout in the eyed egg stage.
Each eyed egg is about the size of a pea.

Brook trout in the alevin stage. Note their yolk sacs and lack of mouths and fins.



Brook trout in the fry stage. Fry are about an inch long.



Brook trout parr have vertical parr marks.
The juvenile, top, has lost its parr marks.

An adult brook trout.

Trout Anatomy

When it comes to the anatomy of brook trout, there are many different factors that play a role in its survival. Below are some important features of brook trout.

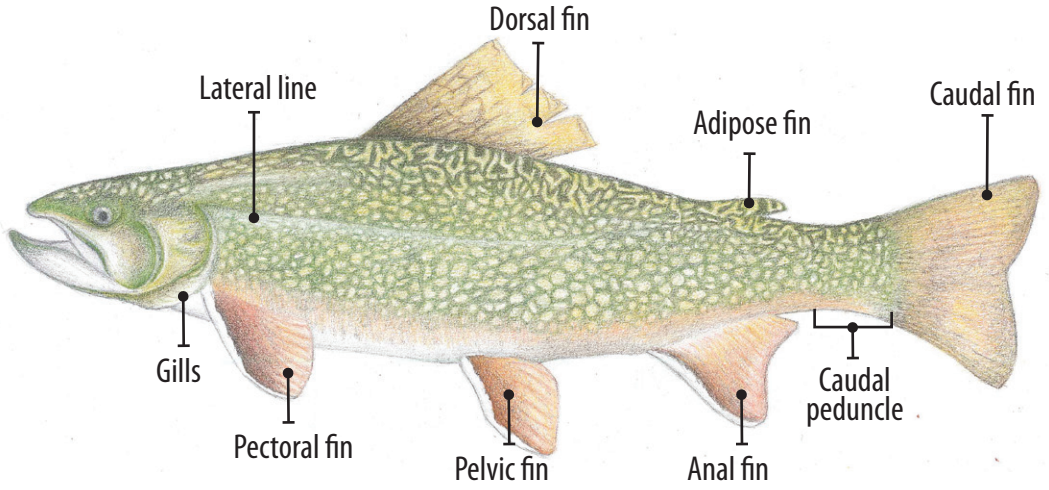
One of the biggest differences between fish and land animals is how they "breathe." Fish get oxygen from the water using **gills**, and waste products (carbon dioxide and ammonium) are released into the water through the **gills**, too.

Fins are a very important part of the trout's anatomy. They come in different sizes and shapes and are attached in various positions. They have many functions: to propel, or move the fish through the water, to provide stability, and to steer. Brook trout have eight **fins**, including the **caudal**, **dorsal**, **anul**, and **adipose fins**, and two sets of paired **fins** – the **pelvic** and **pectoral fins**. The muscular **caudal peduncle** attaches the **caudal fin** to the trout's body, helping to move the fish forward.

Like many fish, brook trout are covered with **scales** that are embedded in their skin. The tiny **scales** serve to protect the fish and overlap like shingles on a roof. A protective film of mucous called the **slime coat** covers their bodies.

You may wonder how well fish see, hear, and smell. In fact, they do all of these very well through highly developed senses. Brook trout's eyes are large and used for hunting and keeping away from predators. They have an acute sense of smell and can sense the unique odors of their home **streams**. Their **lateral line**, a series of cells arranged in a line on both sides of the fish, allows them to sense vibrations in the water, also protecting them from danger.

Finally, brook trout have **air bladders** that are like a bag of air inside the fish. The **air bladder** changes their buoyancy, enabling them to stay in a certain place in the water. By moving up or down in the water, trout can add or remove air from the bladder. When trying to maintain a certain position, fish don't waste as much energy by using their **air bladders**.



Indicator Species

The prevalance of brook trout is a measure of a water system's health because they are a type of **indicator species**, or a species whose presence, absence, or relative well-being in an environment indicates the overall health of its surrounding ecosystem.

Presumpscot River, Windham, Maine
Photo by Matthew Plummer

In Maine, many aquatic organisms require clean, cold water systems to survive. The entire trout population thrives when trout live in water that is clean, cold, and full of lots of oxygen. Trout are highly sensitive to their surrounding environment and require cool **temperatures** between 4° to 17°C (39.2 to 62.6°F) to survive. Any **temperatures** greater than 20°C (72°F) are fatal to trout and would kill a brook trout within hours.

