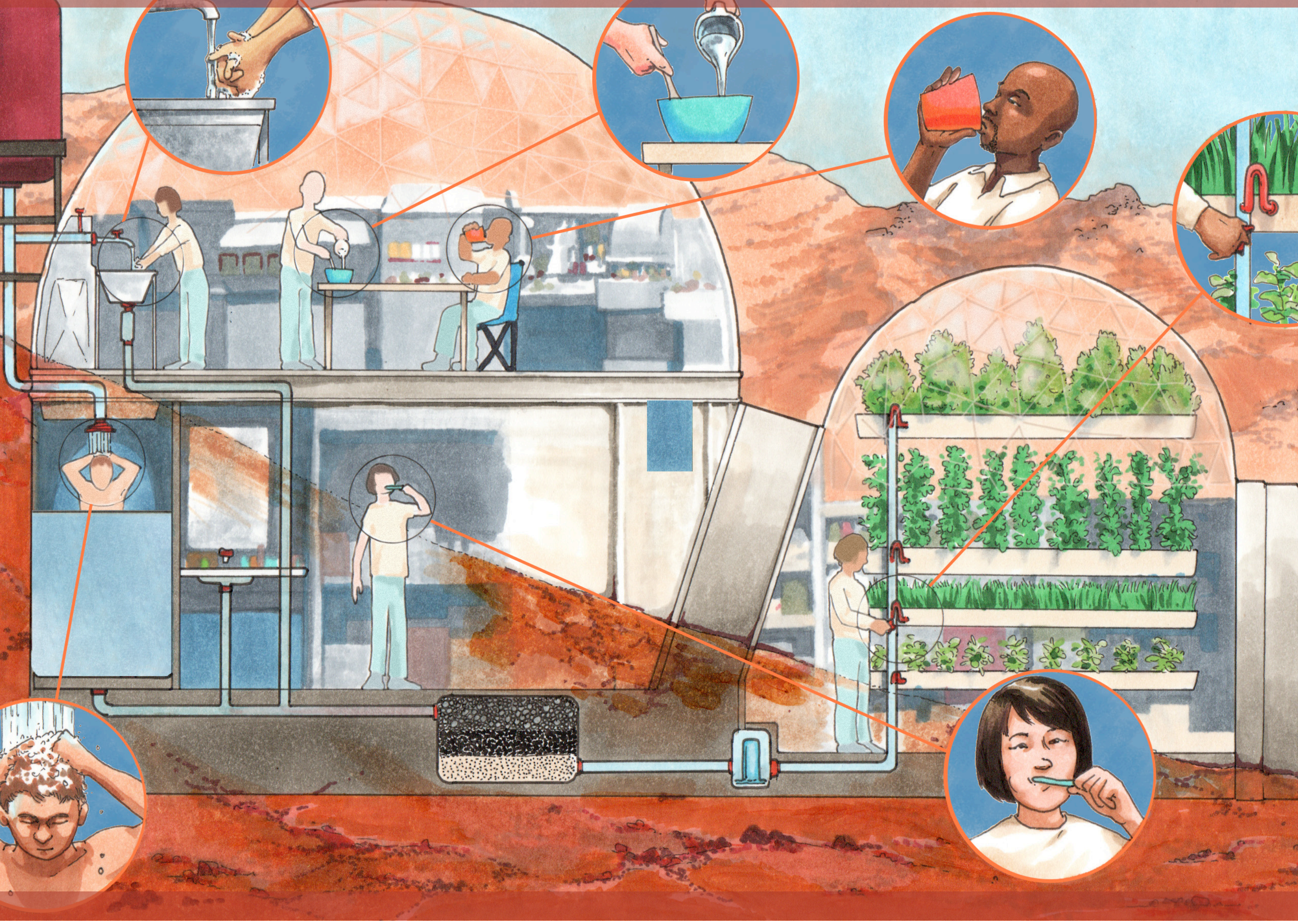
Engineering Everywhere™

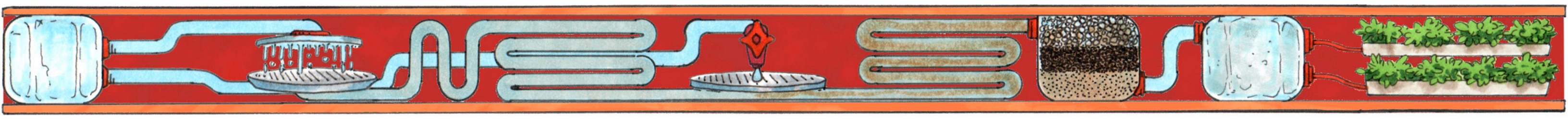
Testing the Waters: Engineering a Water Reuse Process

Water Resource Engineering for Out-of-School Time • Grades 6–8



Written by the Engineering is Elementary® Team
Illustrated by Ross Sullivan-Wiley and the Engineering is Elementary® Team

EiE Engineering is Elementary® | Engineering Everywhere™
Developed by the Museum of Science, Boston



Engineering is Elementary
Museum of Science
1 Science Park
Boston, MA 02114

Written by the Engineering is Elementary team:

Project Director:
Christine Cunningham

Curriculum Development:
Owen Berliner
Martha Davis
Marisa Garcia
Jordan Jozwik
Katherine Katzer
Katy Laguzza
Mary Eileen McDonnell
Natacha Meyer
Bekka Nolan
Kate Sokol

Operations:
Ian Burnette
Jonathan Hertel
Corey Niemann
Jack Payette
Leandra Rizzo

Research and Evaluation:
Christine Gentry
Cathy Lachapelle
Lauren Redosh
Christopher San Antonio-Tunis

Professional Development:
Chantal Balesdent
Kathryn Bartholomew
Shava Glater
Marlene Guay
Katy Hutchinson
Elissa Jordan
Nia Keith
Matthew Nelson
Nicole O'Neil
Karen Saur

Communications:
Hannah Erb
Amielle Major
Robin Staley
Annie Whitehouse

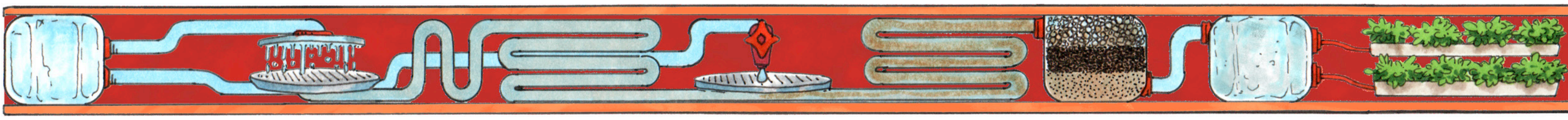
Sales and Customer Relations:
Kate Asquith
Judy Campbell
Cheryl Deese
Dianne Kelley
Jonathan Lobato
Sean McLaughlin
Elizabeth Mijal
Danielle Rodriguez
Cecilia So
Pete Sobel
Merrick Teti

Multimedia:
Alex Hennessy
Richard Sutton
Kathleen Young

Interns and Consultants:
Kristen Zarrelli

This material is based upon work supported by NASA under cooperative agreement award number NNX16AC53A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration (NASA).

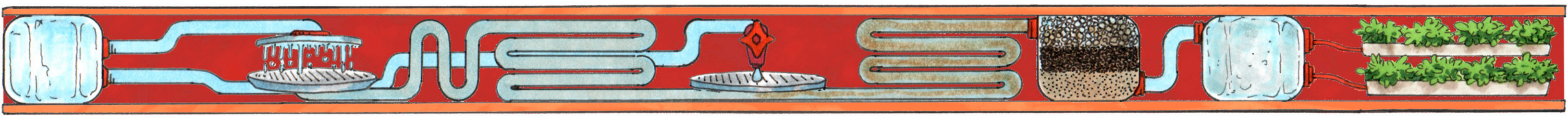
Engineering is Elementary
Developed by the Museum of Science, Boston



Pilot Sites for Testing the Waters:

This unit would not be possible without the valuable feedback from our pilot sites!

Bellesini Academy Lawrence, MA
Bethel Math and Science Jamaica Plain, MA
Blue Ridge Junior High School Lakeside, AZ
Boys & Girls Clubs of Boston, Jordan Club Chelsea, MA
Chaminade Julienne Catholic High School Dayton, OH
Coconino County Parks and Recreation Flagstaff, AZ
Fox Creek Junior High Bullhead City, AZ
Girls, Inc. of Lynn Lynn, MA
Knoles FACTS Flagstaff, AZ
Lawrence Catholic Academy Lawrence, MA
Mesa Public Schools, Summit Academy Chandler, AZ
Quabbin Regional School District Hubbardston, MA
Quality Life Center of Southwest Florida, Inc. Fort Myers, FL
Roosevelt Elementary School Port Angeles, WA
Sinagua Middle School Flagstaff, AZ
Spark of Knowledge Learning Center Fountain Valley, CA
St. Ann's Home and School Methuen, MA
The STAR School Flagstaff, AZ
Tennessee Valley 4-H Huntsville, AL
Tompkins Square Middle School New York, NY
Tuba City Junior High School Tuba City, AZ
Vermont Afterschool, Inc. Burlington, VT
Wayne Metro Community Action Agency Wyandotte, MI
YMCA Southcoast New Bedford, MA



PLANETS

Planetary Learning that Advances the Nexus of Engineering, Technology, and Science (*PLANETS*) is an interdisciplinary and cross-institutional partnership that integrates planetary science, education, technology, and engineering (NASA #NNX16AC53A).

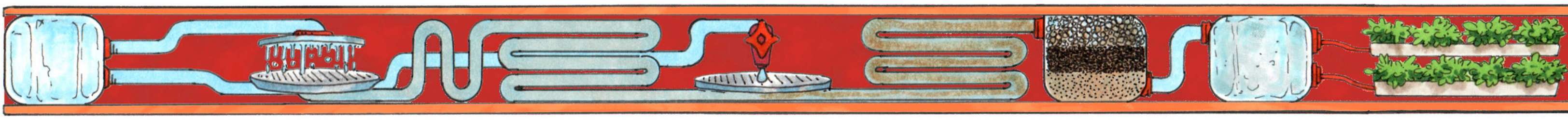
The Center for Science Teaching and Learning at Northern Arizona University (NAU), the U.S. Geological Survey (USGS) Astrogeology Science Center, and the Museum of Science, Boston have partnered to develop, pilot, and research the impact of three curriculum units and related professional development resources (http://planets-stem.org).

The purpose of *PLANETS* is to increase public awareness and use of NASA resources by highlighting the relationship between science, technology, engineering, and mathematics in the context of planetary science in out-of-school time settings.

<u>NAU Collaborators:</u>
Haylee Archer Graduate student
Nadine Barlow Professor, Department of Physics and Astronomy
Amy Beeler Undergraduate student
Mindy Bell Flagstaff STEM City
Christopher Benson Graduate student
Nena Bloom Evaluation Coordinator and Researcher
Joëlle Clark Principal Investigator
Vanessa Fitz-Kesler Professional Development Associate
Maegan Foltz Undergraduate student
Dane Henderson Graduate student
Elisabeth Roberts Evaluation Coordinator and Researcher
Lori Rubino-Hare Professional Development Coordinator
Sean Ryan Professional Development Associate
Brandon VanBibber Undergraduate student

<u>USGS Collaborators:</u>
Ryan Anderson Research Scientist
Tenielle Gaither Research Scientist
Moses Milazzo Research Scientist
Greg Vaughan Research Scientist
Lauren Edgar Research Scientist

<u>*PLANETS* Evaluation:</u>
Carol Haden Magnolia Consulting



Unit Map

Here is an overview of the activities in this unit and how they all fit together.

Prep Activity 1: What is Engineering?

Youth are introduced to the Engineering Design Process as they work together to engineer a tower to support a model water tank.

Prep Activity 2: What is Technology?

Youth will play a quiz game to define the word “technology” and learn that engineers design technologies to solve problems.

Activity 1: A Grey Area

Youth *investigate* how using water for various tasks can impact the water’s quality.

Activity 2: Investigating Filters

Youth *investigate* the properties of filter materials and create their own water filters to remove or treat contaminants from a water sample.

Activity 3: Order Up!

