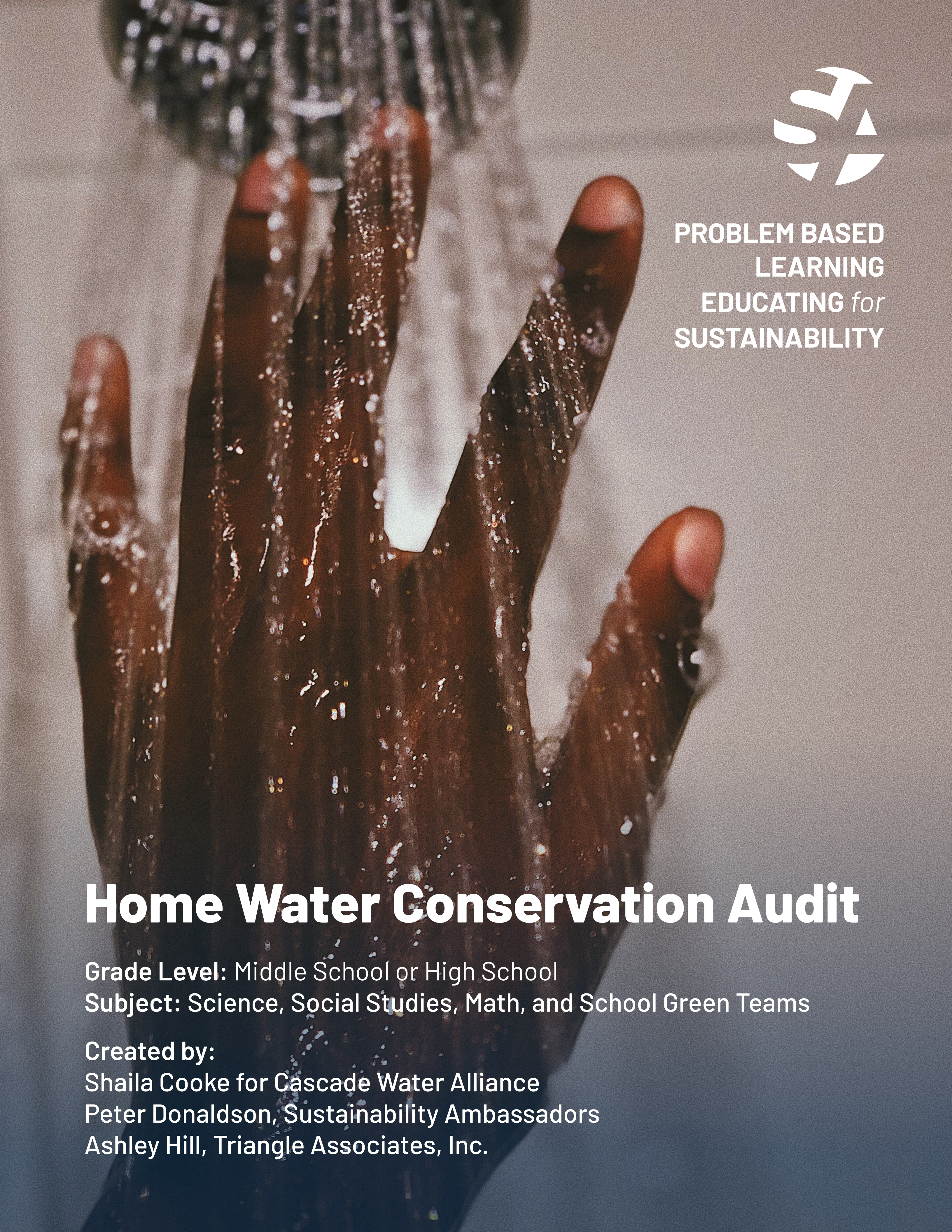


PROBLEM BASED LEARNING
EDUCATING *for* SUSTAINABILITY

Home Water Conservation Audit

Grade Level: Middle School or High School
Subject: Science, Social Studies, Math, and School Green Teams

Created by:
Shaila Cooke for Cascade Water Alliance
Peter Donaldson, Sustainability Ambassadors
Ashley Hill, Triangle Associates, Inc.

PROBLEM STATEMENT

What are the systemic implications of me and my family conserving water in our home or apartment?

SUMMARY

Students use an **excel spreadsheet** to collect and analyze data on water used in their homes or apartments for drinking, cooking, showers, toilets and appliances. The spreadsheet has **built-in formulas** to calculate the potential savings if selected water conservation measures are taken.

It also features a calculation based on how much **energy** it takes to treat, clean, transport, and heat water, as well as the associated **greenhouse gas emissions** avoided through water conservation. Analyzing the potential savings inspires students to take action.

The unit begins with a jigsaw using a number of infographics about how we use water regionally and nationally, and also how water use among American families compares to other countries.

Students will gain skills in reading **graphics, maps, and graphs** and in applying **systems thinking** as they explore the **cause and effect relationship** between social, economic, and ecological issues related to water consumption.

They will notice, of course, that Americans consume a lot of water, and that as consumers, we make an **assumption** that clean, safe, affordable water will always be available to us whenever we turn on the tap.

The jigsaw entry event leads to an inquiry where students think through all of the water they use in their homes or apartments and how the **gallons add up** over the course of a year. Students practice reading their family's **water bill** to see how water is paid for and they begin to recognize that conserving water can also **save money**.

They can explore disparities in access to clean and safe water through the lens of water bill support programs like this example in Seattle.

Working through these estimates and learning about their water bill, prepares students for **conducting the actual water use audit at home**.

They will be using tools such as a **water flow rate bag** to measure water volume, **dye test strips** to check toilets for leaks, and the **excel spreadsheet** to calculate water, energy, and greenhouse gas potential savings.

This is the very same process that is **used by working professionals** determining how a city government or water utility can achieve water conservation goals.

Students are guided in exploring a range of **water saving ideas**. They select one or more **impact projects** and develop a classroom report on total water savings. Students learn how to analyze the webpages of city and utility websites which provide information about drinking water quality and water conservation goals.

A final **classroom report** is provided to city and utility staff responsible for water supply.

Reporting to stakeholders is crucial as it establishes for students that they have agency in advancing conservation goals and that shifts in collective behavior really matter as more people understand the **systemic implications** of conserving water now and into the future. See Foundation lesson Engaging Stakeholders

EXTENSION

As an extension to learning about their family's **direct water use**, the water that comes into their home through a water pipe from a city connection, students may want to open up a much bigger challenge by analyzing their total **water footprint** which includes **indirect or virtual water** used to grow and process food, make energy, and manufacture consumer products.

Here are a few handy resources...

Student Impact Project ideas for Direct Water Use

Student Impact Project ideas for Indirect Water Use

Facts About Water Leaks in Your Home

Video: How To Detect A Toilet Leak

America's Report Card on Infrastructure for Drinking Water

World Water Footprint Calculator
(With lots of other great resources, solutions and lessons!)

Strategies for designing a Net Zero Water Building (Cool diagram!)

Learning Objectives / Student Outcomes

1. **I can apply systems thinking to understand the implications of conserving water in my home or apartment.**
2. **I can use an excel spreadsheet to calculate potential savings in gallons of water, energy, and avoided greenhouse gas emissions.**
3. **I know how to take personal action to measurably decrease my water consumption.**
4. **I understand how the actions we take together as a classroom can directly contribute to my city or utility water conservation goals.**

Formative Assessment

Menu of possibilities...

1. Notes from an initial jigsaw on water consumption around the world.
2. A sheet of estimates for all direct water consumption by me and my family.
3. Practice reading my family's water bill.
4. Notes from conducting a home water audit.
5. Review and prioritization of possible impact projects for water conservation.
6. A draft impact project plan.
7. Contribution of data to a classroom report.

Summative Assessment

1. **Design and implement a water conservation impact project that demonstrates a clear connection between personal action and city water conservation goals.**
2. **Produce a personal reflection, mind map, or video-self-interview on your growth as a learner.**

ACADEMIC STANDARDS

Science and Engineering Practice of Analyzing and Interpreting Data
Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.

NGSS #HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions.

CCSS 7.RPA.3. Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

CCSS 7.EE.B.3. Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

CCSS.ELA-LITERACY.W.8.4
8th grade Common Core Standards for Writing
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Washington State Civics Standards C4.11-12.2
Analyze and evaluate ways of influencing local, state, and national governments and international organizations to establish or preserve individual rights and/or promote the common good.