Presumpscot River, Windham, Maine
Photo by Matthew Plummer

If the health of the trout's ecosystem declines, the opposite outcome is expected: the trout population will decline as well. It is a fairly simple relationship to understand: a better ecosystem means more trout; a poor ecosystem results in fewer trout.

Land Use and Trout Habitat

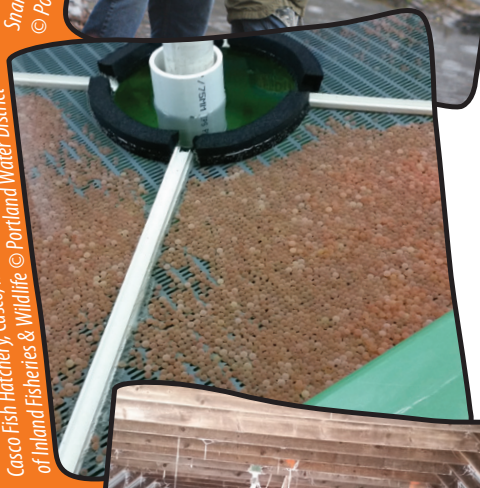
Many factors can affect the overall health of an ecosystem, including what's happening in the water as well as on the land surrounding the water. These surrounding areas can harm the water quality if they are not cared for properly. For instance, when lumber companies decide to clear forest land near a water body, they may not think about the impact on a nearby water source. Perhaps it never even crosses their minds because trees can't be useful to the ecosystem of a **river**, right? Wrong. Trees that surround water bodies provide shade in **rivers** and **streams**, which helps keep the water cooler. And if the **temperature** of a **river** becomes too warm, many species of fish may not be able to reproduce or survive, including brook trout.

Presumpscot River, Gorham, Maine

Snake Pond, Sebago Lake Land Reserve, Standish, Maine © Portland Water District - Photo by Denise Michaud

Snake Pond, Sebago Lake Land Reserve, Standish, Maine © Portland Water District - Photo by Denise Michaud

Snake Pond, Sebago Lake Land Reserve, Standish, Maine © Portland Water District - Photo by Kris Rolleston



Casco Fish Hatchery, Casco, Maine - Maine Dept. of Inland Fisheries & Wildlife © Portland Water District

Casco Fish Hatchery, Casco, Maine - Maine Dept. of Inland Fisheries & Wildlife © Portland Water District

Fishing & Hatcheries

Another factor that plays a role in the absence of the brook trout population is overfishing. Too many fish are being caught for their populations to increase, and if the same rate continues for another hundred years, the common brook trout may not be so common anymore. Once a certain species is overfished, like trout for example, another species, such as carp, may move in and take its place, making it nearly impossible for the trout to reestablish its breeding population. This can become a huge issue when trying to reestablish the population of a species after such a large decrease in its population. Now, thanks to fishing regulations as well as **hatcheries**, the worry of overfishing has diminished.

Fishing regulations are designed to **conserve** fish populations to ensure that they will exist in the future while also providing the anglers (fishermen and fisherwomen) with the fishing experience they desire. Because there are a variety of **rivers** in Maine, it is difficult to create specific regulations for each different **river**. Instead, regulations are set using "General Laws" that are similar for all waters. These "General Laws" include bag limits (number of fish caught throughout the season), length limits of the fish being caught, and the use of artificial lures only, which is meant to reduce the number of hooking injuries to fish from baited hooks.

In terms of maintaining trout populations, there are **hatcheries** throughout Maine that focus on the continuation of the species. A fish **hatchery** produces and raises young fish, and once they have matured, they are released into **rivers, lakes**, and **ponds**. **Hatcheries** maintain and track the trout population, so the dramatic decline of the species is no longer a huge threat. However, even with **hatcheries**, there still are problems that arise and can affect the population of the brook trout.

Water Pollution

The most common factor that negatively affects the brook trout population, as well as any organism living within an aquatic ecosystem, is water pollution. As we already learned, a decline in the well-being of an environment means a decrease in the native organisms living in that environment. Picture all the waste from nearby factories and mills and sewage from households in a city's surrounding **rivers**. Now imagine how devastating that would be to the ecosystem and organisms within that water source. To prevent further contamination of our water systems, the Clean Water Act was passed in 1972. It required factories to install water treatment facilities. Sewage treatment systems have also been installed in cities and towns to reduce the amount of pollution released from household sewage.