Youth apply what they learned about filters and water quality to re-pipe a model house to reuse as much water as possible.

Activity 4: Create a Process

Youth work in groups to *plan*, *create*, and *test* their water reuse processes designed for an extreme environment scenario.

Activity 5: Improve a Process

Youth work in groups to *improve* their water reuse process to better meet the criteria in their extreme environment.

Activity 6: Engineering Showcase

Youth *communicate* their ideas about designing a water reuse process in the Engineering Showcase.

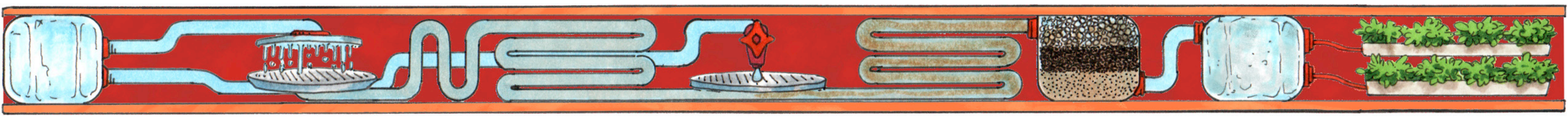
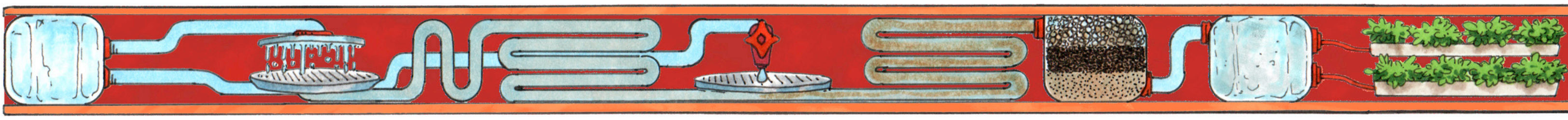


Table of Contents



About Engineering is Elementary

Engineering is Elementary® (EiE®) fosters engineering and technological literacy among children. Most humans spend over 95% of their time interacting with technology. Pencils, chairs, water filters, toothbrushes, cell phones, and buildings are all technologies—solutions designed by engineers to fulfill human needs or wants. To understand the world we live in, it is vital that we foster engineering and technological literacy among all people, even young children! Fortunately, children are born engineers. They are fascinated with building, taking things apart, and learning how things work. Engineering is Elementary harnesses children's natural curiosity to promote the learning of engineering and technology concepts.

The EiE program has four primary goals:

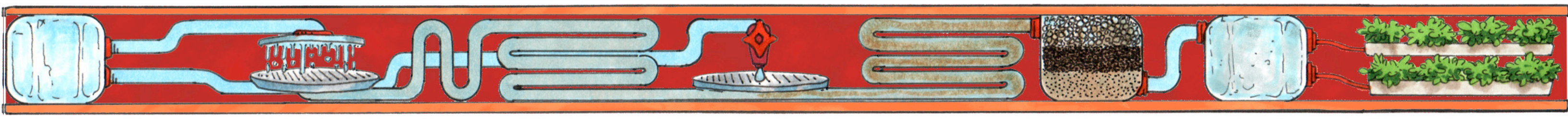
- Increase children's technological literacy.
- Increase educators' abilities to teach engineering and technology.
- Increase the number of schools and out-of-school time (OST) programs in the US that include engineering.
- Conduct research and assessment to further the first three goals and contribute knowledge about engineering teaching and learning.

The first product developed by the EiE program was the Engineering is Elementary curriculum series. Designed for use in elementary school classrooms, this curriculum is hands-on, research-based, standards-driven, and classroom-tested. For more information about EiE, visit: www.eie.org.

In 2011, EiE began development of Engineering Adventures® (EA®), a curriculum created for 3rd–5th grade children in OST environments. EA is designed to provide engaging and thought-provoking challenges appropriate for the OST setting. More information about EA can be found online at: www.engineeringadventures.org.

In 2012, the Engineering Everywhere™ (EE™) curriculum was created. EE is designed to empower middle school-aged children in OST settings to become engineers and solve problems that are personally meaningful and globally relevant. For more information, visit: www.engineeringeverywhere.org.

Engineering is Elementary is a part of The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston. The NCTL aims to enhance knowledge of technology and inspire the next generation of engineers, inventors, and innovators. Unique in recognizing that a 21st century curriculum must include today's human-made world, the NCTL's goal is to introduce engineering as early as elementary school and continue through high school, college, and beyond. For more information, visit: www.nctl.org.



About Engineering Everywhere

The mission of Engineering Everywhere is to create engaging out-of-school time learning experiences for 6th–8th graders that positively impact youth's attitudes about their abilities to engineer. Our goal is to provide youth with personally meaningful and globally relevant challenges that empower them to problem solve, think creatively, and learn from one another.

The main ideas that guide the developers of EE are listed below.

We believe youth will best learn engineering when they:

- engage in activities that are fun, exciting, and connect to the world in which they live.
- choose their path through open-ended challenges that have multiple solutions.
- have the opportunity to succeed in engineering challenges.
- communicate and collaborate in innovative, active problem solving.

Through EE units, youth will learn that:

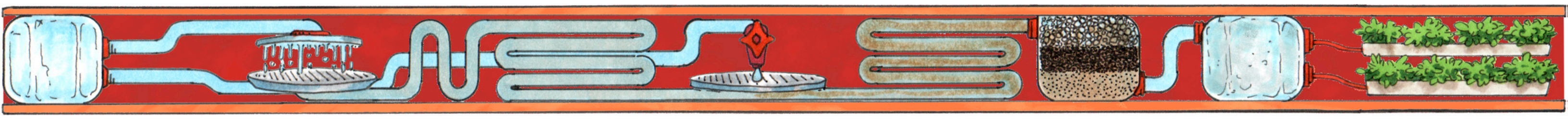
- they can use the Engineering Design Process to help solve problems.
- engineers design technologies to help people and solve problems.
- they have the talent and potential to design and improve technologies.
- they, too, are engineers.

As youth work through their engineering design challenges, they will have the opportunity to build their problem solving, teamwork, communication, and creative thinking skills. Most importantly, this curriculum is designed to provide a fun learning opportunity!

Unit Goals

In this unit, youth will be introduced to engineering and the eight-step Engineering Design Process as they work together to design a solution to an engineering challenge. Youth will explore the problem of water scarcity and learn how to evaluate water quality and *improve* it by creating filters. Then, they will engineer a process for reusing water that makes it safe and clean enough for people to use in a variety of extreme environments.

By the end of the unit, youth will be ready to present what they learned about water resource engineering, water quality, and the Engineering Design Process by sharing the water reuse processes that they have engineered.



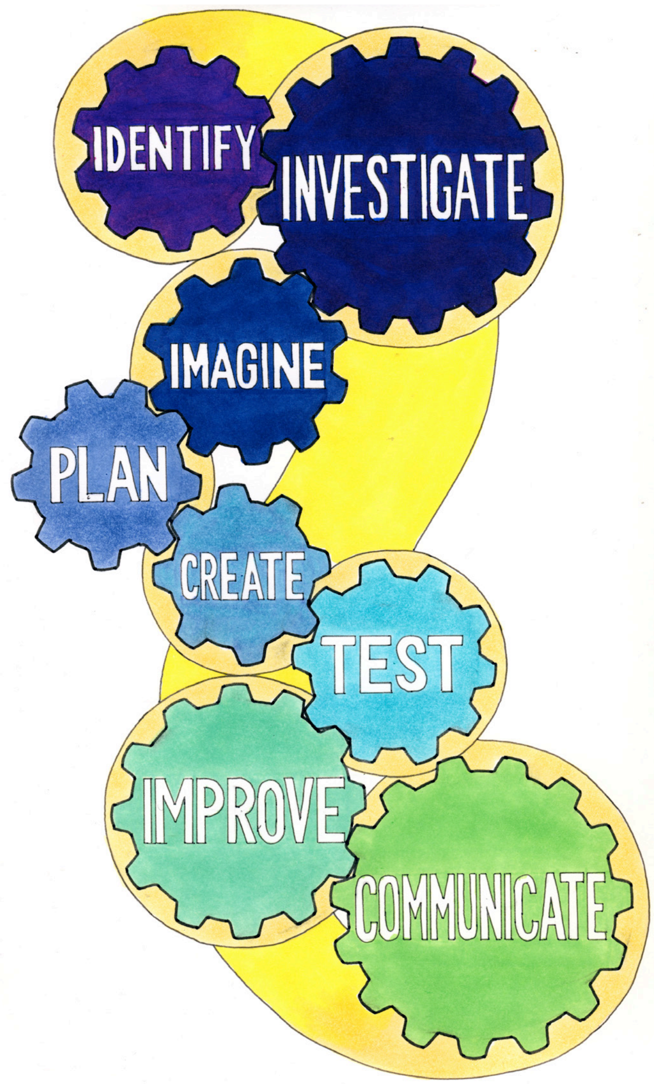
The Engineering Design Process

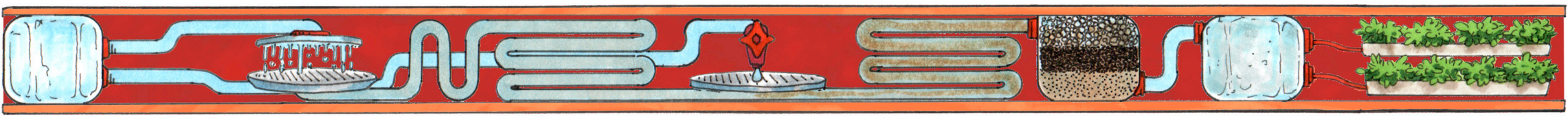
The Engineering Everywhere Engineering Design Process (EDP) is the backbone of each Engineering Everywhere (EE) unit. It is an eight-step process that guides youth in solving engineering challenges. Our goal for each EE unit is for youth to understand that the EDP can help them solve problems not only in engineering, but also in other areas of their lives.

While there are many versions of the EDP used in academic and professional fields of engineering, we developed an eight-step process that builds on the five-step process used in our elementary curriculum. There are guiding questions throughout the activities for the educator to ask to promote discussion about the EDP. There are also sections in the Engineering Notebook to encourage youth to engage in the process.

The EDP begins with *identifying* a problem that needs to be solved and *investigating* what has already been done. Next, engineers *imagine* different solutions and *plan* their designs. Then, they *create* and *test* their designs and make *improvements* based on the test results. Finally, engineers *communicate* their findings to others. While the process is shown as linear, youth may jump around to different steps as they are engineering. For example, they may need to *imagine* and *plan* new designs in order to *improve*.

To further highlight the EDP throughout the unit, the steps are italicized in this guide. Youth are also provided with an explanation of each step, which can be seen in their Engineering Notebooks. The EDP used in EE units is illustrated to the right.

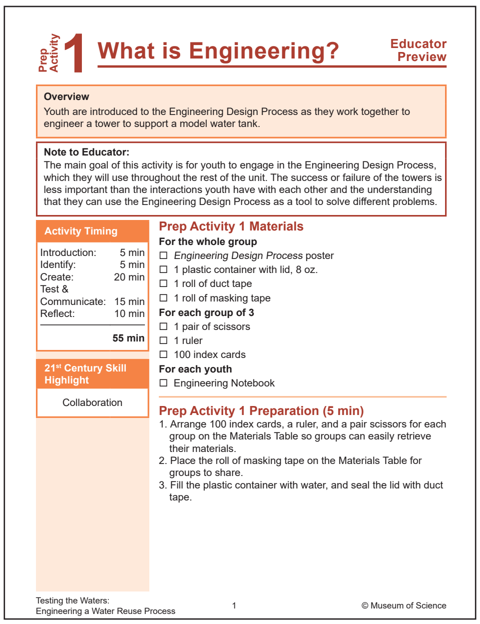




Educator Guide Components

An **Educator Preview** with background information, activity timing, key concepts, materials lists, and preparation.

An **Activity Guide** with step-by-step instructions, including discussion questions, extension ideas, and tips.



Prep Activity 1 What is Engineering? Educator Preview

Overview
Youth are introduced to the Engineering Design Process as they work together to engineer a tower to support a model water tank.