BIG PICTURE

NGSS Global Climate Change

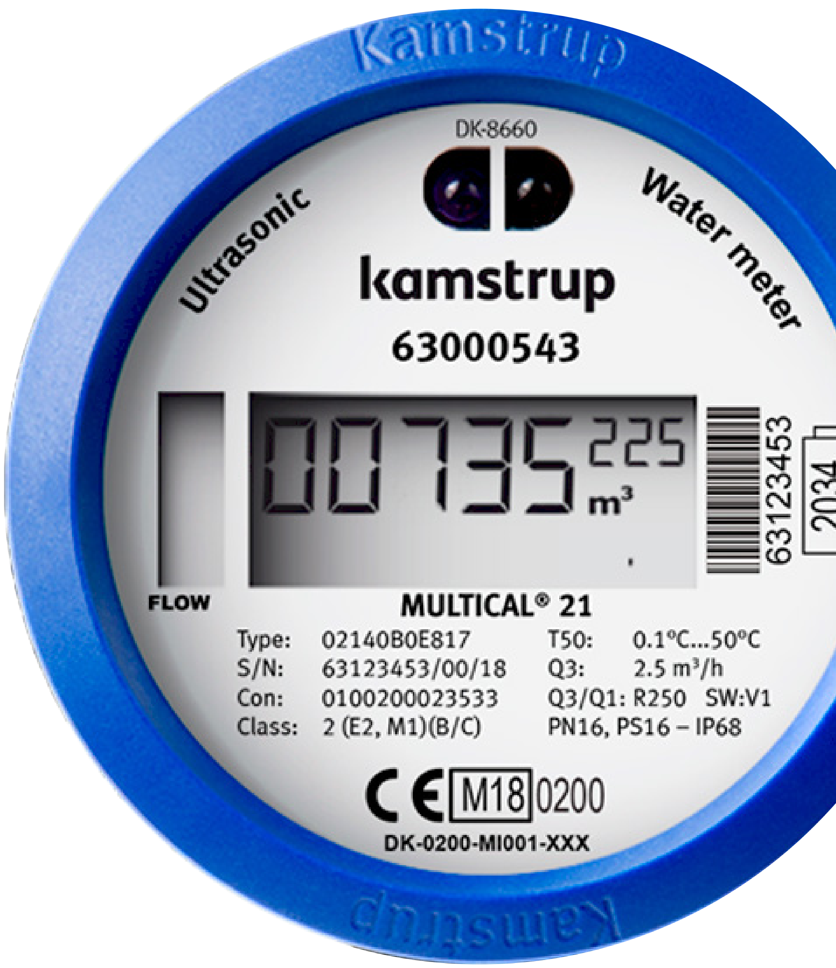
NGSS Human Sustainability Standards

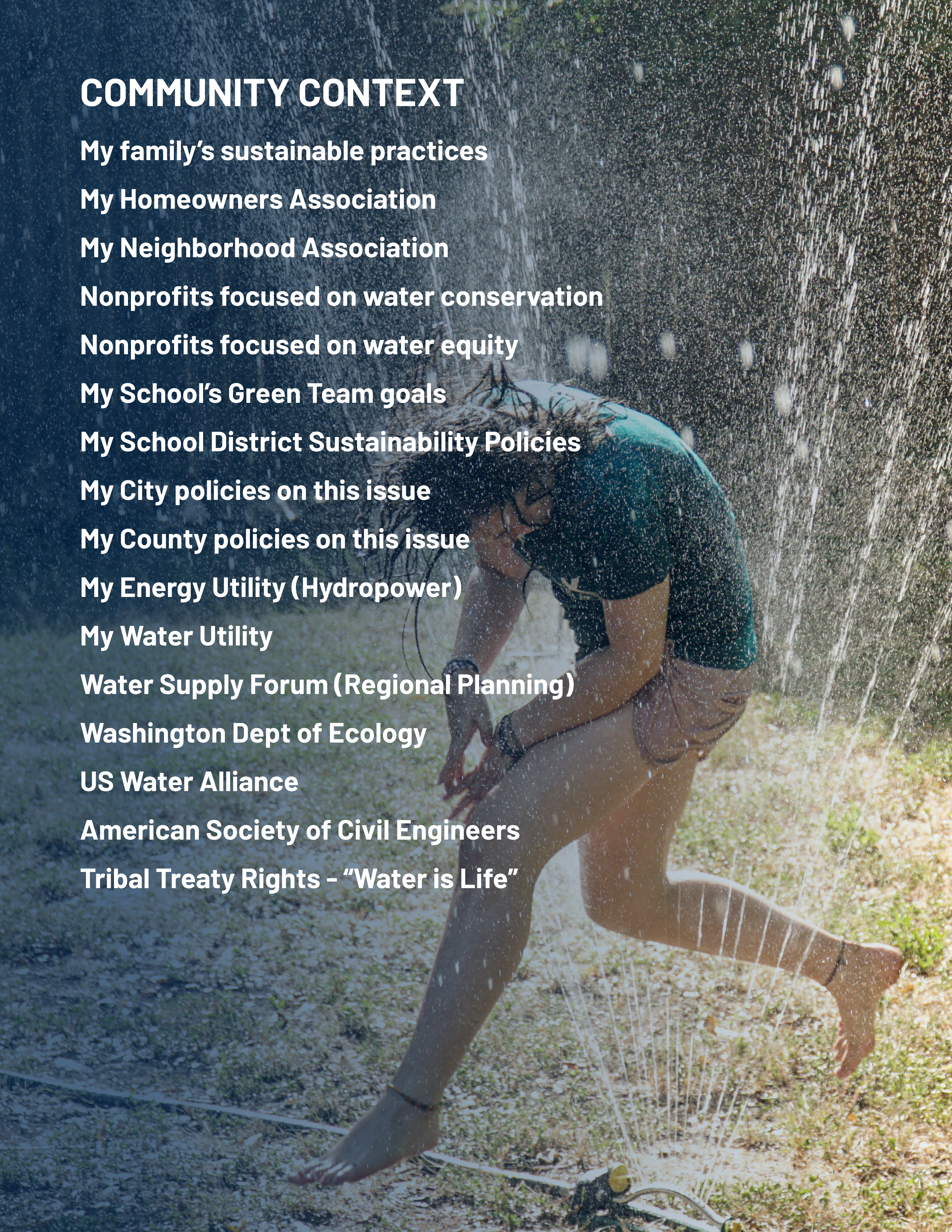
OSPI Environmental Sustainability Standards

OSPI Social Studies Standards

College, Career, and Civic Life (C3)

Common Core State Standards





COMMUNITY CONTEXT

My family's sustainable practices

My Homeowners Association

My Neighborhood Association

Nonprofits focused on water conservation

Nonprofits focused on water equity

My School's Green Team goals

My School District Sustainability Policies

My City policies on this issue

My County policies on this issue

My Energy Utility (Hydropower)

My Water Utility

Water Supply Forum (Regional Planning)

Washington Dept of Ecology

US Water Alliance

American Society of Civil Engineers

Tribal Treaty Rights - "Water is Life"

Breaking Down the Problem Statement

What are the systemic implications... of me and my family... conserving water in our home or apartment?

What are the systemic implications...

- What do we mean by system or systemic?
- What are all the considerations related to collecting, treating, transporting, storing, heating, and consuming clean water in my home or apartment?
- Do we also consume energy when we use water?
- Are there greenhouse gas emissions associated with my water use?
- What happens when the water we consume goes down the drain, or through us and down the toilet? Where does it go?
- Who manages our water supply system? How is it paid for?
- How is it treated and cleaned?
- How is it transported to my neighborhood? How is it stored?
- Can the treatment and conveyance process ever stop? Even at night?
- Do we ever use water up? What is the total supply on our planet? How does it cycle?
- What are the likely impacts from climate change on our local water supply? Do you see evidence of this already happening?
- What percentage of our water supply comes from snowpack in the Cascades? What percentage is from groundwater?
- What about virtual water? How do I use water indirectly from the water inputs embedded in producing, processing, transporting, and consuming the products I use?
- What do you think are the implications for population growth in our region? How do we manage our water resources effectively when lots more people want water?

of me and my family...

- How much water do I directly consume as a member of my household? Besides me, what are the water consumption patterns of my family?
- How much does my family use in a typical day, week, or in the winter vs. the summer? How many gallons per year?
- How much money do we pay for the privilege of clean water?
- What are the implications of my family's current water consumption habits for the future? Will conditions for my grandchildren be the same or different?