To learn more about the Clean Water Act, refer to chapter 5. Even with these regulations, water pollution still remains a major problem that we are working to solve. For more information on the importance of water quality, see chapter 4.

© Portland Water District

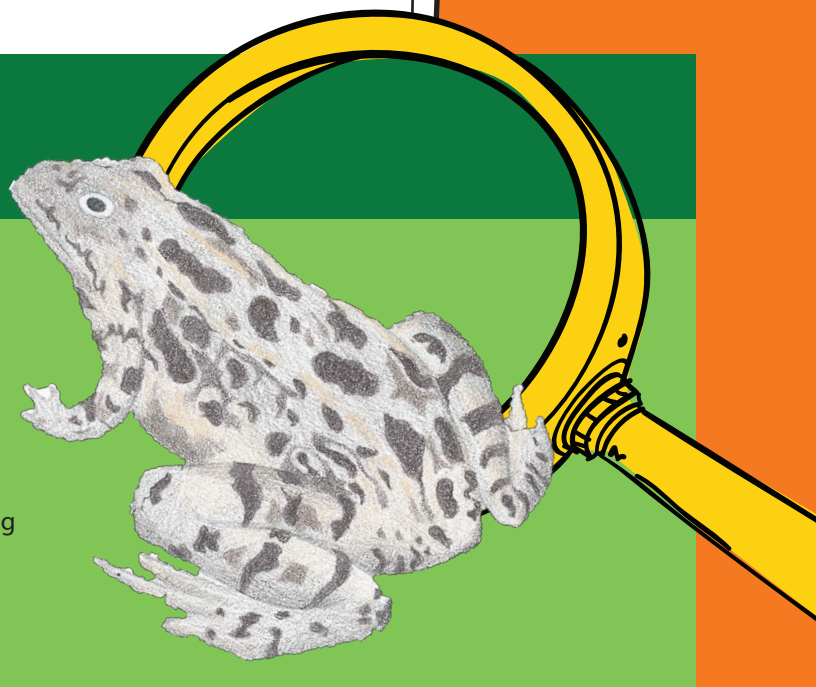
You can protect brook trout habitat!

Brook trout just happen to be another reason for you to prevent water pollution. Don't forget to stop and consider that pollution, overfishing, and unhealthy ecosystems not only affect brook trout, but other organisms as well; these things can affect you and everyone around you, too. In the end, pollution is a human error and can only be corrected by humans. All it takes is one person to step up and protect the environment, so why not start today?