Note to Educator:
The main goal of this activity is for youth to engage in the Engineering Design Process, which they will use throughout the rest of the unit. The success or failure of the towers is less important than the interactions youth have with each other and the understanding that they can use the Engineering Design Process as a tool to solve different problems.

Activity Timing

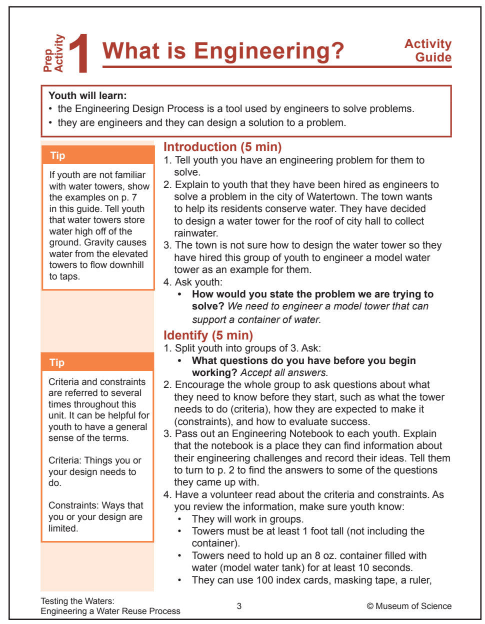
Introduction:	5 min
Identify:	5 min
Create:	20 min
Test & Communicate:	15 min
Reflect:	10 min
	55 min

21st Century Skill Highlight
Collaboration

Prep Activity 1 Materials
For the whole group
☐ *Engineering Design Process* poster
☐ 1 plastic container with lid, 8 oz.
☐ 1 roll of duct tape
☐ 1 roll of masking tape
For each group of 3
☐ 1 pair of scissors
☐ 1 ruler
☐ 100 index cards
For each youth
☐ Engineering Notebook

Prep Activity 1 Preparation (5 min)
1. Arrange 100 index cards, a ruler, and a pair scissors for each group on the Materials Table so groups can easily retrieve their materials.
2. Place the roll of masking tape on the Materials Table for groups to share.
3. Fill the plastic container with water, and seal the lid with duct tape.

Testing the Waters: Engineering a Water Reuse Process 1 © Museum of Science



Prep Activity 1 What is Engineering? Activity Guide

Youth will learn:
- the Engineering Design Process is a tool used by engineers to solve problems.
- they are engineers and they can design a solution to a problem.

Tip
If youth are not familiar with water towers, show the examples on p. 7 in this guide. Tell youth that water towers store water high off of the ground. Gravity causes water from the elevated towers to flow downhill to taps.

Tip
Criteria and constraints are referred to several times throughout this unit. It can be helpful for youth to have a general sense of the terms.

Criteria: Things you or your design needs to do.

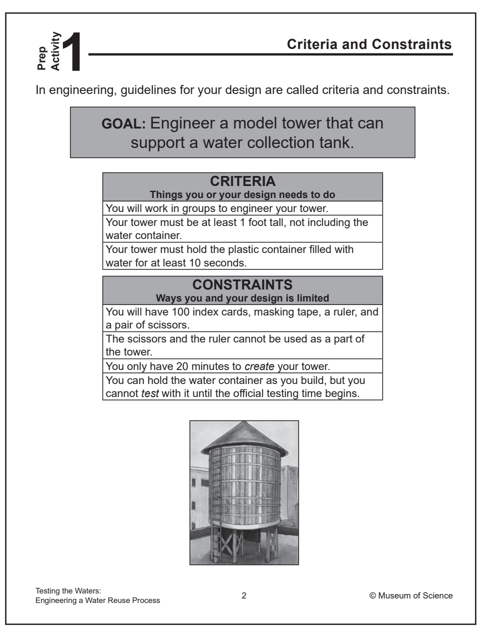
Constraints: Ways that you or your design are limited.

Introduction (5 min)
1. Tell youth you have an engineering problem for them to solve.
2. Explain to youth that they have been hired as engineers to solve a problem in the city of Watertown. The town wants to help its residents conserve water. They have decided to design a water tower for the roof of city hall to collect rainwater.
3. The town is not sure how to design the water tower so they have hired this group of youth to engineer a model water tower as an example for them.
4. Ask youth:
   - **How would you state the problem we are trying to solve?** *We need to engineer a model tower that can support a container of water.*

Identify (5 min)
1. Split youth into groups of 3. Ask:
   - **What questions do you have before you begin working?** *Accept all answers.*
2. Encourage the whole group to ask questions about what they need to know before they start, such as what the tower needs to do (criteria), how they are expected to make it (constraints), and how to evaluate success.
3. Pass out an Engineering Notebook to each youth. Explain that the notebook is a place they can find information about their engineering challenges and record their ideas. Tell them to turn to p. 2 to find the answers to some of the questions they came up with.
4. Have a volunteer read about the criteria and constraints. As you review the information, make sure youth know:
   - They will work in groups.
   - Towers must be at least 1 foot tall (not including the container).
   - Towers need to hold up an 8 oz. container filled with water (model water tank) for at least 10 seconds.
   - They can use 100 index cards, masking tape, a ruler,

Testing the Waters: Engineering a Water Reuse Process 3 © Museum of Science

Engineering Notebook pages that allow youth to record their findings and reflect on their learning.



Prep Activity 1 Criteria and Constraints

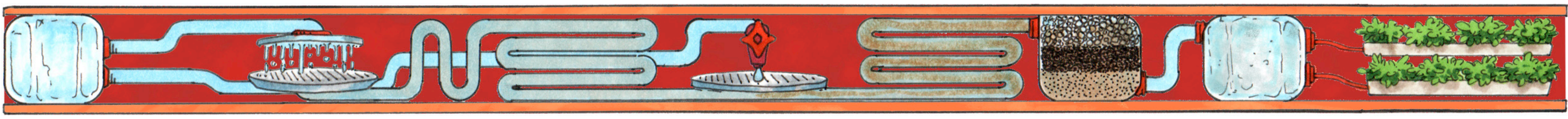
In engineering, guidelines for your design are called criteria and constraints.

GOAL: Engineer a model tower that can support a water collection tank.

CRITERIA Things you or your design needs to do
You will work in groups to engineer your tower.
Your tower must be at least 1 foot tall, not including the water container.
Your tower must hold the plastic container filled with water for at least 10 seconds.

CONSTRAINTS Ways you and your design is limited
You will have 100 index cards, masking tape, a ruler, and a pair of scissors.
The scissors and the ruler cannot be used as a part of the tower.
You only have 20 minutes to *create* your tower.
You can hold the water container as you build, but you cannot *test* with it until the official testing time begins.

Testing the Waters: Engineering a Water Reuse Process 2 © Museum of Science



What You Need to Know Before Teaching an EE Unit

Engineering is Fun

The EE team hears this from many OST educators and youth. Engineering is a way of problem solving—a way of thinking about the world—that is very fun and creative. Any time you need to solve a problem in order to reach a goal, you are engineering.

There are No Right or Wrong Answers

There are often many great ways to solve the same problem. Not only is this a good engineering lesson, it is a good life lesson for the youth in your program.

You are a Guide

As the educator, it is your role to guide youth through these activities by encouraging them to pursue and communicate their own ideas, even if you think they might not work. Every problem has many possible solutions and multiple ways to reach them.

Ask Questions

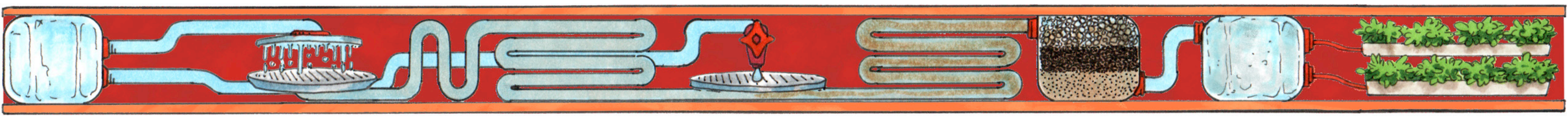
Throughout the activities, you can ask questions prompting youth to share their prior knowledge, predict what they might find, or remind them of criteria that will help them as they engineer. Asking questions like these sets your youth up to succeed and feel confident in their ability to engineer.

It is Okay to Try It Out

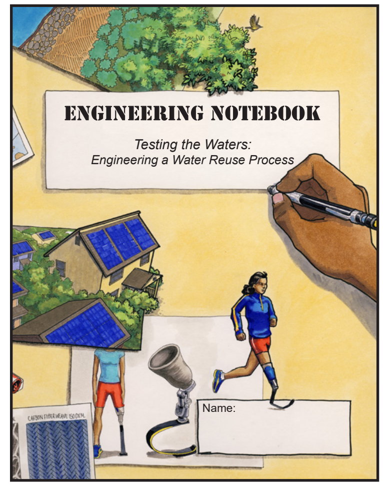
It can be very helpful to try out the engineering challenge yourself—either beforehand or right alongside the youth in your program as they work through the activities. This can help you understand the challenges they might face.

Support Reflection

Each activity includes 5-10 minutes at the end for youth to communicate with their peers by sharing their work. This gives youth the chance to discuss new ideas, think about their own work and the work of others, and reflect on what was learned. Group reflection can help reduce competition by encouraging youth to support each other as they move through the Engineering Design Process.



Engineering Notebooks



Make a copy of the Engineering Notebook for each youth before you begin working through this Engineering Everywhere unit. Youth will use them as directed in the Educator Guide during every activity.

The Engineering Notebook serves as a central location for youth to record their thoughts and ideas as they move through the unit. Its pages guide youth through the Engineering Design Process, pose questions, and prompt youth to reflect on their engineering work. The time youth spend with their Notebooks during each activity will allow them to create a personalized record of their engineering learning.

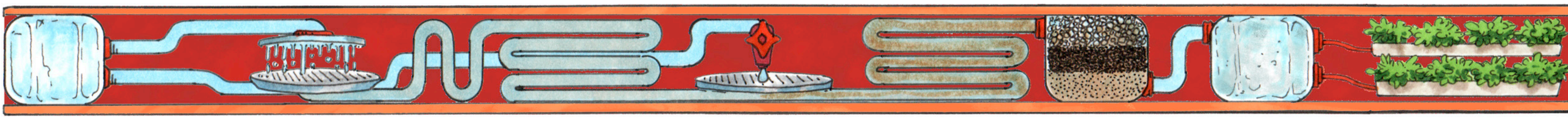
There are a few ways you can use the Engineering Notebook. You may want to have groups share one Engineering Notebook as a central recording spot for all group data and findings. This allows group members who enjoy writing and recording to do so. You may also encourage groups to share the responsibility by having group members rotate who records.

Alternate Prep Activities

The two prep activities, “What is Engineering?” and “What is Technology?” introduce youth to engineering and technology. “What is Engineering?” gives youth the chance to collaborate, experience a mini hands-on engineering challenge, share their designs, and learn about the Engineering Design Process. This activity sets the stage for what they can expect in the rest of the unit.

“What is Technology?” has youth interact with technologies, working with the definition that a technology is any thing or process designed by humans to help solve a problem. Most youth think of technology as things that can be plugged into the wall. They do not realize that the items that they interact with every day—including pencils, paper, and water bottles—are also technologies. This activity introduces the definition of technology that they will refer to as they engineer their own technologies to solve the problem presented in the unit.

While the prep activities for Engineering Everywhere are unit-specific, there are alternate prep activities you can use if you would like to reinforce the concepts and vocabulary related to these activities. You can find the alternate activities online at www.engineeringeverywhere.org. If you have questions about these activities, please email engineeringeverywhere@mos.org.



Tips and Tricks for Teaching the Unit

Post a Daily Agenda

Giving youth a sense of the day's activity will help them to plan ahead and manage their time.