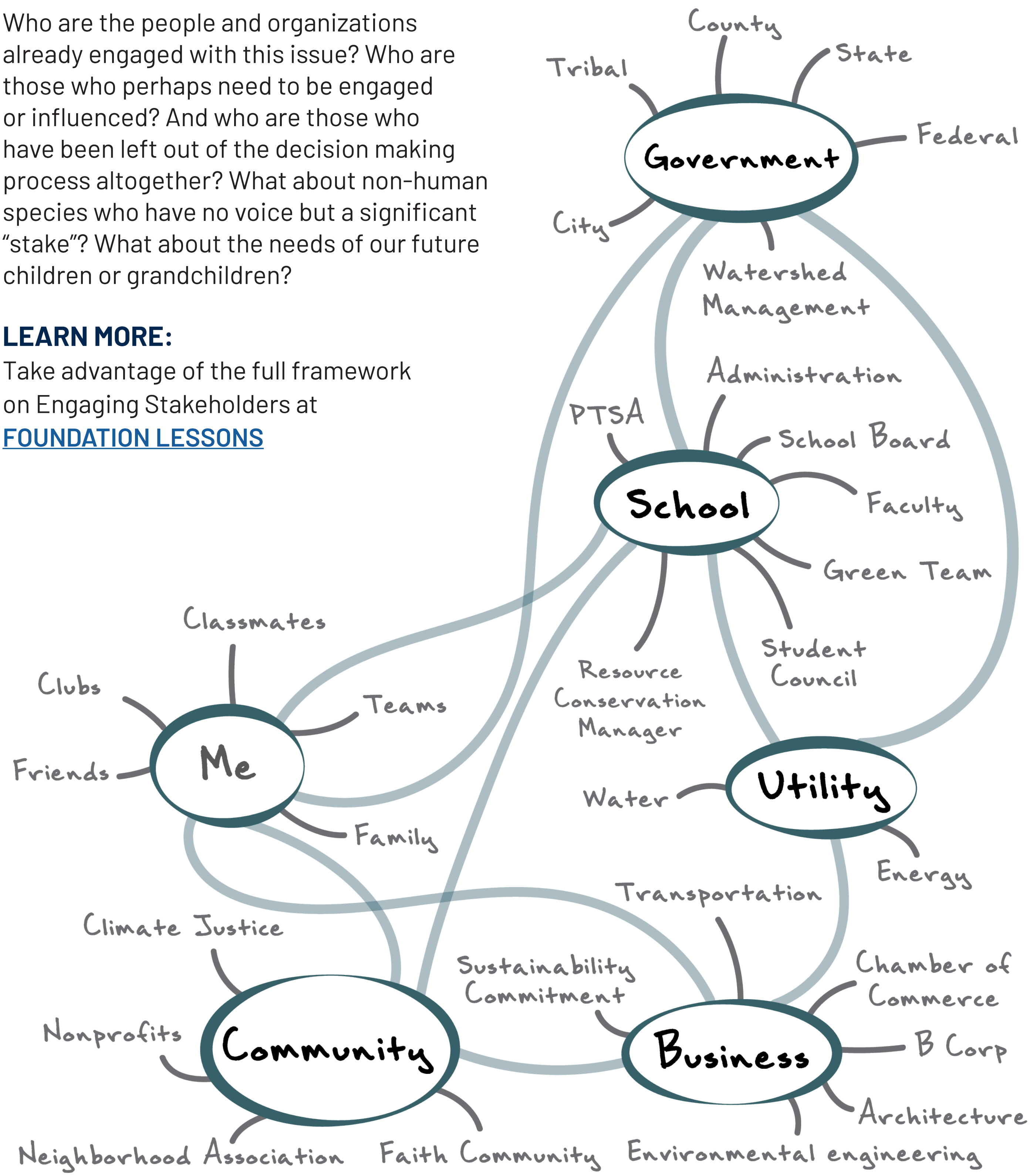
conserving water in our home or apartment?

- How can I measure my water use from sinks and showers? Toilets? Washing dishes and clothes?
- How does my family consume water outside around my house? Watering the lawn or garden? Washing the car?
- What do I have control over in my apartment or condo complex related to water use?
- What are the easiest ways for me and my family to conserve water?
- Who is manufacturing the most water-efficient appliances? Is there a rating system so consumers know which appliances are most water efficient?
- Is it possible to harvest and store all of the water we need for our home just by collecting the rain that falls on the roof? How might that be engineered?
- Can we recycle wastewater? What's the engineering behind this opportunity?
- How can we achieve a net zero water

Stakeholder Brainstorming

Who are the people and organizations already engaged with this issue? Who are those who perhaps need to be engaged or influenced? And who are those who have been left out of the decision making process altogether? What about non-human species who have no voice but a significant "stake"? What about the needs of our future children or grandchildren?

LEARN MORE:
Take advantage of the full framework on Engaging Stakeholders at
[FOUNDATION LESSONS]

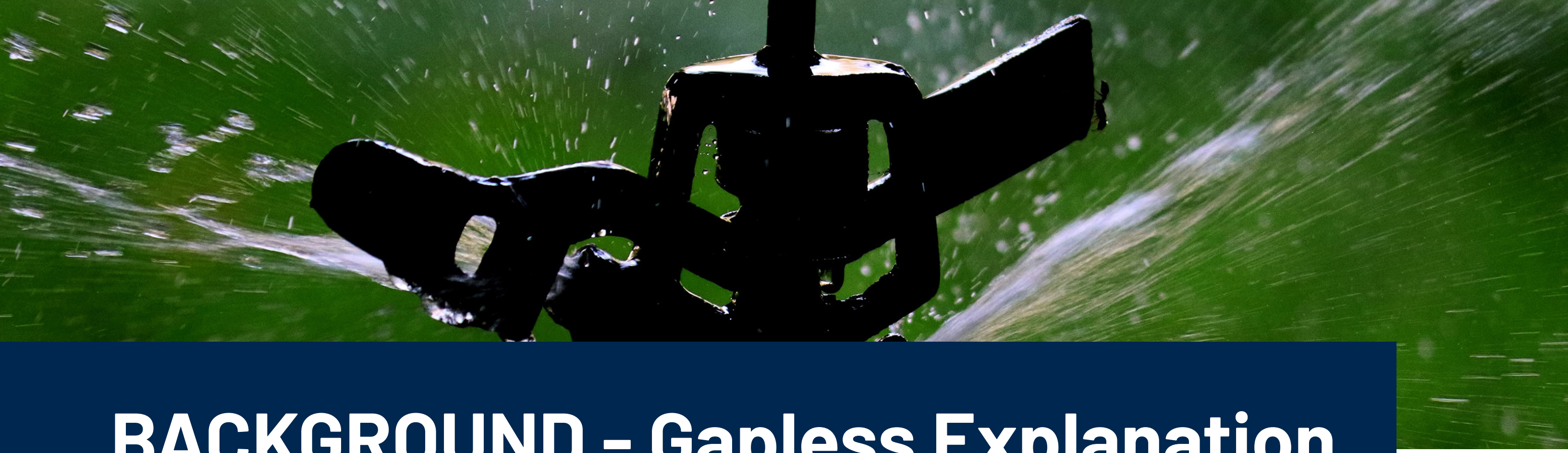


Stakeholder Perspectives

As students identify specific stakeholders relevant to this topic, they will want to consider each point of view with integrity. This practice provides a critical opportunity to develop social-emotional learning skills and cultural competency by building an awareness of our own internalized biases and expanding our capacity for empathizing with stakeholder perspectives different than our own.
See sample stakeholder paragraph descriptions.

EXAMPLE: Stakeholder Engagement Table

STAKEHOLDERS	INTERESTS	GOALS	APPROACH
Name of stakeholder group	**What motivates them? What do they care about? What are they responsible for?**	**Do they have specific action plans, goals, or projects they are pursuing?**	**What is the best message and timing to engage with this group?**
My family	Survival and the ability to carry out normal activities (drinking, cooking, washing).	Survival. Saving money on water bills.	Word of mouth, informal family resolutions about water conservations.
School (Green Team, RCM, PTA, ASB)	Implementing water conservation and efficiency actions at school.	Saving money. Conserving natural resources. Building community.	Green Team group chat or social media. PTA and school e-news.
My City	Ensuring residents have access to clean water for drinking, cooking, washing, and irrigation.	Functioning drinking water, wastewater, and stormwater infrastructure.	Presenting at City Council meetings. Proposing resolutions. Contacting city staff and elected representatives.
Local Water Utility	Ensuring rate-payers have access for domestic and commercial uses. Financial interest in rate-payers.	Meeting needs for future water use. Maintain and update infrastructure as needed.	Email or call utility staff responsible for community engagement. Speak at public hearings.
Tribal Governments	Access to healthy fishing grounds for salmon, shellfish, plants, as guaranteed by treaty rights.	Maintain natural resources for current and future livelihoods as well as cultural connections.	Building relationships acknowledging treaty rights and advocacy for supportive policies.