Presumpscot River, Gorham, Maine

Finally! Stage #6

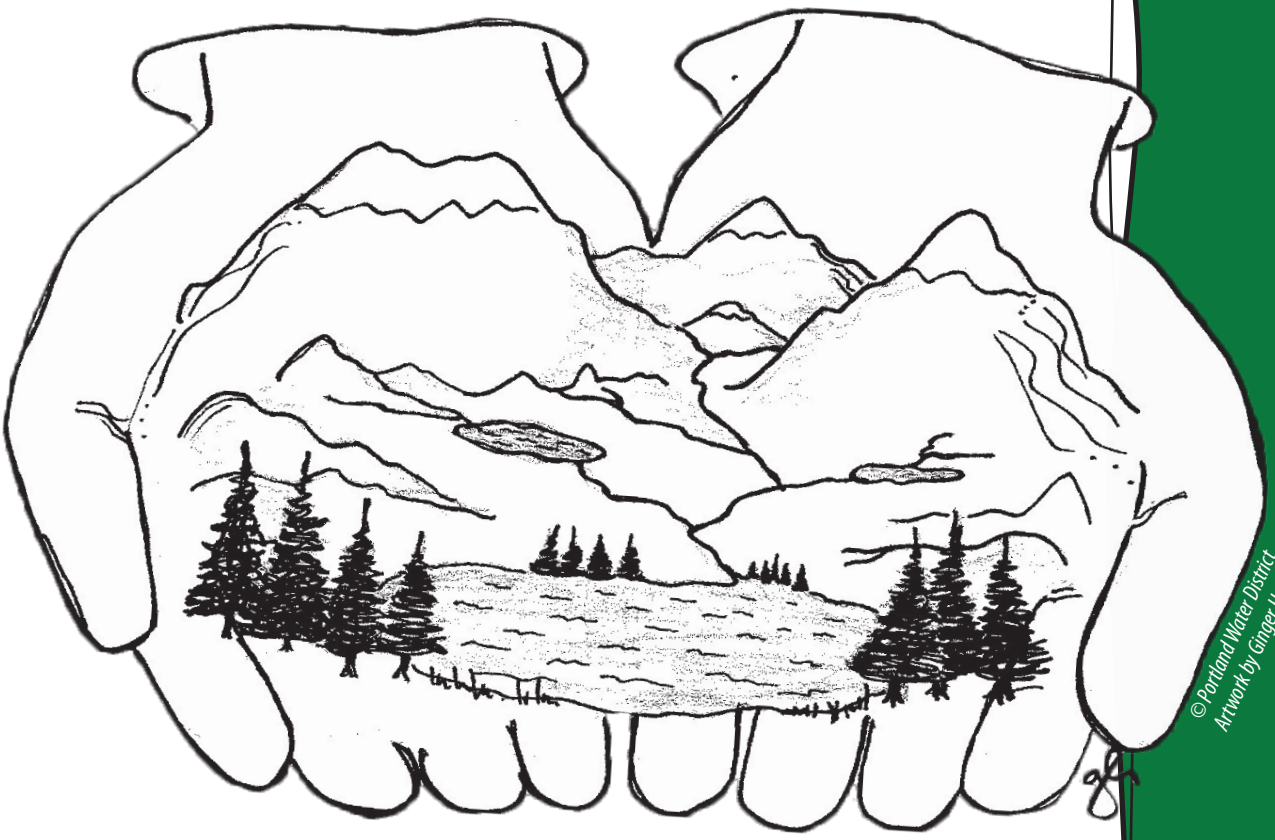
Check it out, guys! I lost my tail! Do you know what this means? **I am finally an adult.** And, now that my tail is gone, and I can breathe air with my new cool lungs, I can travel the world! Well, I can at least travel to lakes and ponds near this one. With these fancy, springy legs, I can leap 3 to 6 feet! So NOW do you know what I am? I am the great American bullfrog, and I can be found all over the United States in any fresh water source, including Maine water bodies. So keep your lakes and ponds clean if you want to see more frogs like me hopping around!



CHAPTER SEVEN: STEWARDSHIP

Pine Point Beach
Scarborough, Maine

Pine Point Beach
Scarborough, Maine



What is Stewardship?

The Earth is covered with a LOT of water - 75% as you discovered in Chapter 1. 1% of all that water is clean enough and available for humans to use. However, humans continue to pollute and waste this small amount of usable water, causing it to grow smaller and smaller! Everyone is responsible for keeping Earth's water clean, including you. In order to do this, you must practice **stewardship**. This is the act of recognizing the negative effects of wasting and polluting water and taking actions to prevent it.

How can you be a Steward in your Community?

Everyone should be a steward and help protect and **conserve** our small amount of clean water! The more people practicing **stewardship**, the better. So how can you make a difference? First, look back at the types of pollution you read about in Chapter 5. With these in mind, check out the following tips on how to keep water safe, healthy, and clean in your favorite swimming hole, your community, and the whole wide world.

Don't waste water at home!

Taking showers instead of baths **conserves** a lot of water. Keep your showers short. Five to ten minutes is all you need to get clean—not 30! Turn off the faucet if you aren't using it, like while you're brushing your teeth or doing the dishes. If you help your parents with laundry, remind them not to wash a load until the machine is filled!

© Portland Water District

We all use and enjoy clean water. Become a steward and help care for your water resources!

Windham, Maine

Clean up pet waste

It may be gross, but this is one of the most important ways you can help keep water safe and clean in your community. If dog poop is left on the ground and it begins to rain, the **runoff** will carry what your pup left behind and bring nutrients and bacteria from it into **streams, rivers,** and **lakes**. Take a plastic bag when you and your pet go on an outdoor adventure. Dispose of any waste in a trash can or the toilet.

Watch out for phosphorous!