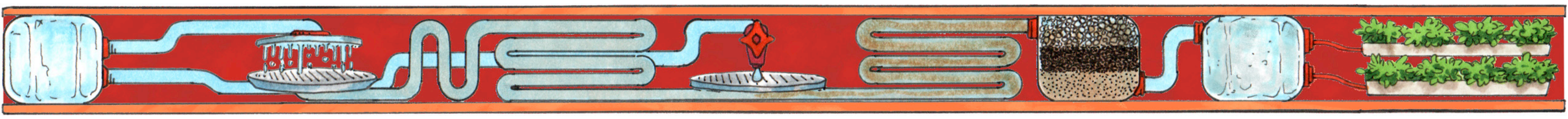
Facilitate Teamwork

Being able to work well in teams is an important skill for any engineer. You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the note taker, the materials gatherer, the tester, and the presenter.

This unit requires a collaborative workspace. Tables, desks, and chairs should be movable. It is a good idea to establish a materials table where you can set up materials for the day. Then, groups can be in charge of gathering their own materials when they are ready.

Invite Others to the Engineering Showcase

The Engineering Showcase, the last activity in the unit, is a big deal! This is a chance for youth to highlight the engineering they have done and share their accomplishments with others. Consider inviting families, program staff, and other youth to come to the Showcase.

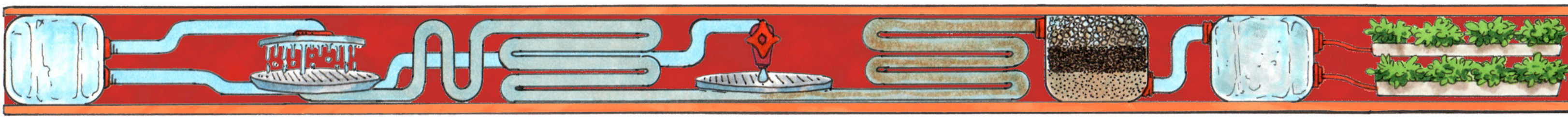


Scheduling the Activities

Each activity requires 50-60 minutes of teaching time. We recommend that you budget at least 8-9 hours in order to complete this unit, as some activities may run longer than expected.

You can schedule this unit in several ways: once a week, several times a week, or daily. It is also possible to group certain activities together. The chart below shows which activities are easily taught together. Use this chart to help you plan your schedule.

Prep Activity 1: What is Engineering? Prep Activity 2: What is Technology?	2 hours
Activity 1: A Grey Area Activity 2: Investigating Filters	2-3 hours
Activity 3: Order Up!	1 hour
Activity 4: Create a Process Activity 5: Improve a Process	2-3 hours
Activity 6: Engineering Showcase	1-2 hours



Background

Process Engineering

Process engineering is a way of thinking and designing that can be applied to problems in many different fields of engineering. A process is any series of steps designed to meet a goal. Process engineers work to optimize and improve processes so they are efficient and result in high-quality products. Process engineering can be a tough area to introduce to youth because the resulting products are less tangible than those in other fields of engineering. A process engineering challenge might involve engineering the steps of an assembly line or directions for creating a product. In this unit, youth will tackle process engineering by creating a step-by-step process to increase the amount of water that can be reused by ordering the flow of water through filters.

Water Resource Engineering

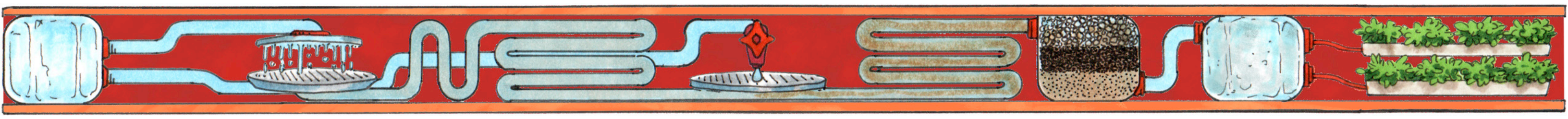
Water resource engineering focuses on the design of systems and equipment, including water treatment facilities, to ensure that people are provided with clean water for drinking, living, and recreation. UNICEF estimates that one in nine people do not have access to safe and clean drinking water. Factors such as environmental pollution and drought conditions threaten the availability of clean, drinkable water for future generations. Access to drinkable water is not just a problem here on Earth—it is one of the biggest challenges facing planetary explorers, who must recycle as much water as possible to stay hydrated on long missions. To do this, they utilize water filtration systems that purify contaminated water to produce drinkable pure water.

Pure water is water that is clean and safe for people to drink. It contains no contaminants introduced by humans, such as pathogens, metals, or harmful microbes.

Greywater is water produced from sources that do not contain fecal contamination. Throughout this unit, greywater is defined as water that has been used at least once and can be used again. Examples of greywater sources include washing machines, dishwashers, and sinks. Until recently, greywater was only deemed safe for uses like irrigation, but advances in water purification technology have made it possible for greywater to be purified to potable (drinkable) standards. These new technologies are being used around the world, from Singapore to California, and in space by scientists aboard the International Space Station.

Online Resources

The *PLANETS* website (http://planets-stem.org) supports both educators and youth through science extension exercises, educator support materials, and youth content enhancements. Science extension exercises are intended to integrate and apply planetary science concepts with the engineering unit. The educator support materials include immediate management tips and provide additional resources for meeting the unique needs of youth in out-of-school time settings. Be sure to check out these videos, infographics, and connections to other NASA resources!



Vocabulary

Constraints: Ways that your design is limited.

Contaminant: A substance that makes water dirty or unsafe to drink.

Criteria: Things your design needs to do.

Engineering Design Process: The steps that engineers use to design technologies to solve a problem.

Extreme environment: A place where it is difficult for people to survive.

Greywater: Water that has been used at least once and can be used again.

Process: A series of steps completed in a certain order to solve a problem.

Pure water: Water that is clean and safe enough to drink.

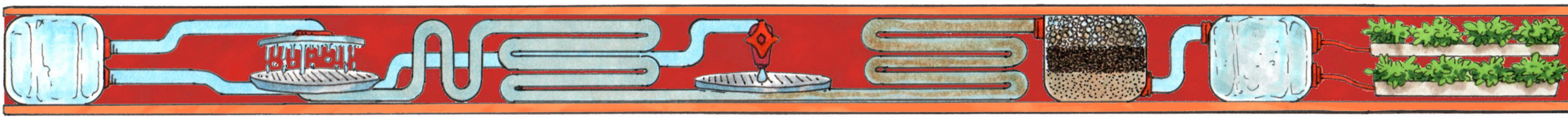
Technology: Any thing or process designed by people to solve a problem.

Waste water: Water that is too dirty to be used again.

Water quality: The characteristics that let us know if water is safe to use.

Water resource engineer: Someone who uses his or her creativity and knowledge of math and science to design technologies that solve problems related to providing people with access to clean and safe water.

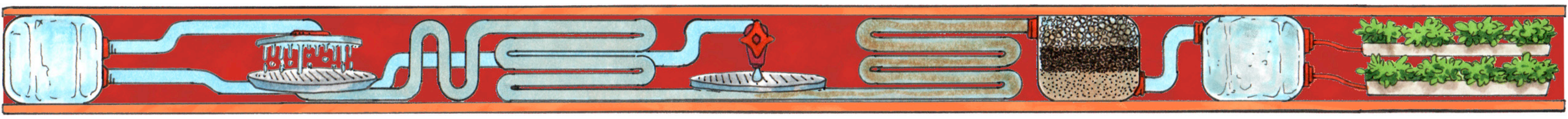
Water scarcity: When people do not have enough water to complete all the tasks they need to live.



Materials List

This kit is prepared for 8 groups of 3.

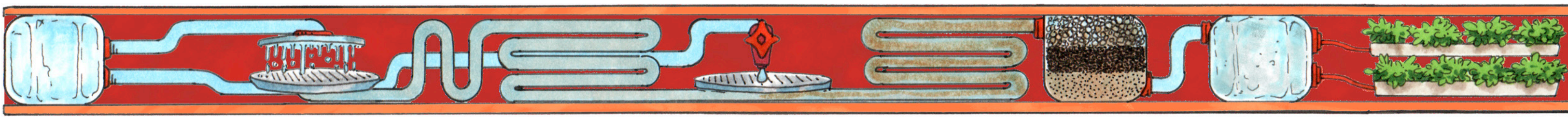
Quantity	Item
Non-Consumable Items	
1	*Engineering Design Process* poster
1	*Engineering Everywhere Special Report* video
1	*Technology Trivia* PowerPoint file
1	measuring cup, 1/4 cup
1	measuring cup, 1 cup
1	container with lid, clear plastic, 8 oz.
1	strainer
4	tablespoons
4	teaspoons
8	jars with lids, clear, 1/2 gallon
8	rulers
8 pairs	scissors
8	trays, foil, 12” x 12”
Consumable Items	
1/4 cup	detergent, powder
1 vial	food coloring, yellow
1 bottle	soap
1 cup	soil
1 cup	vinegar, white
1 roll	tape, duct
1 roll	tape, masking
1 spool	thread
1 tube	toothpaste, travel size
2 packages	modeling clay, 1 lb.
4 cups	charcoal, activated
4 cups	limestone gravel
4 rolls	tape, painter’s
5 sheets	cardstock
6 cups	sand
6	tea bags, black tea
8	markers, black, permanent
8 packets	pH strips



Materials List (continued)

Quantity	Item
Consumable Items	
32	craft sticks
37 pieces	*cheesecloth, 12” x 12”
40	rubber bands
40	straws, jumbo, color 1
40	straws, jumbo, color 2
40	straws, jumbo, color 3
60 sheets	copy paper
120	cups, plastic, clear, 8 oz.
150	cotton balls
800	index cards, 3” x 5”
NOT INCLUDED IN KIT	
1	chart paper and markers
1	computer and projector
1 roll	plastic wrap (optional)
1 pad	sticky notes (optional)
1	utility knife
2 rolls	paper towels, half-sheet perforations
8	buzzers (optional)
16	bottles, 2-liter (caps not needed)
18	sheet protectors (optional)
24	Engineering Notebooks

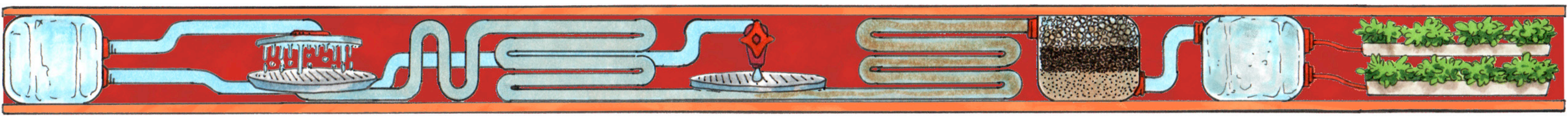
* Youth use cheesecloth in their water filter technologies in Activities 2, 4, and 5. Consider cutting squares (12” x 12”) in advance.



National Education Standards

Engineering Everywhere units are written with the goal of teaching engineering skills and critical thinking practices. Many Engineering Everywhere units also touch upon a variety of science topics and principles. The engineering standards taught in this unit and the science topic links in this unit are noted below.

		Prep Activity 1: What is Engineering?	Prep Activity 2: What is Technology?	Activity 1: A Grey Area	Activity 2: Investigating Filters	Activity 3: Order Up!	Activity 4: Create a Process	Activity 5: Improve a Process	Activity 6: Engineering Showcase
National Science Education Standards	Science as Inquiry	✓		✓	✓	✓	✓	✓	✓
	Physical Science								
	Life Science								
	Earth and Space Science			✓			✓	✓	✓
	Science and Technology		✓	✓	✓	✓	✓	✓	✓
	Science in Personal and Social Perspectives		✓	✓	✓	✓	✓	✓	✓
	History and Nature of Science								
ITEEA	The Nature of Technology	✓	✓	✓	✓	✓	✓	✓	✓
	Technology and Society		✓						
	Design	✓	✓		✓	✓	✓	✓	✓
	Abilities for a Technological World	✓	✓		✓	✓	✓	✓	✓
	The Designed World		✓						



		Prep Activity 1: What is Engineering?	Prep Activity 2: What is Technology?	Activity 1: A Grey Area	Activity 2: Investigating Filters	Activity 3: Order Up!	Activity 4: Create a Process	Activity 5: Improve a Process	Activity 6: Engineering Showcase
Next Generation Science Standards	MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.			✓	✓	✓	✓	✓	✓
	MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	✓				✓	✓	✓	✓
	MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	✓				✓	✓	✓	✓
	MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	✓				✓	✓	✓	✓
	MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	✓		✓	✓		✓	✓	✓

How to Recognize Success Rubric

How do you know if you are leading these activities successfully? This tool will help you keep track of your youth's successful moments and will ask you to identify how your own actions enabled youth to succeed.