BACKGROUND – Gapless Explanation

We Use a Lot of Water

According to a 2014 Government Accountability Report, 40 out of 50 state water managers expect water shortages under average conditions in some portion of their states over the next decade. And with climate change, we will not be facing "average" conditions.

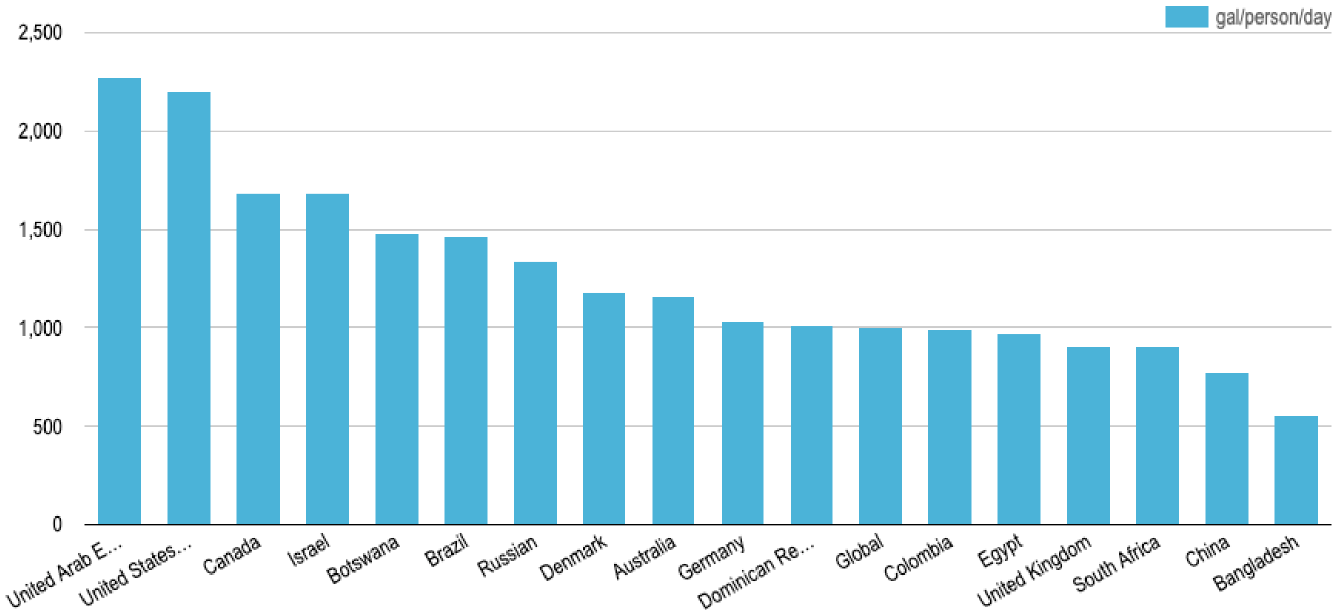
Each American uses an average of 82 gallons of water a day at home. EPA Water Facts. The typical European uses about 150 liters per day which translates to just 40 gallons of water or less than half of what a typical American uses. Water use Ranking in Europe

This is **direct water** use, meaning the water that comes into your home from a single ¾" pipe and is distributed to each fixture, faucet, shower, or toilet, and outside to your garden hose. The amount of water you directly consume for washing, cooking, cleaning, flushing and gardening is measured by a **water meter** which shows up on your **water bill**. You pay for what you use. If you use less you pay less, except for a flat rate that supports all of the big pipes, pumps and purification systems that water travels through to get to your house. We all pay for the **infrastructure**.

Indirect or virtual water use: It takes a lot of water to produce food, to make energy and to manufacture consumer products. This is what's known as virtual water. Globally, virtual water use is increasing, as more people consume more water-intensive food, electricity, and consumer goods, putting increasing pressure on water resources. **Water footprints** reveal both direct and indirect water use patterns, from the individual level all the way to the national level.

If we **combined** the total direct and indirect water use of the average American, we get 2,200 gallons of water per person per day. Remember that 82 gallons is our average ***direct*** water use. So the remaining 2,118 gallons is our ***indirect*** use. The water footprint of what we buy really matters.

How our water footprint compares to other countries



Water Conservation is Critical

Water **conservation** means using less water and making sure that what we do use is as efficient as possible. Water conservation can include simple everyday **behavior changes** like shorter showers or running full loads in the dishwasher and clothes washer. It means checking for toilet leaks, which is a bigger problem than most people realize.

Water conservation can also involve **new technologies**, such as low flow toilets, aerators for faucets and showers, and appliances like dishwashers and clothes washers that are as energy and water efficient as possible. The EPA's WaterSense label helps consumers find the most efficient appliances.

The choices we make in using water have **financial and environmental impacts**. Reducing the amount of water we use can save families and communities money.

Depending on the **energy source** used to clean, store, transport, and heat water, a range of greenhouse gasses can be released including **carbon dioxide, methane, and nitrous oxide**.

For the calculator used in this unit, a **carbon dioxide equivalent** (CO_{2e}) combines all three greenhouse gasses into an "equivalent" number of pounds of CO2. See this excellent infographic on how water and energy systems are interdependent.

The choices we make related to our indirect or virtual water use have implications for people **living in water scarce countries**. See this excellent but startling infographic from UNICEF.

Who Manages My Water Supply?

Water Supply Forum (Forum) addresses current and future water supply issues, including supply system resiliency, planning, policy and regulation, and environmental stewardship. It is composed of representatives of public water systems and local governments in the **central Puget Sound region**. Working cooperatively, the Forum's members listed below promote the reliable delivery of safe, clean water throughout the region.

- Alderwood Water & Wastewater District
- Bellevue Utilities
- Cascade Water Alliance
- City of Auburn
- City of Everett
- City of Kent
- Covington Water District
- Everett Water Utility Committee
- King County
- Lakehaven Water & Sewer District
- Regional Water Cooperative of Pierce County
- Seattle Public Utilities
- Tacoma Water

Five of the Larger Members of the Forum

Cascade Water Alliance (Cascade) provides water to approximately 380,000 homes and 20,000 businesses over seven eastside cities. Cascade has provided the resources to develop and implement the Home Water Conservation Audit designed for educators and students. Cascade Water Alliance

Everett Water Utility supplies water to about 615,000 people or 75 percent of the businesses and residents of Snohomish County through a network of local water providers. Everett Water

King County Wastewater Treatment provides services to 17 cities, 17 local sewer districts, and more than 1.5 million residents across a 420-square-mile area in King, Snohomish, and Pierce counties. King County Wastewater Treatment

Seattle Public Utilities manages two large, regional watersheds that supply quality drinking water to 1.4 million people in the greater Seattle area. SPU Services/Water

Tacoma Water provides direct service to more than 300,000 people throughout Pierce and King counties including 117 square miles of service area, 95,893 residential customers and 7,223 commercial and industrial customers. Tacoma Water

Background on US Water Infrastructure

Safety and Supply

The U.S. installed most of its water infrastructure in the **early 1900s**, and these pipes have a lifespan of only about 100 years. Instances of leaking pipes and full-on failures have been increasing as these pipes begin to age out. Unless municipalities across the U.S. fully overhaul the drinking water system, **safety and supply are at risk**.

Every day, six billion gallons of water are lost from **leaking drinking water pipes** across the United States – enough water to support the daily needs of 20,000 households. As this water leaks into the ground, it is an out-of-sight, out-of-mind problem. The effort to update the U.S. water supply system, even in the face of compounding threats like **growing population** and climate change, has been a slow process.

Drying Up

Securing water supply systems requires **planning for shortages**. In the face of a shortage, managers can either find more water to increase supply or they can reduce demand which means all of us conserving the water we have.

Over 70 percent of U.S. watersheds could expect decreased water supplies under future climate scenarios. Furthermore, the highest demands for water occur in areas with the lowest supply levels like the Southwest and Great Plains.

To protect against shortages, conventional solutions could include increasing the use of groundwater and surface water sources or increasing reservoir storage capacity. Solutions can also include increased **irrigation efficiencies and soil management** practices that hold more water. Any solutions in the agriculture sector need to be balanced with **food security issues**. In the Pacific Northwest we have a legal requirement to ensure there is enough water in our rivers to support salmon populations as laid out in long-standing treaty rights with Native American Tribes.