Phosphorous is a nutrient that is harmful to water in large amounts. It is often found in many personal hygiene and cleaning products, such as soap. When too much **phosphorous** gets into a body of water, it can cause an unhealthy amount of algae to grow. This algae takes up sunlight and oxygen that are necessary for other living things to survive. Talk to your parents about buying products that do not contain phosphorous - read the product's label. The less **phosphorous** you send down the drain, the cleaner the water in your community! If you are washing the car or your bike, do so on the lawn instead of the driveway. The lawn will soak up the **phosphorous** in the soap and prevent it from washing down the road into the nearest source of water, and the plants can use the **phosphorus** as a nutrient. Try to use as little soap as possible.

Get the "dirt" on your lawn.

Ask your parents if you use lawn fertilizer. This is a very common water pollutant. **Runoff** that washes over your lawn carries nutrients like **phosphorus** from the fertilizer into the nearest body of water. But, being the steward that you are, you can get down and dirty and take action! By conducting a soil test, you can find out what nutrients are contained in the soil beneath your lawn. With this information, you and your parents can purchase a healthier fertilizer that provides your lawn with the nutrients it actually needs. A soil testing kit costs only $15 and is a fun, easy and interesting tool to help you learn about protecting your lawn and the water in your community. The following link provides information about obtaining a soil testing kit: http://anlab.umesci.maine.edu/soillab_files/prices/index.html

Know your stuff about storm drains

Storm drains exist on roads to prevent flooding from rainwater and melting snow. Whatever ends up flowing down into these drains isn't gone forever— in most cases, it goes untreated right into the nearest **stream, river, lake**, or the ocean. Often the **runoff** that flows down into storm drains passes over many unclean and contaminated surfaces such as parking lots and roads with sand or salt from winter treament, lawns with fertilizers, pesticides, or pet waste. Never pour or drop anything down a storm drain. You and your friends can help remind other people not to dump things down the drains by using a stenciling kit. Contact your public works department or, if you live in the greater Portland area, the Friends of Casco Bay (cascobay.org) to obtain one. With this kit, you can label storm drains with a message such as: "Don't Dump! Drains to River!" Be sure to get permission from your town's public works department before you stencil. A storm drain stenciling tool kit, including detailed instructions, is available by clicking "tool box" at thinkbluemaine.org.

© Cumberland County Soil and Water Conservation District

Plant Trees

This is one of the most fun and earth-friendly ways to keep our water clean. Talk to your parents about planting trees in or around the edge of your lawn. If you live on a **lake, river**, or another body of water, you can plant small trees and shrubs along the shoreline. The roots will soak up **runoff** that is headed for the nearest water body and will also use excess nutrients found in animal waste, soil, soaps, and fertilizers (such as **phosphorus** and nitrogen) to help them grow.

Baxter State Park, Millinocket, Maine

Report any pollution

If you're swimming at the beach and notice any unnatural looking substances in the water, tell a lifeguard or other adult right away. These could be **polluants** that may create unsafe water quality. It's important for the community to know if there is a pollution problem in any body of water, especially a public one.

Sebago Lake, Maine © Portland Water District - Photo by Claire Crocker

Don't litter—and clean up trash!

Storm water carries people's garbage right into the nearest water source. Some trash can harm the quality of the water and it may be dangerous to the wildlife living in the surrounding environment. Animals may try to eat the trash or get tangled up in it. An example is fishing line, which has become a major problem for wildlife. So never leave your trash lying around in the park, at the beach, your fishing spot, or anywhere else! Get a group of friends and family together to do a community trash clean up along a local water body.

Glossary

adipose fin- a small, fleshy fin, usually lacking rays, behind the main dorsal fin

air bladder- a sac containing air, located against the roof of the body cavity

anal fin- the median, unpaired fin located behind the anus

candal fin- the final vertical fin; also called the tail fin

caudal peduncle- the muscular portion of the body to which the candal fin attaches

coliform bacteria- encompasses a number of different bacteria, especially E. Coli

condensation- when water vapor rises and enters the colder regions of the atmosphere, the gas returns back to its liquid form and creates clouds

conserve- to use a resource wisely

dissolved oxygen- amount of oxygen in a body of water not bonded with another atom

dorsal fin- the fin located on the back, or dorsal side

evaporation- when liquid water molecules become a gas and begin rising into the atmosphere

fins- a wing like organ attached to any various parts of the body of aquatic species (such as fish), used for steering, balance, and forward movement in water