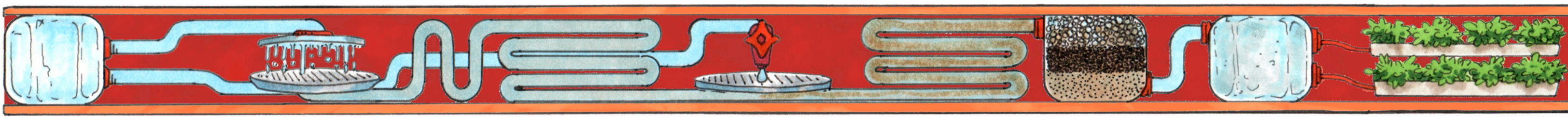
Elements of success	What does this look like?	How does the guide help me facilitate this?
Youth are engaged and challenged by the activity. They persist through difficulties.	• Youth are on-task. • Youth are trying out their ideas. • Youth *identify* what is working well in their designs. • Youth troubleshoot their own work. • Youth *improve* their designs.	• Use the bold prompts to **ask open-ended questions** to help youth troubleshoot their work. • Use the bold prompts to **ask youth about what they think is working well** in their designs and what they would like to improve. This will help youth feel more confident about their problem-solving abilities.
Youth do most of the talking, sharing their ideas with each other during the entire activity.	• Youth bring their own ideas to the activity and are comfortable sharing them. • Youth brainstorm and debate within their groups. • Youth share their designs with others. • Youth talk about how their ideas are changing over time.	• Use the bold prompts in the guide to **encourage youth to share and explain their thinking**. • Have youth **collaborate in groups** so they can brainstorm and *create* a design together. • Use the bold prompts in the Reflect section to **help youth share their new ideas about designs.**
Youth value their engineering work as a process, not just as the end result.	• Youth go beyond talking about their design to talking about how they thought of it and why they designed it. • Youth use the Engineering Design Process to describe their actions.	• Use the bold prompts in the guide to **ask youth how they use the Engineering Design Process.** Spending time talking and thinking about their process will help youth see the value in it. • Use the bold prompts to **ask all youth about *improving*** their designs, even if their designs are working well. • **Encourage youth to reflect individually** in their Engineering Notebooks to give them time for their experiences to sink in and be remembered.

How to Recognize Success Rubric Template

How do you know if you are leading these activities successfully? This tool will help you keep track of your youth's successful moments and will ask you to identify how your own actions enabled youth to succeed.

Date: Activity:

Elements of success	Evidence: Where did I see this during the activity?	What was my role in making this happen?
Youth are engaged and challenged by the activity. They persist through difficulties.		
Youth do most of the talking, sharing their ideas with each other during the entire activity.		
Youth value their engineering work as a process, not just as the end result.		



Dear Family, Date: ________________

We are beginning an engineering unit called *Testing the Waters: Engineering a Water Reuse Process,* a curriculum developed by the Engineering is Elementary program at the Museum of Science, Boston. This week, your child will be introduced to water resource engineering and the Engineering Design Process as the group works together to engineer a solution to an engineering challenge. This unit is set in a real-world context: throughout the unit, your child will explore water quality, investigate filter materials, and work with teammates to create a process for reusing water in extreme environments. There are many reasons to introduce children in grades 6–8 to engineering:

- **Engineering projects reinforce topics children are learning in school.** Engaging students in hands-on, real-world engineering experiences can enliven math, science, and other content areas.
- **Engineering fosters problem-solving skills,** including problem formulation, creativity, planning, and testing alternative solutions.
- **Children are fascinated with building and with taking things apart to see how they work.** By encouraging these explorations, we can keep these interests alive. Describing their activities as "engineering" when children are engaged in the natural design process can help them develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

If you have expertise in water resource engineering, water reuse, or have any general questions or comments about the engineering unit we are about to begin, please let me know.

Sincerely,

If you have any of the following materials available and would like to donate them, I would greatly appreciate having them by the following date: ______________________ . Thank you!

____________________________ ____________________________

____________________________ ____________________________

____________________________ ____________________________

Prep Activity **1**

What is Engineering?

Educator Preview

Overview

Youth are introduced to the Engineering Design Process as they work together to engineer a tower to support a model water tank.

Note to Educator:
The main goal of this activity is for youth to engage in the Engineering Design Process, which they will use throughout the rest of the unit. The success or failure of the towers is less important than the interactions youth have with each other and the understanding that they can use the Engineering Design Process as a tool to solve different problems.

Activity Timing

Introduction:	5 min
Identify:	5 min
Create:	20 min
Test & Communicate:	15 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Collaboration

Prep Activity 1 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ 1 cup of water
- ☐ 1 plastic container with lid, 8 oz.
- ☐ 1 roll of duct tape
- ☐ 1 roll of masking tape

For each group of 3

- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ 100 index cards

For each youth

- ☐ Engineering Notebook

Prep Activity 1 Preparation (5 min)

1. Arrange 100 index cards, a ruler, and a pair of scissors for each group on the Materials Table so groups can easily retrieve their materials.
2. Place the roll of masking tape on the Materials Table for groups to share.
3. Fill the plastic container with water and seal the lid with duct tape.

Notebook Pages for Prep Activity 1

Criteria and Constraints, p. 2

Prep Activity **1** — **Criteria and Constraints**

In engineering, guidelines for your design are called criteria and constraints.

GOAL: Engineer a model tower that can support a water collection tank.

CRITERIA Things you or your design needs to do
You will work in groups to engineer your tower.
Your tower must be at least 1 foot tall, not including the water container.
Your tower must hold the plastic container filled with water for at least 10 seconds.

CONSTRAINTS Ways you and your design is limited
You will have 100 index cards, masking tape, a ruler, and a pair of scissors.
The scissors and the ruler cannot be used as a part of the tower.
You only have 20 minutes to *create* your tower.
You can hold the water container as you build, but you cannot *test* with it until the official testing time begins.

Testing the Waters:
Engineering a Water Reuse Process — 2 — © Museum of Science

Prep Activity **1**

What is Engineering?

Activity Guide

Youth will learn:
- The Engineering Design Process is a tool used by engineers to solve problems.
- They are engineers and they can design a solution to a problem.

Tip

If youth are not familiar with water towers, show the examples on p. 7 in this guide. Tell youth that water towers store water high off of the ground. Gravity causes water from the elevated towers to flow downhill to taps.

Tip

Criteria and constraints are referred to several times throughout this unit. It can be helpful for youth to have a general sense of the terms.

Criteria: Things you or your design needs to do.

Constraints: Ways that you or your design are limited.

Introduction (5 min)

1. Tell youth you have an engineering problem for them to solve.
2. Explain to youth that they have been hired as engineers to solve a problem in the city of Watertown. The town wants to help its residents save water. They have decided to design a water tower for the roof of city hall to collect rainwater.
3. The town is not sure how to design the water tower so they have hired this group of youth to engineer a model water tower as an example for them.
4. Ask youth:
   - **How would you state the problem we are trying to solve?** *We need to engineer a model tower that can support a container of water.*

Identify (5 min)

1. Split youth into groups of 3. Ask:
   - **What questions do you have before you begin working?** *Accept all answers.*
2. Encourage the whole group to ask questions about what they need to know before they start, such as what the tower needs to do (criteria), how they are expected to make it (constraints), and how to evaluate success.
3. Pass out an Engineering Notebook to each youth. Explain that the Notebook is a place they can find information about their engineering challenges and record their ideas. Tell them to turn to p. 2 to find the answers to some of the questions they came up with.
4. Have a volunteer read about the criteria and constraints. As you review the information, make sure youth know:
   - They will work in groups.
   - Towers must be at least 1 foot tall (not including the container).
   - Towers need to hold up an 8 oz. container filled with water (model water tank) for at least 10 seconds.
   - They can use 100 index cards, masking tape, a ruler, and a pair of scissors.

Tip

For an additional challenge, you can limit each group's masking tape to anywhere between 1 and 4 feet.

- The scissors and ruler can be used as tools, but cannot be used as a part of the structure.
- Groups can hold the water container as they build, but they cannot *test* with it until the official testing time begins.

Create (20 min)

1. Pass out 100 index cards, a ruler, and scissors to each group. Have groups share the masking tape.
2. Let groups know that they will have 20 minutes to engineer their towers.
3. As groups work, pass around the container of water so everyone can hold it and get a sense of its weight, but remind youth they cannot *test* with it yet.
4. Visit each group and ask:
   - **How did your group come up with this design?**
   - **Why do you think your design will work well?**
   - **What are you doing to the cards to make them stronger?**
5. Every 5 minutes, let groups know how much time is left.

Test and Communicate (15 min)

1. When time is up, have groups step away from their designs and observe the structures other groups *created*. Ask:
   - **What do you observe is the same about all of the designs? What is different?** *Same materials, shapes, etc.; different ways of using the index cards, different heights, etc.*
2. Point out that every group engineered a different solution to the same problem, and that is great! In engineering, there are always many solutions to the same problem.
3. Have the groups take turns sharing their design. Ask:
   - **Tell us about your design. Why did you use the materials this way?**
   - **What do you predict will happen during testing?**
4. Allow a group member to measure their tower and then *test* by placing the water container on top to see if it will hold for at least 10 seconds.
5. Whether or not their design met the criteria, ask each group:
   - **How would you *improve* your design if you had more time?**

Reflect (10 min)

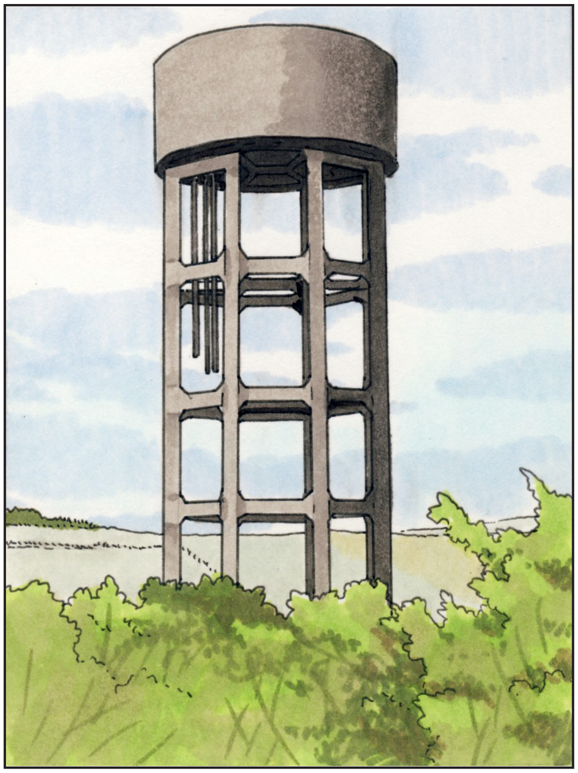
1. Post the *Engineering Design Process* poster.
2. Explain that engineers use a tool called the Engineering

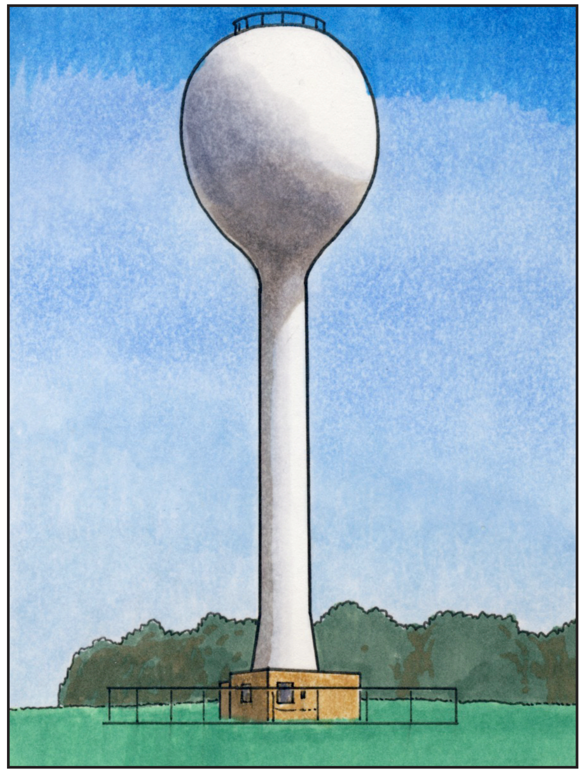
Design Process to help them solve problems. Ask:

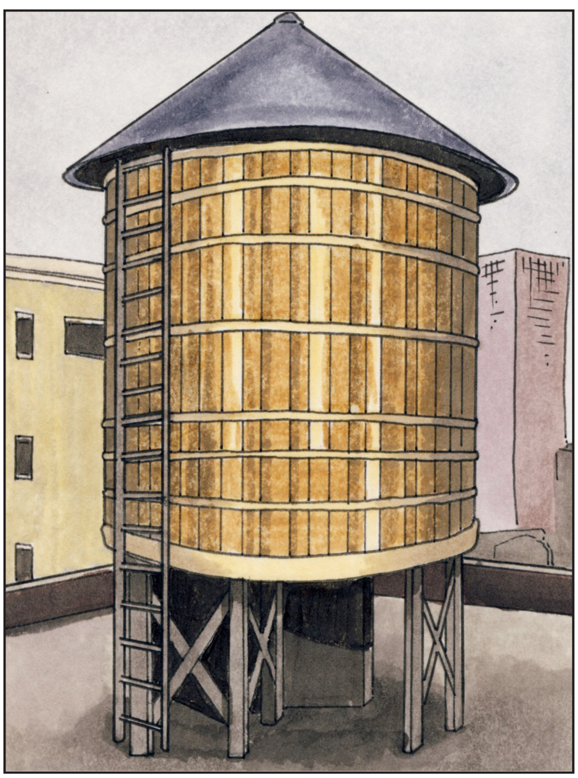
- **How did your group use these steps, or steps like these, as you engineered your model tower?** *Encourage groups to link specific actions to specific steps, for example: we used the* imagine *step when we brainstormed different designs.*

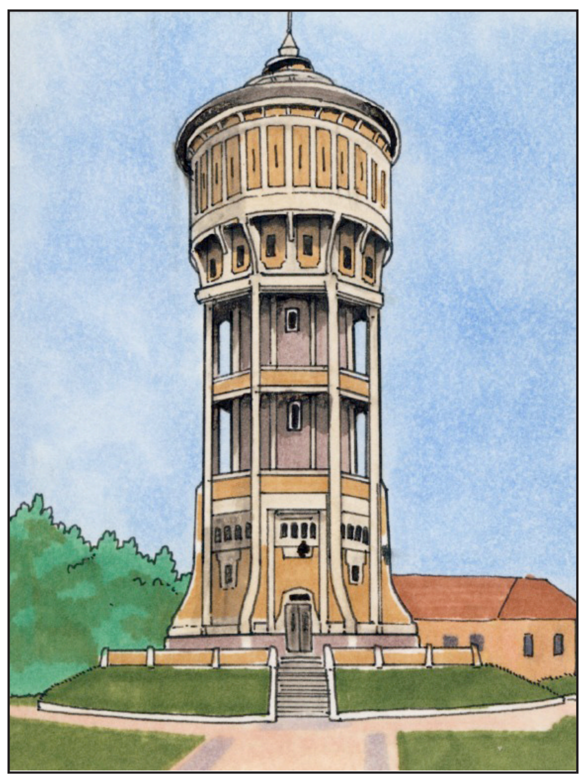
3. Explain that they will continue to use the Engineering Design Process to guide their engineering work throughout the unit.
4. Tell youth that because they all used the Engineering Design Process to solve a problem, they are all engineers!

Water Tower Examples









Prep Activity

2 What is Technology?

Educator Preview

Overview

Youth play a quiz game to help them define the word “technology” and learn that engineers design technologies to solve problems.

Note to Educator:
Many people do not realize that engineers are people who design technologies. Furthermore, many people think of technologies only as things that require electricity. This activity introduces youth to the idea that a technology is any thing or process designed by humans to solve a problem.

Activity Timing

Introduction:	5 min
Tech Trivia:	35 min
Special Report Video:	15 min
Reflect:	5 min
	60 min

21st Century Skill Highlight

Critical Thinking

Prep Activity 2 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Engineering Everywhere Special Report* video
- ☐ chart paper and markers
- ☐ *Technology Trivia* PowerPoint file
- ☐ a computer and projector that will play the PowerPoint*
- ☐ *alternative: 1 pad of sticky notes

For each group of 3

- ☐ optional: 1 buzzer

For each youth

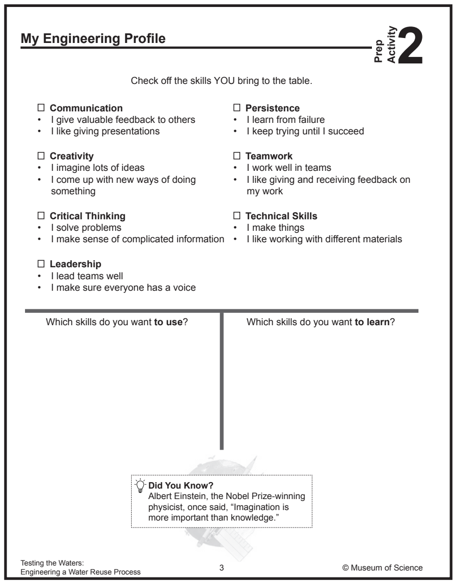
- ☐ Engineering Notebook

Prep Activity 2 Materials Preparation (20 min)

1. Post the *Engineering Design Process* poster.
2. Write the definition of technology on a sheet of chart paper: *Technology is any thing or process designed by humans to solve a problem.*
3. Prepare to play the *Engineering Everywhere Special Report* video (8:47): www.eie.org/water-reuse.
4. Make sure you are able to play the *Technology Trivia* PowerPoint. Test the projector to make sure it can be seen from the back of the room. Familiarize yourself with the PowerPoint and instructions for playing the game.
5. Alternatively, if you cannot project the electronic game board, draw a *Trivia Game Chart* as shown on the next page. Using *Technology Trivia Game*, p. 15 in this guide, write the answer on the paper, then cover it with a sticky note displaying the appropriate point value. You can use the *Technology Trivia Game* page to help ask the questions.

Engineering Notebook Pages for Prep Activity 2

My Engineering Profile, p. 3


My Engineering Profile

Prep Activity 2

Check off the skills YOU bring to the table.

☐ **Communication**
- I give valuable feedback to others
- I like giving presentations

☐ **Creativity**
- I imagine lots of ideas
- I come up with new ways of doing something

☐ **Critical Thinking**
- I solve problems
- I make sense of complicated information

☐ **Leadership**
- I lead teams well
- I make sure everyone has a voice

☐ **Persistence**
- I learn from failure
- I keep trying until I succeed

☐ **Teamwork**
- I work well in teams
- I like giving and receiving feedback on my work

☐ **Technical Skills**
- I make things
- I like working with different materials

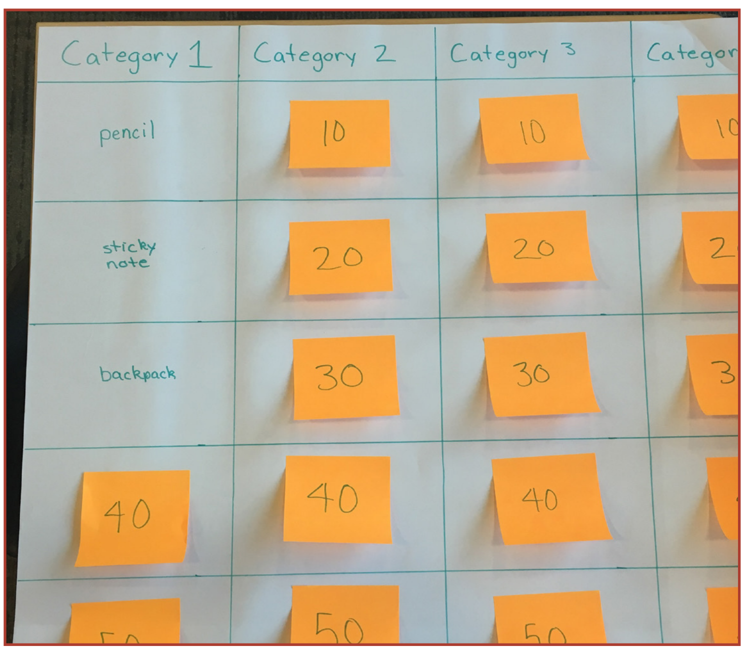
Which skills do you want **to use**?	Which skills do you want **to learn**?

Did You Know?
Albert Einstein, the Nobel Prize-winning physicist, once said, "Imagination is more important than knowledge."

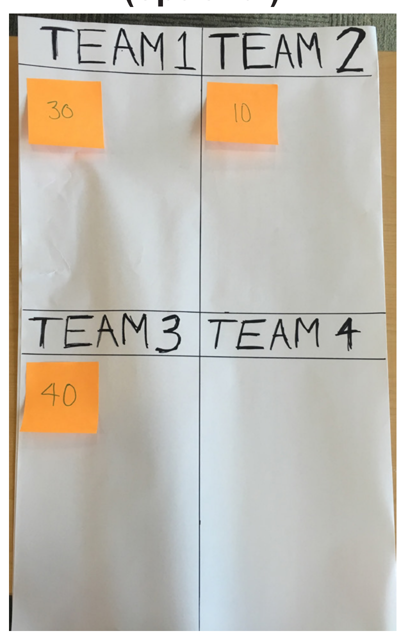
Testing the Waters: Engineering a Water Reuse Process 3 © Museum of Science

Charts for Prep Activity 2

Trivia Game Chart (optional)



Scoreboard (optional)



<u>Double Points Rules:</u>

1. Only the group that picked the "Double Points" question can answer.
2. The group must wager some or all of their points BEFORE seeing the question.
3. The group picks the next question whether or not they answer correctly.

Prep Activity

2 What is Technology?

Activity Guide

Youth will learn:
- A technology is any thing or process designed by humans to solve a problem.
- A process is a series of steps done in a certain order to solve a problem.
- Water is an important resource that is not always plentiful.
- Greywater is water that has been used once and can be used again.

Tip

Using the term "engineer" will help youth become more comfortable with it!

Tip

If youth identify natural objects as technologies, let them know that rocks, leaves, and other natural objects on their own are not technologies. If they are used as tools, like an arrowhead, then they are considered technologies.

Tip

Distribute buzzers to each group so they can buzz in instead of raising their hands to answer the question.

Introduction (5 min)

1. Explain that today, groups will start thinking about the concept of "technology." Ask youth:
   - **What are some technologies you can think of?** *Accept all answers.*
   - **How would you define the word "technology"?** *Accept all answers.*
2. Let youth know you have a definition of technology you would like to share. Write the definition of technology on chart paper: *Any thing or process designed by humans to solve a problem*. Ask:
   - **Is there anything about this definition that surprises you?**
   - **Can you share some more examples of technologies based on this definition?** *Encourage youth to think of non-electronic things or common objects that solve problems, such as cups, pens, shoes, etc.*
3. Point out to youth that, as shown by the technologies they have shared, they use many different technologies in their lives! Engineers design all of these different technologies.
4. Tell youth that for the rest of today's activity, they will play a game of *Technology Trivia* to learn more about technologies and the problems they solve.

Technology Trivia (35 min)

1. Split youth into four teams.
2. Project the *Technology Trivia* PowerPoint on the wall (or hang the paper-based version) and explain the rules. Let youth know that a group will start by picking a category and a point value. You will read the question, and the first group to raise their hands and provide a correct answer will win the associated points. That group then gets to pick the next category and point value.
3. Play the Technology Trivia game.
4. If you are playing the paper-based version, keep score

Tip

There may be more than one correct response for any given question in Technology Trivia. Use your judgment to determine if a group's response appropriately answers the question.

Tip

To further challenge youth, have them:

- make a list of three new objects that are/are not technologies.
- make a list of three new technologies that are processes.

by removing the sticky notes and distributing them to the appropriate team. The electronic version will automatically grey out questions that have already been used.