Aging Out

The U.S. Environmental Protection Agency estimates that **nearly $475 billion** will need to be invested in the drinking water infrastructure system over the next 20 years to secure supplies. On a municipal scale, utility infrastructure improvements are funded by **fees charged to end users**, which may not generate enough revenue to fund expensive, system-wide improvements. Significant federal funding will be needed to help cities and water utilities cope with the scale of repairs and upgrades needed. This can generate millions of **green collar jobs**.

Lead Pipes

Lead pipes, known sources of contamination, are often still found in US communities. Cities like Flint, Michigan are focusing their attention on **environmental justice issues** related to water supply. This highlights the dire need to improve the quality of drinking water nationwide. It is important to know that today most illnesses from drinking water can be traced to deteriorating infrastructure, not to inadequately treated water.

Urban Efficiency

After addressing watershed supply security and infrastructure upgrades, there is also an opportunity to shift water use and waste management at **much smaller scales** such as neighborhood and household levels. Current urban wastewater management strategies rely on **huge quantities of water, large infrastructure investments, and long planning timeframes**. These qualities have slowed many cities' abilities to adapt to challenges such as climate change and population growth.

Water use efficiencies can be expanded at the household scale by adopting WaterSense appliances that use less water, smart water meters, drip irrigation, and natural yard care strategies.

Recycled Water

Expanding the **reuse of treated wastewater**, such as using it for agricultural irrigation or groundwater recharge, can remove pressure on treatment systems by creating another option for some of the largest water users. See King County Recycled Water. If the agricultural sector had methods for accessing treated wastewater, for example, a significant portion of demand would be shifted away from the drinking water supply. Recycled water use in California is a rapidly growing strategy.

Harvesting the Rain

Harvesting rainwater that falls on the rooftops of homes, schools, and commercial buildings can also improve local water security. **Large underground cisterns** can be engineered to hold water harvested during the rainy season so that it can be used during the dry season for toilet flushing, laundry, and irrigation.
See VIDEO - Stone 34 Case Study

Water Systems Information

The key is to move to more local, flexible, and **integrated water management systems** that allow for innovation and adaptation. Policy makers have been averse to overhauling drinking water systems because the process is widely disruptive. However, forecasted water shortages and infrastructure failures could become even more **disruptive to daily life**, especially when we factor in the dual pressures of **population increase** and the way that **climate change** is altering our local water cycle.

The United States can **safeguard against future water crises** by shifting consumption patterns, investing in long-term infrastructure improvements, and exploring creative, local solutions for water use and management.

SOURCE: Much of the content integrated in this section on American water infrastructure was adapted from the Yale School of the Environment, ***Environment Review***, a student-run review that provides weekly updates on environmental research findings. See: Transforming U.S. water supply systems toward a robust, water-secure future.

Future Need

Our nation's drinking water systems face staggering **public investment needs** over the next several decades. American Society of Civil Engineer's 2020 economic study, "The Economic Benefits of Investing in Water Infrastructure: How a Failure to Act Would Affect the U.S. Economic Recovery" found that the annual drinking water and wastewater **investment gap** will grow to $434 billion by 2029. This means what we need to **repair, fix, or build** to maintain our water infrastructure compared to how much money we have at the federal, state, or local level. And since these funding sources come from taxpayers, like your family, it is a real challenge to gather enough in taxes to pay for the actual need in infrastructure investment.

Drinking water utilities also face increasing **workforce challenges**. Much of the current drinking water workforce is expected to retire in the coming decade, taking their institutional knowledge along with them. Between 2016 and 2026, an estimated 10.6% of water sector workers will retire or transfer each year, with some utilities expecting as much as half of their staff to retire in the next five to 10 years.

SOURCE: From the American Society of Civil Engineers, ***Report Card for America's Infrastructure*** focused on Drinking Water.

Can we get to net zero water?

The ultimate **design solution** for water efficiencies and water conservation is to build our homes, schools, and commercial buildings to achieve net zero water.

This means that over the course of a year, you only use the water that rains on your roof. You collect it in one or more carefully sized cisterns, and then manage it over 12 months. It's like having a **rain budget**. You need to engineer your building and manage your water consumption habits so you do not overdraw your account.

The Federal Energy Management Program offers an example of a net zero water building through this excellent engineering diagram.

The small island nation of **Singapore** has long been a leader in integrating water systems including what they call the Four National Taps: harvesting rainwater, importing water, recycling wastewater, and removing salt from seawater. Singapore's National Water Agency has worked hard to build a public information campaign that debunks and reduces the "yuck factor" associated with reclaimed wastewater or what they have branded NEWater.

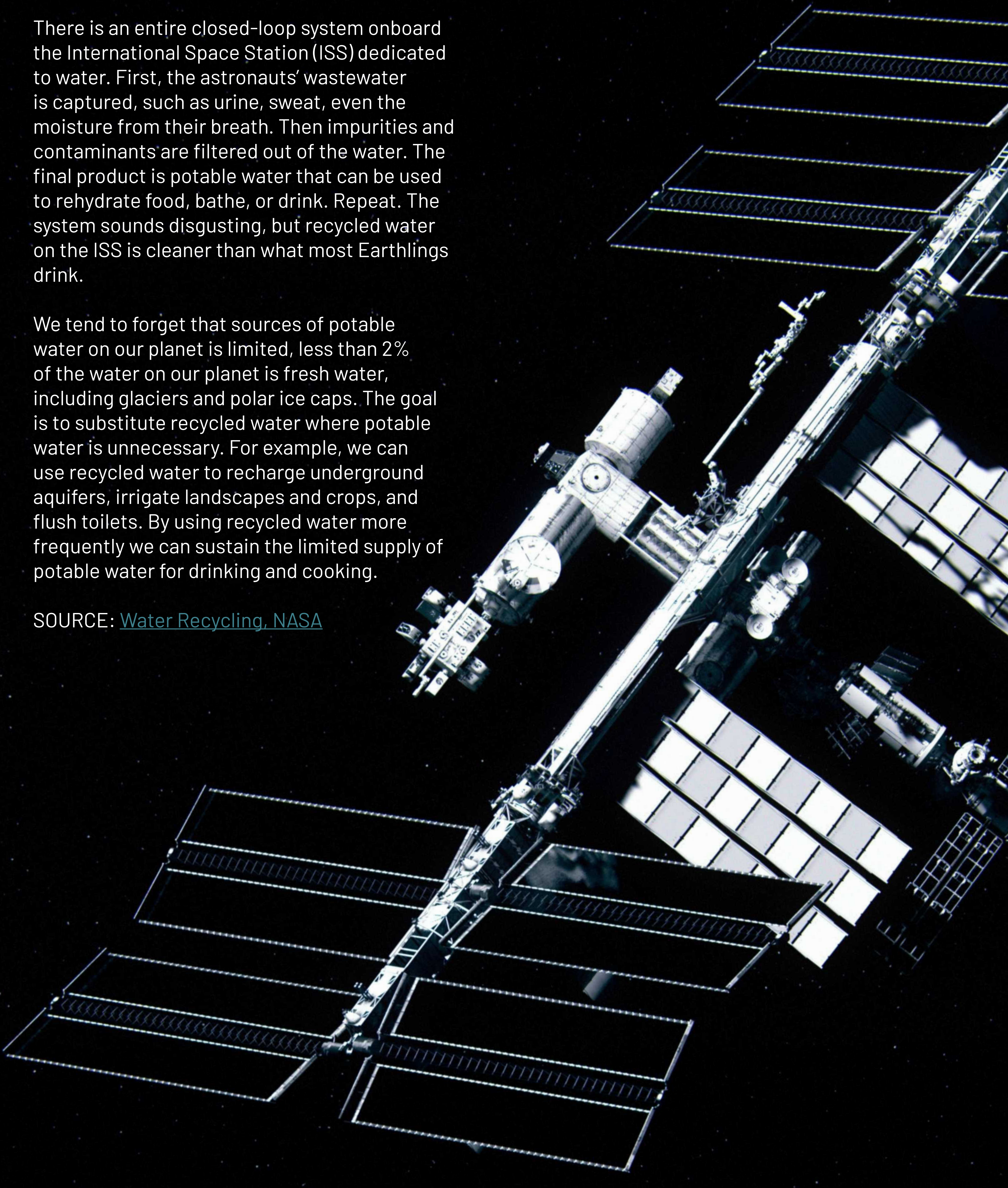
Singapore, Gardens by the Bay

Water Recycling Onboard the International Space Station

There is an entire closed-loop system onboard the International Space Station (ISS) dedicated to water. First, the astronauts' wastewater is captured, such as urine, sweat, even the moisture from their breath. Then impurities and contaminants are filtered out of the water. The final product is potable water that can be used to rehydrate food, bathe, or drink. Repeat. The system sounds disgusting, but recycled water on the ISS is cleaner than what most Earthlings drink.