gills- the respiratory organ used to breathe in the oxygen dissolved in water

glaciers- large masses or rivers of compacted ice and snow

groundwater- water contained in the ground

hatchery- an establishment in which young fish are produced and raised and when they have matured, released back out into rivers, lakes, and ponds

hydrogen bond- (in water) an attractive force between the two positive charged atoms and the negative charged atom

hydrologic cycle (water cycle)- the movement of water between oceans, atmospheres, and continents

impervious surface- any surface that does not allow water to soak through it

indicator species- is a species whose presence, absence, or relative well-being in an environment indicates the overall health of its surrounding ecosystem

lake- a large body of water, surrounded by land, filled with water all year round

lateral line- the line or system of lines of sensory structures along the head and sides of some aquatic species (such as fish), which is used to detect water current and pressure changes and vibrations

macroinvertebrate- non-microscopic organism without vertebrae (backbone)

nonpoint source pollution- pollution that has no known source or origin and comes from many different sources

pectoral fins (pelvic fins)- the pair of fins usually situated behind the head on the "bottom" or ventral side

pelvic fins- the pair of fins attached to the pelvic region on the "bottom" or ventral side

pervious surface- any surface that allows water to be absorbed into it

pH- expresses acidity or alkalinity based on how many hydrogen ions present in a substance

phosphate, nitrate/nitrite- compounds found in fertilizing material

phosphorus- a chemical element found in many nonpoint source pollutants

point source pollution- pollution that comes directly from one source

pollutant- a substance that harms the water, soil, air, or other natural resource, or makes it unsuitable in some way

pond- a depression in the ground that is filled with water all year round

precipitation- the process in which water returns to earth from the atmosphere

redd- the depression certain female fish species (like brook trout) prepare in the gravel of a stream using their caudal fin

residence time- the concept of water being anywhere in the world, and remaining in specific states and stages of the water cycle for a period of time

river- body of surface water driven by gravity that is larger than a stream

runoff - happens when the water from the melting snow or falling rain is too much for the ground to absorb. This water runs over the surface of the land often picking up and carrying sediment and pollutants

scales- the small, flattened, rigid plates that cover the body of many aquatic organisms

slime coat- the slippery, protective mucous layer that covers the scales of many fish

stewardship- the responsible protection of something worth conserving and caring for

stormwater- water that comes as rain, other precipitation, or melting snow

stream- any size body of moving surface water moving to sea level

temperature- a measure of the warmth or coldness of an object or substance

topography- the physical or natural features of an area, including elevation, such as mountains or rivers

turbidity- a measurement of the clarity of a substance

watershed- a specific area of land that drains to any body of water, like streams, rivers, ponds, lakes, or the ocean

wetlands- saturated areas of land that are covered with shallow water, such as a marsh or swamp

Index

BIBLIOGRAPHY

Bastin, S., & Henken, K. (1997, December). Water content of fruits and vegetables [PDF]. Retrieved from http://www2.ca.uky.edu/enri/pubs/enri129.pdf

Boyd, M.J., Bufill, M.C., & Knee, R.M. (1993). Pervious and impervious runoff in urban catchments [PDF]. Hydrological Sciences Journal, 34(December 6), 463-478. Retrieved from http://itia.ntua.gr/hsj/38/hysj_38_06_0463.pdf

Caddisflies. (2008). In K. L. Lerner & B. W. Lerner (Eds.), The Gale Encyclopedia of Science (4th ed., Vol. 1, pp. 713-714). Detroit: Gale. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX2830100391&v=2.1&u=wind67882&it=r&p=GVR L&sw=w&asid=f9965ec85908c73b39f68ccea60f74d3

Dragonflies. (2008). In K. L. Lerner & B. W. Lerner (Eds.), The Gale Encyclopedia of Science (4th ed., Vol. 2, pp. 1379-1380). Detroit: Gale. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX2830100753&v=2.1&u=wind67882&it=r&p=GVR L&sw=w&asid=69db2c0fb3930c0ad2ea3ce8cb8cb731

Duncan, L. (2005). Rivers. In K. L. Lerner, L. W. Baker, & B. W. Lerner (Eds.), UXL Encyclopedia of Water Science (Vol. 1, pp. 125-131). Detroit: UXL. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX3437400035&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=bf086754899d0078893426927957aab9