5. When all the questions have been answered or 30 minutes have passed, have youth summarize what they learned while playing the game. Ask:
    - **After doing this activity, what would you tell others about technologies? About engineers?** *Accept all answers.*
    - **What is a process?** *A series of steps completed in a certain order to solve a problem.*
6. If youth do not mention the important points listed below, be sure to underscore them:
    - Technology is any thing or process designed by humans to solve a problem.
    - Engineers are people who design technologies.
    - They have the ability to engineer technologies. They are engineers!

Special Report Video (15 min)

1. Let youth know that you have more to share with them about the work of engineers. Have youth think about the term "water scarcity." Use chart paper to record youth's definitions and ideas.
2. Explain that they will watch a video to learn more about how engineers solve the problem of water scarcity. Play the *Engineering Everywhere Special Report* video (8:47): www.eie.org/water-reuse.
3. After playing the video, ask youth:
    - **What is an extreme environment?** *A place where it is difficult for people to survive.*
    - **What is the problem engineers are trying to solve in the video?** *Water scarcity in an extreme environment.*
    - **How did the engineers solve this problem?** *Reusing water.*
    - **How did the engineers use a process to reuse water?** *First they used the water, then they collected the water after it was used. After that, they filtered the water so it could be reused.*
    - **What are the three categories of water in the video?** *Pure water—water that is clean and safe enough to drink, greywater—water that has been used at least once and has been cleaned so it can be used again, waste water—water that is too dirty to be used again.*

4. Tell youth that throughout the unit, they are going to work as water resource engineers. They will have to consider different extreme environments where water scarcity is an issue and design a process for reusing water, just like they saw in the video.
5. Let youth know that they will learn more about this problem and ways to solve it in the next activity.

Reflect (5 min)

1. Gather youth in front of the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process did you use today?** *We* identified *the problem of water scarcity and* investigated *how other engineers have solved this problem.*
2. Have youth fill out *My Engineering Profile*, p. 3 in their Engineering Notebooks, to get a sense of the skills they might use throughout this unit. Some might be things they are already good at, while others might be things they hope to work on. Tell youth they will return to this profile at the end of the unit to see how they have grown as engineers.

Technology in the Classroom	Water Technologies	Hi-Tech Tech	Technology in the Home	Process Technologies
10 This technology holds a piece of graphite that allows you to write. What is a <u>pencil</u>?	**10** This portable technology holds your water so you can drink it on the go. What is a <u>cup/water bottle</u>?	**10** This technology uses wheels and an engine to help us travel long distances on land. What is a <u>car/train</u>?	**10** This technology uses waves to heat up food faster than a traditional oven. What is a <u>microwave</u>?	**10** This series of steps helps to make sure your teeth are clean. What is <u>brushing your teeth</u>?
20 These technologies are records of words printed onto paper. What are <u>books</u>?	**20** This technology is long, narrow, and flexible. It helps move water from the house to the garden. What is a <u>hose</u>?	**20** This technology is used in airports to make sure passengers do not bring dangerous objects on board. What is a <u>metal detector/ body scanner</u>?	**20** Most versions of this technology use suction and rotating brushes to help you clean floors. What is a <u>vacuum</u>?	**DOUBLE POINTS** **20** This series of steps helps engineers figure out how to solve problems. What is the <u>Engineering Design Process</u>?
30 Many students use these technologies, often made of fabric, to carry things to and from school. What are <u>backpacks</u>?	**30** This technology stops water from flowing down a river so it can be used to make electricity. What is a <u>dam</u>?	**30** This pocket technology helps people to communicate over long distances. What is a <u>cell phone</u>?	**30** This technology uses blades to move air. What is a <u>fan</u>?	**30** This series of steps helps to make sure your shoes stay on your feet. What is <u>tying your shoelaces</u>?
40 This technology is used to accurately measure the lengths of objects. What is a <u>ruler/measuring tape</u>?	**40** This technology helps people to breathe and swim underwater. What is <u>SCUBA/snorkeling gear</u>?	**40** This technology uses sound waves to create an image of body tissue. What is an <u>ultrasound/ sonogram</u>?	**40** This technology provides a comfortable place to sit and often has space for multiple people. What is a <u>couch/sofa</u>?	**40** This series of steps helps to make a cake come out just right. What is a <u>recipe</u>?
50 This technology is used to display information in the classroom. What is a <u>projector</u>?	**50** This technology uses muscle power to propel a boat through the water. What is a <u>paddle/oar</u>?	**DOUBLE POINTS** **50** This technology can explore the surfaces of planets and moons. Some versions can take pictures and test samples of rocks and dirt. What is a <u>rover</u>?	**50** This kitchen technology has multiple loops that blend ingredients and add air to a mixture. What is a <u>whisk</u>?	**50** This series of steps makes sure cans and paper are reused instead of going to landfills. What is <u>recycling</u>?

Activity **1** # A Grey Area

Educator Preview

Overview

Youth *investigate* how using water for various tasks can impact the water's quality.

Note to Educator:
During this activity, groups will create a model water sample and test the water quality using real tools. Lead this activity in a room with a sink for easy setup. Use towels or paper towels to clean up any spills. The pH strips may stain the tabletop, so have youth place their used strips on a paper towel. **If you have less than 8 groups, be sure to create a sample from each location. Save the water samples for use in Activity 3.**

Activity Timing

Introduction:	5 min
Modeling:	20 min
Water Quality:	25 min
Reflect:	10 min
	60 min

21st Century Skill Highlight

Critical Thinking

Activity 1 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ 1 permanent marker
- ☐ 1 roll of masking tape
- ☐ 1 roll of paper towels
- ☐ 2 pairs of scissors
- ☐ 4 tablespoons
- ☐ 4 teaspoons
- ☐ 4 rulers
- ☐ 5 sheets of cardstock

For the Materials Table

- ☐ 1 bottle of soap
- ☐ 1 bottle of white vinegar
- ☐ 1 spool of thread
- ☐ 1 Tbsp of detergent
- ☐ 1 tube of toothpaste, travel size
- ☐ 1 vial of food coloring, yellow
- ☐ 2 sticks modeling clay
- ☐ 4 Tbsp of soil
- ☐ 4 tea bags, black tea

For each group of 3

- ☐ 1 craft stick
- ☐ 1 jar, 1/2 gallon, filled with water
- ☐ 1 packet of pH strips
- ☐ 1 Secchi disk
- ☐ 1 *Water Sample Recipe*

For each youth

- ☐ Engineering Notebook

Activity 1 Materials Preparation (15 min)

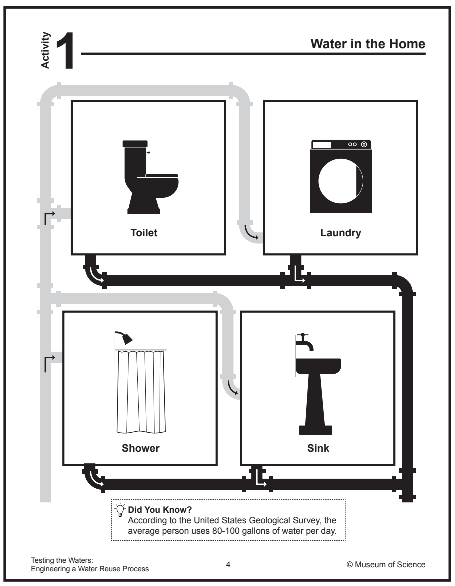
1. Post the *Engineering Design Process* poster.
2. Make two copies of *Water Sample Recipes*, p. 23 in this guide. Cut out each recipe, and distribute one to each group.
3. Make copies of *Secchi Disk* onto the cardstock, p. 27 in this guide. Cut out the Secchi disks, one for each group, and save the rest

in case they get wet. Consider laminating these so they are water resistant.

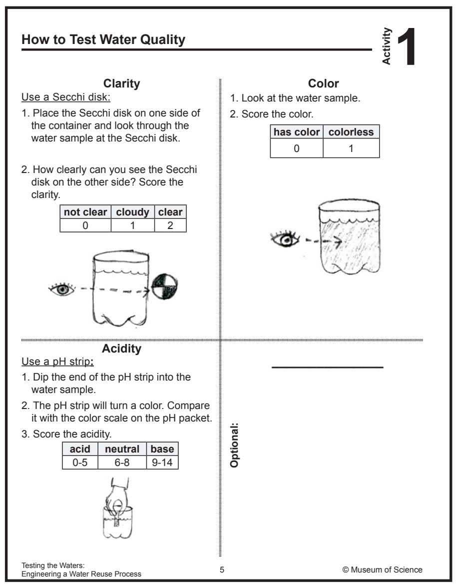
4. Review instructions on *How to Test Water Quality*, p. 25 in this guide; p. 5 in the Engineering Notebook.
5. Arrange the materials (model contaminants) listed above on the Materials Table for youth to access throughout the activity. Place the teaspoons, tablespoons, and scissors on the Materials Table for youth to share.
6. Optional: Make copies of the *Acidity Chart*, p. 29 in this guide. Allow groups to compare the acidity of their water samples with the common contaminants on the chart.

Notebook Pages for Activity 1

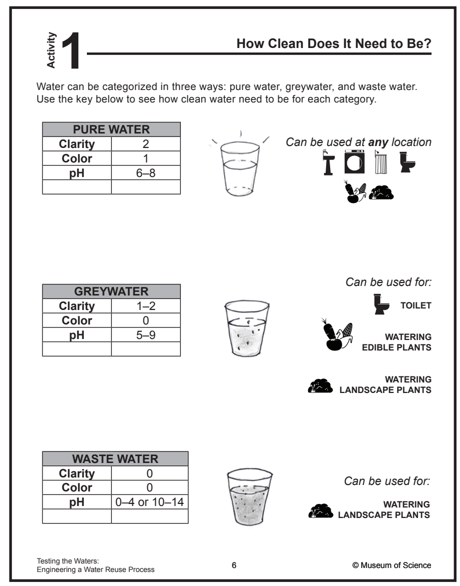
Water in the Home, p. 4



How to Test Water Quality, p. 5



How Clean Does It Need To Be?, p. 6



Activity 1

A Grey Area

Activity Guide

Youth will learn:
- Engineers use models to *investigate* the problem they are trying to solve.
- Engineers and scientists measure water quality to find out how safe the water is to use for certain tasks.
- They can use tools to evaluate water quality.

Tip

Replay the *Special Report* video from 0:50 to 1:42 to review the problem of water scarcity in extreme environments.

Tip

On *Water in the Home*, p. 4, have students use their fingers to trace the white pipes that show pure water going in, then the black pipes that show waste water going out.

Tip

While drinking water and cooking water will not be modeled in this unit, discuss with youth that these are essential tasks that must also be considered in water-scarce environments.

Introduction (5 min)

1. Have youth think back to the *Special Report* video they watched in the last activity and help them remember their challenge over the next few days. Ask:
   - **What problem are we working to solve?** *We need to design a process to reuse water in a water-scarce environment.*
2. Let youth know that before they think about ways to reuse water, they will *investigate* how people typically use water in their homes. Ask:
   - **When do you use water in your home?** *Drinking, cooking, washing dishes, showering, washing hands, etc.*
3. Have youth turn to *Water in the Home*, p. 4 in their Engineering Notebooks. Explain that they will focus on the water used in four locations: the Bathroom Sink, Laundry, Shower, and Toilet.
4. Show youth how the piping in the house starts at “pure water in”, travels to each location in the home, and ends as “waste water out” after it has been used.
5. Ask:
   - **What everyday tasks use water from these locations?** *Hand washing, teeth brushing, body washing, etc.*
   - **What might you find in the water after it has been used?** *Soap, dirt, urine, etc.*
6. Explain that things that make water dirty are called contaminants.
7. Explain that engineers often develop and use models to *investigate* the problems they are working to solve. Today, they will work together to create models of contaminated water at four locations in the home.

Modeling Contaminated Water (20 min)

1. Split youth into groups of 3 and distribute one Water Sample Recipe to each group, with two groups assigned to each recipe.