We tend to forget that sources of potable water on our planet is limited, less than 2% of the water on our planet is fresh water, including glaciers and polar ice caps. The goal is to substitute recycled water where potable water is unnecessary. For example, we can use recycled water to recharge underground aquifers, irrigate landscapes and crops, and flush toilets. By using recycled water more frequently we can sustain the limited supply of potable water for drinking and cooking.

SOURCE: Water Recycling, NASA



LESSON OUTLINE

Materials Needed:

Student Home Conservation Audit Instructions and Worksheet

Student Home Conservation Calculator Excel spreadsheet

Sample Water Bills

Outdoor Water Conservation Best Management Practices Handout

Indoor Water Conservation Best Management Practices Handout

Student Home Water Audit Glossary

Home Water Conservation Resources

Time Needed:

2-4 days with time to conduct the audit at home between lessons

VOCAB AND KEY SEARCH WORDS

Consumption Patterns

Water Conservation

Water Efficiency

Water Supply / Water Quality

Water Infrastructure

Drinking Water Treatment

Reservoir

Conveyance Pipes and Pumps

Water Meter / Smart Meter

WaterSense Label

Water Tank / Tower

Potable Water Supply

Fee Structure / Ratepayer

End User / Consumer

Water Equity / Water Justice

Water Affordability

Water Security

Water Utility

Water Footprint

Energy/Water Nexus

Greenhouse Gas Emissions (GHG)

ENTRY EVENT

Using infographics, maps, and charts, engage students in an open-ended jigsaw and/or webquest to uncover as many **systemic implications** of world water availability and consumption patterns as they can.

A starter set of resources might include:

World Domestic Water Use: Crazy distorted maps that help to visualize which countries consume more water and which are experiencing increased water scarcity.

Water for a Sustainable World: Gorgeous (and huge) infographic poster with lots of overlapping stories related to Society, Economy, and the Environment. Zoom in and explore.

Water Footprint Product Gallery: Get a snapshot of the impact of your daily lifestyle. Compare how much water is used to make a variety of products so that you can choose to reduce your water footprint.

World Water Use by Country: A graph and chart showing a selection of countries and their relative water footprint.

How We Use Water in the United States: EPA website featuring pie charts and maps on water use. (PDF Handout)

Statistics and Facts: Why We Need to Save Water: US EPA (PDF Handout)

Total Water Use in the United States: Maps, graphs and charts - USGS (PDF Handout)

Water Use Ranking in Europe: The typical European uses about 150 liters per day which translates to just 40 gallons of water, less than half of what a typical American uses.

River Flow Allocations: comparing natural and managed river systems. Learn more at International Union for Conservation of Nature (IUCN)

Going with the Flow: Working with natural water/river infrastructure optimizes engineered infrastructure performance and financial benefits. Learn more at International Union for Conservation of Nature (IUCN)

Investing in Natural Water Infrastructure: See how the right investments can generate multiple benefits. Learn more at International Union for Conservation of Nature (IUCN)

Water, Energy, Food Nexus: Recognition of the closely bound interaction between water, energy and food production and use – the nexus - has led to new demands for water infrastructure and technology solutions. Learn more at International Union for Conservation of Nature (IUCN)

Suggested Inquiries...

What are the systemic implications of water use in our region, our country, the world?

If you wanted to use 40 gallons a day like a typical European, versus 82 gallons a day like a typical American, how would you achieve this? Behavior changes? Engineering design?

What is the relationship between my family's total water footprint and the ability for families in developing countries to access clean water?

*771 million people lack access to safe water. Nearly 1.5 times the population of the United States lives without a household water connection. These people, in particular women and children, must spend time getting water, instead of working or going to school or caring for their families. If this is a **huge systemic challenge**, what do you think are some of the **systemic solutions**?*

USGS Water Use Changes over Time

1950	Municipal	Irrigation	Rural			Self-Supplied Industrial						Water Power	
1955	Public Supply	Irrigation	Rural			Other industrial			Fuel-Electric Power: Condensor Cooling	Fuel-Electric Power: Other		Water Power	
1960	Public Supply	Irrigation	Rural Domestic	Rural Livestock		Other industrial			Fuel-Electric Power: Condensor Cooling	Fuel-Electric Power: Other		Water Power	
1965-1980	Public Supply	Irrigation	Rural Domestic	Rural Livestock		Other industrial			Thermoelectric power: Condensor Cooling	Thermoelectric power: Other		Hydroelectric Power	
1985	Public Supply	Irrigation	Domestic	Livestock		Commercial	Industrial	Mining	Thermoelectric power: Fossil Fuel	Thermoelectric power: Geothermal	Thermoelectric power: Nuclear	Hydroelectric Power	Sewage Treatment (releases)
1990-1995	Public Supply	Irrigation	Domestic	Livestock	Animal Specialties (incl. fish farming)	Commercial (incl. offstream fish hatcheries)	Industrial	Mining	Thermoelectric power: Fossil Fuel	Thermoelectric power: Geothermal	Thermoelectric power: Nuclear	Hydroelectric Power	Wastewater Treatment (releases)
2000-present	Public Supply	Irrigation	Domestic	Livestock	Aquaculture (incl. fish farming & hatcheries)	*Commercial not estimated*	Industrial	Mining	Thermoelectric power: Once-through cooling	Thermoelectric power: Closed-loop cooling		*Hydroelectric Power not estimated*	*Wastewater Treatment not estimated*

ACTIVITY 1

Humans use a lot of water!

We use water to stay clean and hydrated, to power places where we live and work, and to grow and produce the food we eat. In 2015, water use in the United States was estimated to be around 322 billion gallons per day. According to the Environmental Protection Agency (EPA), someone in the United States uses an average of 82 gallons of water each day for indoor uses.

Analyzing Historical Patterns of Water Use

The United States Geological Survey (USGS) started collecting data on water use in 1950. This fascinating infographic demonstrates interesting changes and shifting priorities in water use since the 1950s. The categories for measuring water use in the US have also changed over time - this table illustrates these changes.

Suggested Inquiries...

What caused the changes in water use categories between the 1950s and now?

What do you notice about state-by-state water use changes over time?

Why do you think we categorize our water use in these ways?

Did anything on the interactive map or the table surprise you? Why?

What is the most important information you gathered from the interactive map and/or table? Why?

What ideas do you have about increasing water conservation in the United States?

What can you and your family do? How would you measure any actions you took?

What About Current Water Use Patterns?

The United States Geological Survey measures water use by category. Students can study the list of short descriptions below to get a big picture understanding of how our personal water use (domestic) fits into the national water use story. Domestic water use is a pretty small piece of the pie!

Public supply water is withdrawn by public and private suppliers who provide water to at least 25 people or have a minimum of 15 connections. This is water used for domestic, commercial, and/or industrial purposes.

Domestic water includes indoor and outdoor water uses (flushing toilets, water lawns, drinking water) at places where people live. This includes water from a public supplier and self-supplied water. It also includes potable and non-potable water.

Irrigation use is water applied by an irrigation system to maintain plant growth in agriculture and horticulture practices.

Thermoelectric power water use is the water used in the process of electricity generation using steam-driven turbine generators.

Industrial water is used for fabricating, processing, washing, diluting, cooling, or transporting a product, incorporating water into a product, or for sanitation at a manufacturing facility.

Mining uses water for the extraction of minerals. It may also include the injection of water to recover oil and gas.

Livestock water use is water used to water livestock, feedlots, dairy operations, and other on-site farm needs. This also includes water used for cooling of facilities, dairy sanitation and cleaning facilities, animal waste disposal systems, and some water losses.

Aquaculture water is used to raise organisms that live in water for food, conservation, or sport.

Estimate Every Drop You Use

Suggested Inquiries...

What are the ways you, as an individual, use water where you live? Try to account for every drop!

How much water do you think a faucet uses every minute? What about a shower? A toilet? A washing machine or dishwasher? How did you come up with those estimates?

Overall, how much water do you estimate you and your family use on a daily or weekly basis?

Do you know if the place you live has water efficient faucets, fixtures, and appliances?