Duncan, L. (2005). Stream Systems. In K. L. Lerner, L. W. Baker, & B. W. Lerner (Eds.), UXL Encyclopedia of Water Science (Vol. 1, pp. 131-136). Detroit: UXL. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX3437400036&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=3c1992439ba5b6ee14b179b8607614c6

Freeman, S. (2007). How water works. Retrieved from How Stuff Works website: http://science.howstuffworks.com/environmental/earth/geophysics/h2o.htm

Hoffman, J. (2009). Watersheds. In J. B. Callicott & R. Frodeman (Eds.), Encyclopedia of Environmental Ethics and Philosophy (Vol. 2, pp. 395-397). Detroit: Macmillan Reference USA. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX32 34100305&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=97453b15745f39a1f591faf843ace48f

Howard, P. (n.d.). The water in you. Retrieved from USGS Water Science School website: http://water.usgs.gov/edu/propertyyou. html

Howard, P. (n.d.). Water properties and measurements. Retrieved from USGS Water Science School website: http://water.usgs.gov/edu/characteristics.html

Hoyle, B. (2005). Ponds. In K. L. Lerner, L. W. Baker, & B. W. Lerner (Eds.), UXL Encyclopedia of Water Science (Vol. 1, pp. 123-125). Detroit: UXL. Retrieved from http://go.galegroup.com/ps/i.do?id=GA

LE%7CCX3437400034&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=5de490755d69c843957600f6457de025

Hydrologic cycle. (2006). In World of Biology. Gale. Retrieved from http://ic.galegroup.com/ic/scic/ReferenceDetailsPage/ReferenceDetailsWindow?failOverType=&query=&prodId=SCIC&windowstate=normal&contentModules=&mode=view&displayGroupName=Reference&limiter=&currPage=&disableHighlighting=true&displayGroups=&sortBy=&search_within_results=&p=SCIC&action=e&catId=&activityType=&scanId=&documentId=GALE%7CCV2431500330&source=Bookmark&u=wind67882&jsid=9e8d63658753944cf19281dc07807619

Hydrologic cycle. (2007). In K. L. Lerner & B. W. Lerner (Eds.), World of Earth Science. Detroit: Gale. Retrieved from http://ic.galegroup.com/ic/scic/ReferenceDetailsPage/ReferenceDetailsWindow?failOverType=&query=&prodId=SCIC&windowstate=normal&contentModules=&mode=view&displayGroupName=Reference&limiter=&currPage=&disableHighlighting=true&displayGroups=&sortBy=&search_within_results=&p=SCIC&action=e&catId=&activityType=&scanId=&d ocumentId=GALE%7CCV2641950232&source=Bookmark&u=wind67882&jsid=36d307c5ee70bffa11fd476694f063b1

It's elemental: The element hydrogen. (n.d.). Retrieved from Jefferson Lab website: http://education.jlab.org/itselemental/ele001.html

It's elemental: The element oxygen. (n.d.). Retrieved from Jefferson Lab website: http://education.jlab.org/itselemental/ele008.html

Lakes. (2008). In B. W. Lerner & K. L. Lerner (Eds.), In Context Series. Climate Change (Vol. 2, pp. 611-614). Detroit: Gale. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX3079000173&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=71f6850abc11d48c0308c761d60627c7

Maine Department of Inland Fisheries and Wildlife. (1984). Panther pond [PDF]. Retrieved from http://maine.gov/ifw/fishing/lakesurvey_maps/cumberland/panther_pond.pdf

Maine Department of Inland Fisheries and Wildlife. (1991). Crescent lake [PDF]. Retrieved from https://maine.gov/ifw/fishing/lakesurvey_maps/cumberland/crescent_lake.pdf

Maine Geological Society, Geological Society of Maine, Northeast Section/Geological Society of America, United States Geological Survey, Maine Water Science Center, National Association of Geoscience Teachers /New England, Geology Department/University of Southern Maine, Geology Department/University of Maine at Farmington...Poland Spring Water Company. (2009). Maine's Water Cycle. [Diagram]. Retrieved from http://www.northgeo.com/cartography.html

Maine Rivers. (n.d.). Watersheds. [Map]. Retrieved from http://mainerivers.org/watershed_profiles/

Millions lack safe water. (2012). Retrieved from Water website: http://water.org/water-crisis/water-facts/water/

Mosquitoes. (2008). In K. L. Lerner & B. W. Lerner (Eds.), The Gale Encyclopedia of Science (4th ed., Vol. 4, pp. 2851-2853). Detroit: Gale. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX2830101538&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=1269f01f698de6e49dec25852d128038

"Regulations and Seasons." www.maine.gov. InforME, 2013. Web. 20 Mar. 2014.