How do you think engineering and technology will improve water conservation in your lifetime?

ACTIVITY 2

Why should I care? I just turn it on and it works.

For some people it is not as simple as turning on the faucet. Invite students to debate the ethical dimensions presented in each of these short animated videos. Student groups make a claim for which video delivers the message best.

[VIDEO 3:30] - **Freshwater Scarcity: An Introduction to the Problem** - Christiana Z. Peppard, (2013)

[VIDEO 5:18] - **Are we running out of clean water?** - Balsher Singh Sidhu, (2018)

[VIDEO 3:02] - **How Fair is Your Water Footprint?** Water Witness (2021)

Suggested Inquiries...

How does access to water differ around the world?

What environmental, political, and social factors influence access to water?

Why does it matter how much water we use when the water cycle is consistently replenishing the water on our planet?

What are behavior changes to conserve water?

What can you and your family commit?

How can technology and engineering design contribute to water use efficiency?

ACTIVITY 3
Conduct a Home Water Audit

Explain to students that they will be conducting a water audit of where they live. Students will need some kind of home water audit kit. They may be able to make these materials themselves with items around the house, find materials online, or get them for free through their local water utility.

Order a Kit from [Cascade Water Alliance]() if you live in their service area.

The basic components of a home water audit kit include:

1 A way to measure gallons of water coming out of a faucet or shower per minute. You could use:
- An empty one-gallon plastic jug
- A one-quart measuring cup
- Ask your local water utility for a flow rate bag

2 A way to measure whether or not a toilet is leaking. You could use:
- A few drops of food coloring to put into the toilet tank
- Toilet leak detection dye strip

3 A water bill (if available)
[See Water Bill Examples]()

In Class Instructions

1. Hand out the [Student Home Water Conservation Audit Instructions and Worksheet]().
2. Walk students through all the different types of data they will be collecting.
3. Read the directions to students stopping to show them the different tools they will be using such as the dye stripes and the water flow rate bags.
4. At the end of class, hand out the water flow bags and dye stripes to students.
5. **Note:** for students who live in apartments, condos, subleased housing, public assistance housing, etc. a water bill may not be available. There is an option in the [Student Home Conservation Calculator]() to calculate approximate water use based on the number of people that reside where they live. To find that option, open the "Start Here" tab and click on the "Water Bill Not Available Calculate Water Use" button.

ACTIVITY 4
Class Debrief of the Home Water Audit

Project the conservation calculator on the screen so all students can see it. Hand out the Student Home Conservation Audit Analysis Worksheet. Walk the students through the conservation calculator showing them what data they will be entering.

Open the Conservation Calculator tool and use the "**Start Here**" tab.

From the "Start Here" tab go to the "**Water**" tab.

The information entered on the "**Water**" tab will automatically populate the "**Energy**" and "**CO2 Equivalent**" tabs.

Students will then enter their data into the calculator. The conservation calculator tool can be used by each individual student, a group of students, or by an entire classroom. This is up to the teacher's discretion.

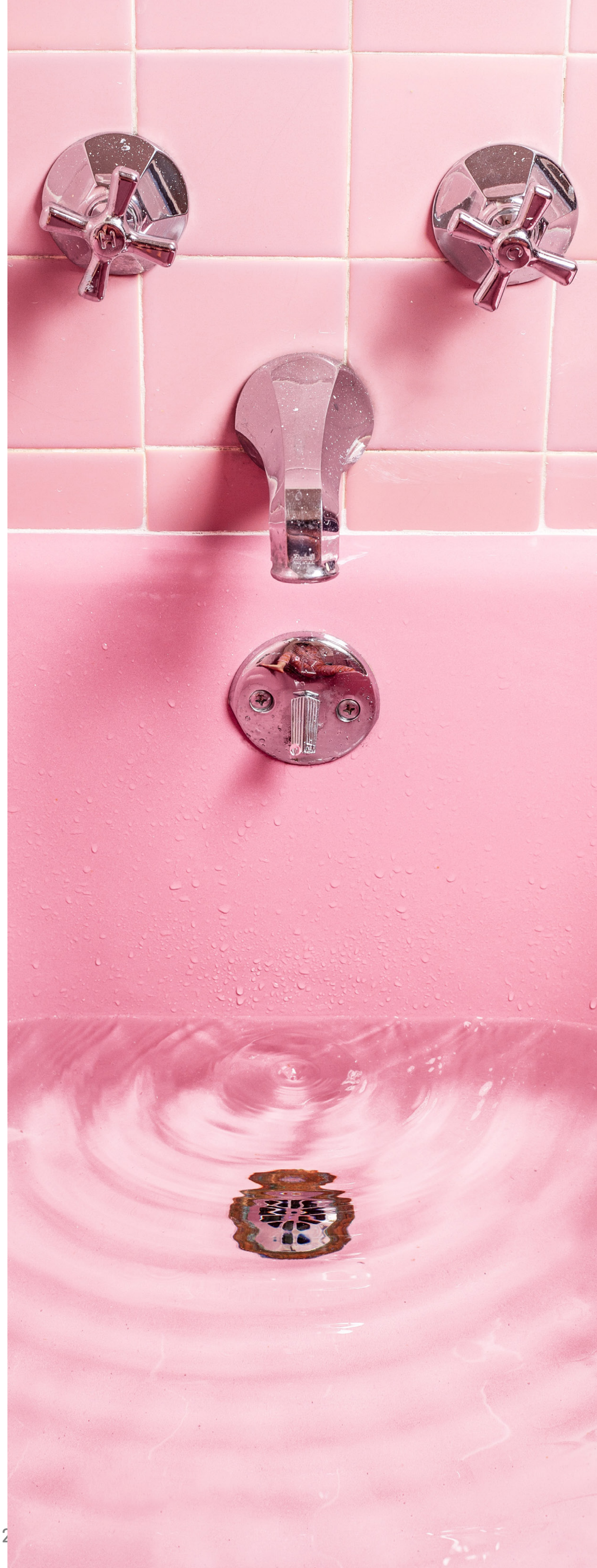
Students will take their data from the calculator and enter it on their Student Home Conservation Audit Analysis Worksheet. Students will then finish answering the questions on their worksheet which will help them analyze the data and reflect on what they found. Invite students to share their data and what they found for where they live.

Suggested Inquiries...

What was the greatest water saving potential where you live?

What were you the most surprised about?

What could you change to conserve water where you live?



ACTIVITY 5
How Much Do I Pay for Water?

Reading the Water Bill

Our local water utilities have two types of spending - operational and capital. As ratepayers we pay to cover these costs. The utilities generate funds for **capital improvements and maintenance** by charging us a little bit more on our water bills. It is the utilities' responsibility to maintain our water infrastructure so their capital investments absolutely **ensure clean, safe, reliable water supply**.

Our water bills tell us how much water we used and how much we are paying for it. But sometimes that information can be difficult to decipher on the bill.

There is a **water meter** near the street in front of where you live. The water district sends workers out to read those meters every other month. The information that is read off the water meter is used to generate the water bill.

Some utilities, like Sammamish Plateau Water have shifted to smart meters that make collecting water consumption rates more efficiently and timely.

See this great short video by student Rishi Hazra to learn how smart water meters can help you and the environment!

Practice using one or more sample water bills to help students identify key numbers that might be useful. Students can pair and share to flesh out their initial understanding of how to read a water bill.

What do you notice / wonder about your water bill?

What else can you learn from EPA's tips on Understanding Your Water Bill?

Converting Cubic Feet to Gallons

As a class, practice and then apply rates and conversions from cubic feet to gallons to answer the following questions:

How many gallons of water does your family use during the billing period?

How much are you paying per billing period?

How many billing periods in a year?

Does your water bill change with each season: fall, winter, spring, summer? If so, why? What is your prediction?

Students may see water use reported on their water bills in c**ubic feet (CF), hundred cubic feet (CCF), or gallons of water**. Encourage students to use the excellent web page provided by the Environmental Protection Agency (EPA) to visualize and convert CF or CCF to gallons of water.

So...How Much Does 1 Gallon of Water Cost?

Using bills from their residences or from these sample water bills or this digital example, calculate how much one gallon of water costs. This will help students quantify how things like leaks impact our collective water use and spending. Be sure students note the billing period in which their water consumption was measured. Is it one month or two months? All of this information can be recorded on the Student Home Water Conservation Audit Worksheet. All examples included are from a hypothetical water bill.

Water units are typically reported on your water bill in cubic feet (CF) or 100 cubic feet (CCF). One cubic foot is 7.48 gallons. 100 cubic feet is 748 gallons.

ONE: For a bill measured in CCF you would multiply (x CCF) x (748 gallons) to get the water use in gallons. 1 CCF = 748 gallons.
Example...

10 CCF x 748 gallons = **7,480 gallons**

TWO: Depending on the length of time your bill covers, you would divide the total gallons by the number of days in the billing period.
Example...

Divide 7,480 gallons by 60 days to determine the average use per day.
7,480 gallons /60 days = **124.7 gallons/day**

THREE: How many dollars per gallon?
Example...

Total cost from a water bill covering a 60 day billing period = $80.60
Cost per day $80.60/60 days = $1.34 per day
($1.34/day) / (124.7 gallons/day) = **$0.01/gallon**

Optional - Estimation skills

Create a classroom graph that estimates the following questions. Consider using post-its on a number line with a range of 10 gallons to 1,000 gallons.

How many gallons of water do I use in a day, week, month, or a year?

How many gallons of water does my family use?

How much does my family pay for a gallon of water?

What is the median for our classroom?

ACTIVITY 6
It's Not Always Obvious!

Toilets are often the **biggest culprit** of high water usage. Sometimes they continue flowing water because the flapper sticks, the chain is caught on something inside the tank, or parts are worn out inside the tank. Since the water flows down the sewer, leaking toilets don't necessarily leave any signs of a leak, ***until you get the bill***.

The average leaky toilet can waste about **200 gallons of water per day**. That's over 6,000 gallons a month for just one leaking toilet (Toilet Leaks). Some toilets may produce a running water sound that is easy to hear. Some leaks are visible as a small trickle running from the rim to the water in the bowl. Toilet leaks are often silent and can be intermittent, allowing loss of water to go undetected for long periods of time. See Video: How To Detect A Toilet Leak

Drips to Dollars

Drips Per Minute	Water Wasted Per Month	Water Wasted Per Year	Cost per Gallon from My Water bill	Drips to Dollars Per Year
10	43 Gallons	526 Gallons	$0.01	$5.50
30	130 Gallons	1,577 Gallons	$	$
60	259 Gallons	3,153 Gallons	$	$
120	518 Gallons	6,307 Gallons	$	$
300	1,296 Gallons	15,768 Gallons	$	$

Using the table above and your water bill math, fill in the fourth and fifth columns to calculate how much a leaky toilet, faucet, or irrigation system might cost you and your family per year. The data in the first three columns on the table came from this resource.

ACTIVITY 7

Water Equity Reflective Writing

Students are invited to reflect on the assumptions we make about access to clean water. It is a **privilege** that not all people share. Water access can be determined **geographically, financially, and racially**. There are more than "2 million Americans who live without basic access to safe drinking water and sanitation" (p. 12, Closing the Water Access Gap in the United States).

From the Navajo Nation in the Southwest to Puerto Rico and Texas, low-income people who live in **rural areas** along with **people of color, tribal communities, and immigrants** experience inequitable water access.

Invite students to reflect on one or more of the big ideas below in **writing, poetry, video or graphic design**. Encourage them to make connections to their local communities and find out what is being done to support **equitable water access**.

A good example of ensuring access to water in relation to COVID-19 can be found in this **case study** by the Water Equity Network on Bill Pay Assistance in Kentucky. (See the summary of strategies on page 7 of the Kentucky case study)

Also see this example of language used: Water Bill Assistance in Seattle

Some big ideas to explore

What is the money my family pays to the water utility used for?

What is my local water utility doing to update and ensure the longevity of water infrastructure?

Does everyone in my community have access to clean and safe water? How do I find out?

Who is responsible for making sure everyone can access clean and safe water?

How are people who struggle to pay their water bill supported by my water utility?

What kind of programs exist for water bill support?

What do you think your community can do to support people who can't pay for water? What are some alternatives to turning the water off if someone can't pay their bill?

ACTIVITY 8
Take Action to Conserve Water

See Foundation Lessons:
Impact Project Design
Engaging Stakeholders

While the usual brochure, poster, or research paper at the end of a unit is easy to grade for the teacher, it is the design of **meaningful and measurable Impact Projects** that awakens student voice and agency. The more relevance that students experience linking community needs to classroom learning, the more intrinsic their motivation for pursuing academic rigor.

Students can explore a range of water saving **Impact Project ideas** using these collections.

Direct Water Use Conservation Ideas

Indirect Water Use Conservation Ideas

Sample inquiries...

Which of the conservation ideas listed in these two collections are you already doing? Make a list and compare with others in your class. What are the total estimated benefits from the actions you are already taking; gallons saved, GHG emissions avoided, money saved?

Identify two to three actions that you are not currently doing but would be really easy to implement.

What are a few actions that would make a big difference if you could implement them?

Analyzing Existing Student Impact Projects

Engage students in analyzing a range of Impact Projects written by other students. Challenge them to scan 3-5 different Impact Projects to see what they find.

Analyze these MACRO Impact Projects

Water Footprint Campaigns for Classrooms and Clubs

Backyard Bites

Fleeing Fast Fashion

Replicate one or more of these easy action MICRO Impact Projects

My Dishwasher - Full Loads for our Future

My Washing Machine - Full Loads for our Future

Money Down the Drain

Recycling Saves Water Too

Hidden Toilet Leaks

Ask students to notice:

Which projects interest you the most?

Could you see yourself replicating or expanding on one or more of these Impact Projects?

As you compare a number of different types of Impact Projects, what do you notice about how they are all structured? What's the template or protocol that each of them follows? Write it out. Why is each element important to a successful project?

Invite students to **replicate** any one of the Impact Projects that interest them or develop one of their own using this template.

City and Utility Website Analysis

Encourage students to **analyze** city and utility web pages that provide information about drinking water quality and water conservation goals.

These sites typically provide a handy checklist for "***What You Can Do.***" Ask, "*How will my Impact Project align with these goals*?"

Contact Your Utility or City for Conservation Kits and Supplies

Cascade Water Alliance will help students in their water service area by providing efficient showerheads, efficient bathroom and kitchen aerators, as well as shower timers. Tally up the number of efficient low flow showerheads, efficient low flow bathroom and kitchen aerators, as well as shower timers students would like to order. Follow these instructions to contact Cascade Water Alliance.

If you are not in the Cascade District, research where your water comes from and reach out to the appropriate water utility to see if they offer free water conservation tools for households.

ACTIVITY 9
Stakeholder Engagement and Impact Storytelling

Take a moment to brainstorm a working definition for the concept of "stakeholder." Who has a stake in the issue or problem we are trying to solve?

Students reflect individually for 5 minutes on a range of possible stakeholders related to the impact project they are developing. After an initial reflection, encourage small group discussion to expand their thinking. Consider these prompts...

Am I a stakeholder on this issue?

What is my cultural, gender, racial, or economic lens on this issue?

Do I recognize my own bias?

Is it possible for me to relate to perspectives on this issue different from my own?

Which stakeholders are already working on this issue?

Are there stakeholders who have legal authority or responsibility to take action?

Are there stakeholders who have been left out of decision making?

What about other species or future generations who have no voice in this issue but are clearly impacted?

Invite students to use any one of the stakeholder Identification graphic organizers on page 12 of the Foundation Lesson: Engaging Stakeholders.

Revist the **Stakeholder Engagement Table earlier in this Unit**. Students may want to expand this table as they build out their knowledge of the roles and perspective of stakeholders relevant to their project, including how to influence them and the most effective approaches to do so.

Handy Email Templates

Requesting Info or Advice from a Stakeholder: Template

Reporting Impact to Stakeholders: Template

Empowering Student Voice through Impact Storytelling

A written report is only one way to communicate individual or classroom impact data. Invite students to explore this inspiring and practical set of Impact Storytelling Tips.

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About Sustainability Ambassadors

Sustainability Ambassadors is a professional development program for student leaders, teacher leaders and community leaders committed to rapidly advance a sustainable future by aligning classroom rigor with community relevance for real world impact.

We support a year-round training program for over 60 highly motivated youth, a paid Equity Advocacy Internship, a Green Jobs Youth Pathways Portal, and a Teacher Fellows Program, working with hundreds of educators to design new models of problem-based, place-based learning around a shared vision of ***educating for sustainability.***

We focus on middle school and high school youth, the teachers and school districts that guide their learning, and the community stakeholders, local government and business leaders who are relying on the next generation to be engaged voters, informed taxpayers, conscious consumers, and employees who can create and lead sustainability initiatives.

Visit: https://www.sustainabilityambassadors.org/