The north American bullfrog. (2014). Retrieved from Sea World website: http://seaworld.org/en/animal-info/animal-bytes/amphibians/north-american-bullfrog/

The problem. (n.d.). Retrieved December 15, 2013, from EPA website: http://www2.epa.gov/nutrientpollution/problem

Protecting the Clean Water Act. (n.d.). Retrieved December 15, 2013, from American Rivers website: http://www.americanrivers. org/initiatives/pollution/clean-water-act/

Storm drains and water pollution [PDF]. (2003). Retrieved from http://act.oceanconservancy.org/site/DocServer/fsStormDrains.pdf

Summary of the Clean Water Act. (n.d.). Retrieved May 19, 2013, from EPA website: http://www2.epa.gov/laws-regulations/summary-clean-water-act

Water Cycle. (2009). In R. Robinson (Ed.), Biology. New York: Macmillan Reference USA. Retrieved from http://ic.galegroup.com/ic/scic/ReferenceDetailsPage/ReferenceDetailsWindow?failOverType=&query=&prodId=SCIC&windowstate=normal&contentModules=&mode=view&displayGroupName=Reference&limiter=&currPage=&disableHighlighting=false&displayGroups=&sortBy=&search_withinesults=&p=SCIC&action=e&catId=&activityType=&scanId=&documentId=GALE%7CCV2642150403&source=Bookmark&u=wind67882&jsid=ebc1b5c45b1552a8a7366113ccf79c85

Water quality. (2011). In Environmental Encyclopedia. Gale. Retrieved from http://ic.galegroup.com/ic/scic/ReferenceDetailsPage/ReferenceDetailsWindow?failOverType=&query=&prodId=SCIC&windowstate=normal&contentModules=&mode=view&displayGroupName=Reference&limiter=&currPage=&disableHighlighting=false&displayGroups=&sortBy=&search_withinesults=&p=SCIC&action=e&catId=&activityType=&scanId=&documentId=GALE%7CCV2644151472&source=Bookmark&u=wind67882&jsid=cc5da25da3aa0f97cdc84dd3cb76dea7

Watershed. (2011). In Environmental Encyclopedia (4th ed., Vol. 2, p. 1747). Detroit: Gale. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX1918701588&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=fc6e628a13a21a246114c14d07071bcf

Watershed. (2008). In K. L. Lerner & B. W. Lerner (Eds.), The Gale Encyclopedia of Science (4th ed., Vol. 6, pp. 4654-4655). Detroit: Gale. Retrieved from http://go.galegroup.com/ps/i.do?id=GALE%7CCX2830102477&v=2.1&u=wind67882&it=r&p=GVRL&sw=w&asid=32d6c116751bc4e165e31c29607fe047

Wetlands. (2013, November 21). Retrieved from EPA website: http://water.usgs.gov/edu/characteristics.html

What you can do: In your home. (n.d.). Retrieved May 17, 2013, from EPA website: http://www2.epa.gov/nutrientpollution/what-you-can-do-your-home

Stevens, Edward. (2010). pH Scale. Retrieved from https://en.wikipedia.org/wiki/File:PH_Scale.svg#filelinks

Front Cover: Presumpscot River, Gorham, Maine

Sebago Lake, Maine © Portland Water District-
Photo by John Allen

Discovering Water, a collaborative effort between Windham High School students, the Portland Water District, and other local schools and support staff was written to share information about water in Maine and the world. This book is one tool for you to use to understand some scientific principles about Earth's water, watersheds, and the connection water has to all locations on, in, or around our Earth's surface.

Portland Water District

WINDHAM RAYMOND SCHOOLS RSU 14 SUCCESS FOR ALL

Special thanks to J.S. McCarthy Printing for their generous support of this project.

J.S. McCARTHY PRINTERS
one source one solution
AUGUSTA ▪ PORTLAND ▪ BOSTON ▪ HARTFORD ▪ STAMFORD ▪ NEW YORK