2. Show groups the Materials Table with the model contaminants. Give groups 10–15 minutes to create their water samples.
3. As groups are working, encourage them to record their model contaminants on *Water in the Home* p. 4 in their Engineering Notebooks.
4. Ask:
   - **What real contaminants do you think these materials represent?**
   - **Are you surprised by any of the model contaminants?**
5. After youth make their models, have them share their contaminated water samples with the entire group. Ask:
   - **What do you notice about your models? What is similar? What is different?** *Our sample is cloudy, this sample is brown, all samples have particles floating in them.*
   - **If you had to choose, which of these water samples would you use again?** *Accept all answers.*
   - **How can we tell if the water is safe enough to reuse?** *Accept all answers.*
6. Explain that the term "water quality" refers to the characteristics that let us know if water is safe to use for tasks like washing hands, taking a shower, swimming, or drinking.
7. Let youth know that for the rest of today, they will measure the quality of their own water sample using the same tools that scientists and engineers use to test water quality.

Tip

The word Secchi is pronounced *SEK-ee.*

Water Quality (25 min)

1. Tell youth that they will measure two features of the water they can see: clarity, or how clear the water is, and color.
2. Hold up a Secchi disk. Explain that this is a tool scientists and engineers use to measure water clarity. Choose one of the water samples and model how to use the Secchi disk, following the directions on *How to Test Water Quality*, p. 23 in this guide.
3. Explain that the second feature they can use to measure water quality is the color. Using the water samples, model how to record whether the water has color or is colorless, following the directions on *How to Test Water Quality*, p. 23 in this guide.
4. Explain that there are also ways that contaminants affect the water that we cannot see. Acidity is one way water is affected. If water is too acidic or too basic, it can be harmful to our health.
5. Hold up a packet of pH strips. Explain to youth that pH strips

Tip

Have a volunteer demonstrate how to use the Secchi disk and the pH strips using *Testing Water Quality*, p. 6 in their Engineering Notebook.

Tip

Remind youth that colorless and clear do not mean the same thing. Give an example, like apple juice, that is clear but has a yellow color.

are a tool used to measure how acidic or basic the water sample is. Choose one of the water samples and model how to use a pH strip, following the directions on *How to Test Water Quality*, p. 23 in this guide.

6. Have youth return to their groups and measure the quality of their own water sample. They should refer to *How to Test Water Quality* on p. 5 in their Engineering Notebooks.
7. Have youth record this information on *Water in the Home*, p. 4 in their Engineering Notebooks.
8. Have groups share out about the quality of their water samples. Encourage youth to record the quality of the other samples in their Engineering Notebooks.

Reflect (10 min)

1. Gather youth together and ask:
   - **What are the three categories of water introduced in the Special Report Video?** *Pure water, greywater, and waste water.*
2. Tell youth they will determine which category their model samples fall into. Have youth turn to *How Clean Does It Need To Be?*, p. 6 in their Engineering Notebooks, to look at the criteria for each category.
3. Ask:
   - **How did you categorize your water sample?** *Waste water.*
   - **Why is it important to measure water quality?** *So we know if the water is safe to use.*
   - **What can we do to make this water reusable?** *We can clean it.*
4. Let youth know that next time, they will use what they learned about water quality to reconfigure the pipes in a home so that the water can be reused.
5. Gather youth in front of the *Engineering Design Process* poster. Ask:
   - **What steps of the Engineering Design Process did you use today?** *We* investigated *how water is used in the home and how water quality is measured.*
6. Using the permanent marker and masking tape, have youth label the water samples they made (Bathroom Sink, Laundry, Shower, or Toilet) and save them for use in the next activity.

Tip

Optional: Pass out the *Acidity Chart*, p. 29 in this guide, to see a chart that displays common water contaminants and their acidity levels.

Tip

Optional: Have the entire group decide on one additional measurable feature to determine water quality. Have youth complete the quality chart and fill in the testing directions on *How to Test Water Quality*, p. 5 in their Engineering Notebooks.

Tip

If youth are having difficulty remembering the three types of water, have them refer to the *Glossary*, p. 24 in their Engineering Notebooks. Alternatively, create a *Types of Water* chart with the three definitions and hang it up for each activity.

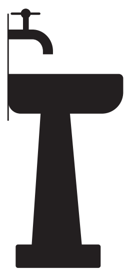
Activity 1

Water Sample Recipes

Bathroom Sink Water Sample

- ☐ 1/2 gallon jar of water
- ☐ 1 tsp soap
- ☐ 2 pea-sized blobs of toothpaste

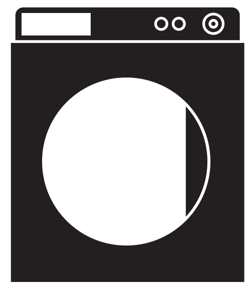
Add everything to the jar and stir well.



Laundry Water Sample

- ☐ 1/2 gallon jar of water
- ☐ 1 tsp tea leaves
- ☐ 1 Tbsp detergent
- ☐ 2 tsp soil

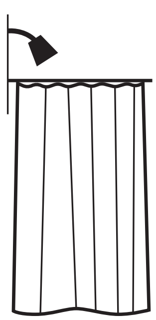
Add everything to the jar and stir well.



Shower Water Sample

- ☐ 1/2 gallon jar of water
- ☐ 1 tsp soap
- ☐ 1 tsp soil
- ☐ 2 Tbsp vinegar
- ☐ 30 pieces of thread approx. 3-5" long

Add everything to the jar and stir well.



Toilet Water Sample

- ☐ 1/2 gallon jar of water
- ☐ 1 tsp soap
- ☐ 1 tsp tea leaves
- ☐ 1 Tbsp soil
- ☐ 2 drops yellow food coloring
- ☐ 2 logs of modeling clay, approx. 2-3" long

Add everything to the jar and stir well.

Activity 1 How to Test Water Quality

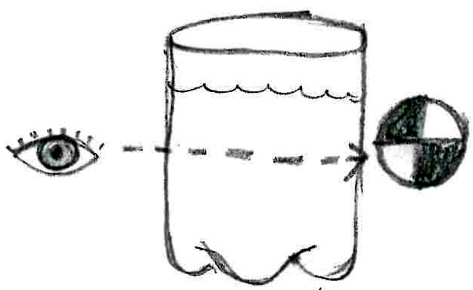
Clarity

Use a Secchi disk:

1. Place the Secchi disk on one side of the container and look through the water sample at the Secchi disk.

2. How clearly can you see the Secchi disk on the other side? Score the clarity.

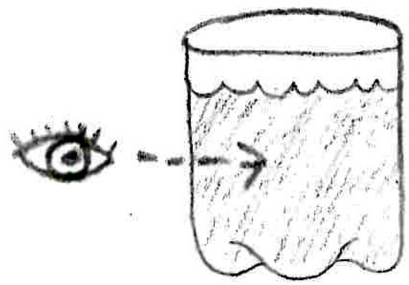
not clear	cloudy	clear
0	1	2



Color

1. Look at the water sample.
2. Score the color.

has color	colorless
0	1

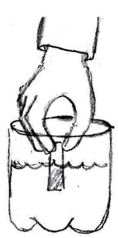


Acidity

Use a pH strip:

1. Dip the end of the pH strip into the water sample.
2. The pH strip will turn a color. Compare it with the color scale on the pH packet.
3. Score the acidity.

acid	neutral	base
0-5	6-8	9-14



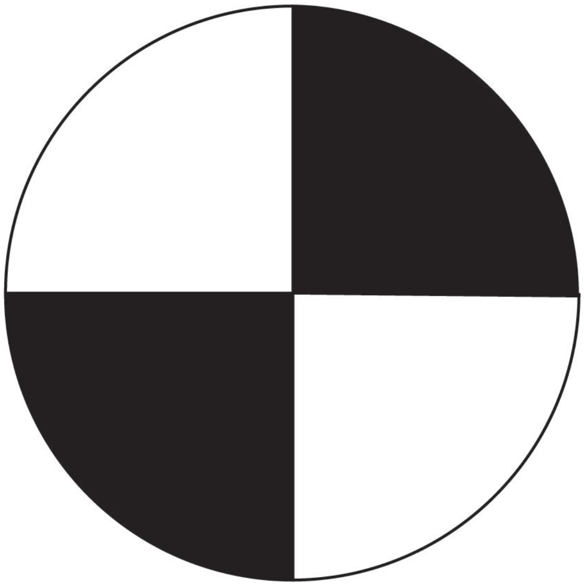
Optional

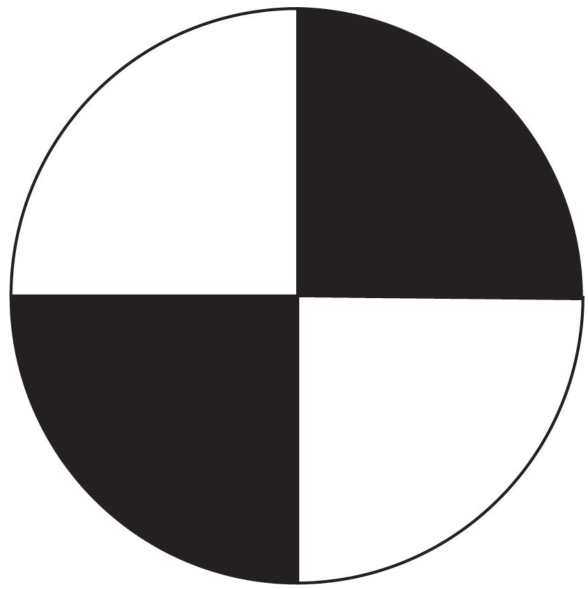
1. Have youth come to a consensus on a fourth feature to evaluate water quality (*e.g., number of particles in the water, size of particles in the water*).
2. Have the entire group decide how to measure this feature and have youth record the group's decision on *How to Test Water Quality*, p. 5 in their Engineering Notebooks.

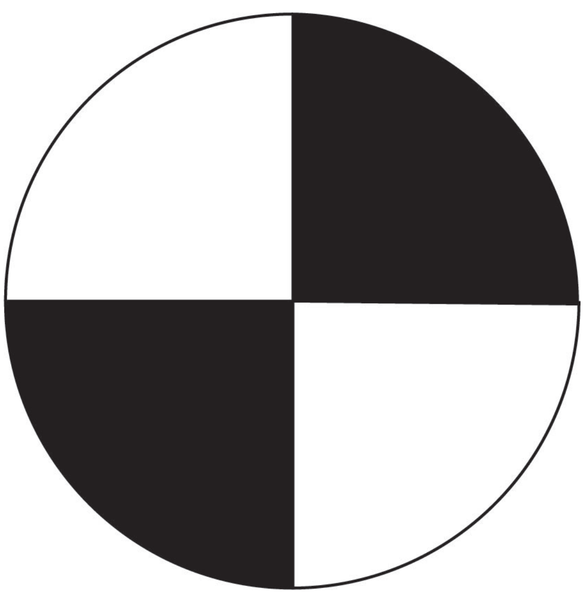
Activity **1**

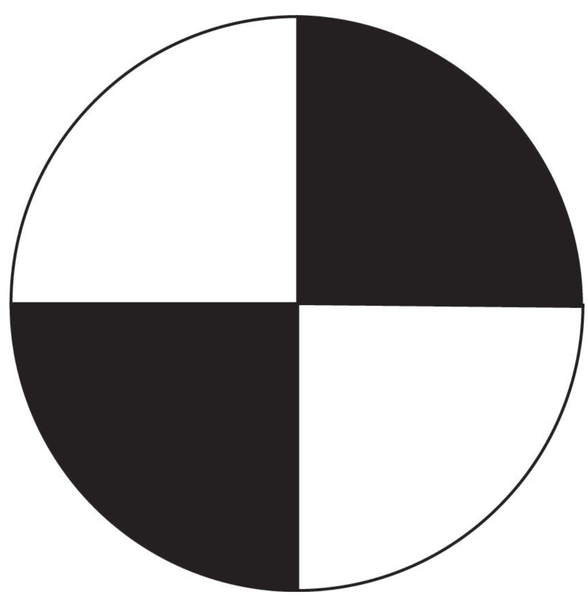
Secchi Disk

Photocopy this page onto cardstock, making one copy for every four groups. Cut out the Secchi disks and give one disk to each group. Keep extra copies in case the disks get wet.



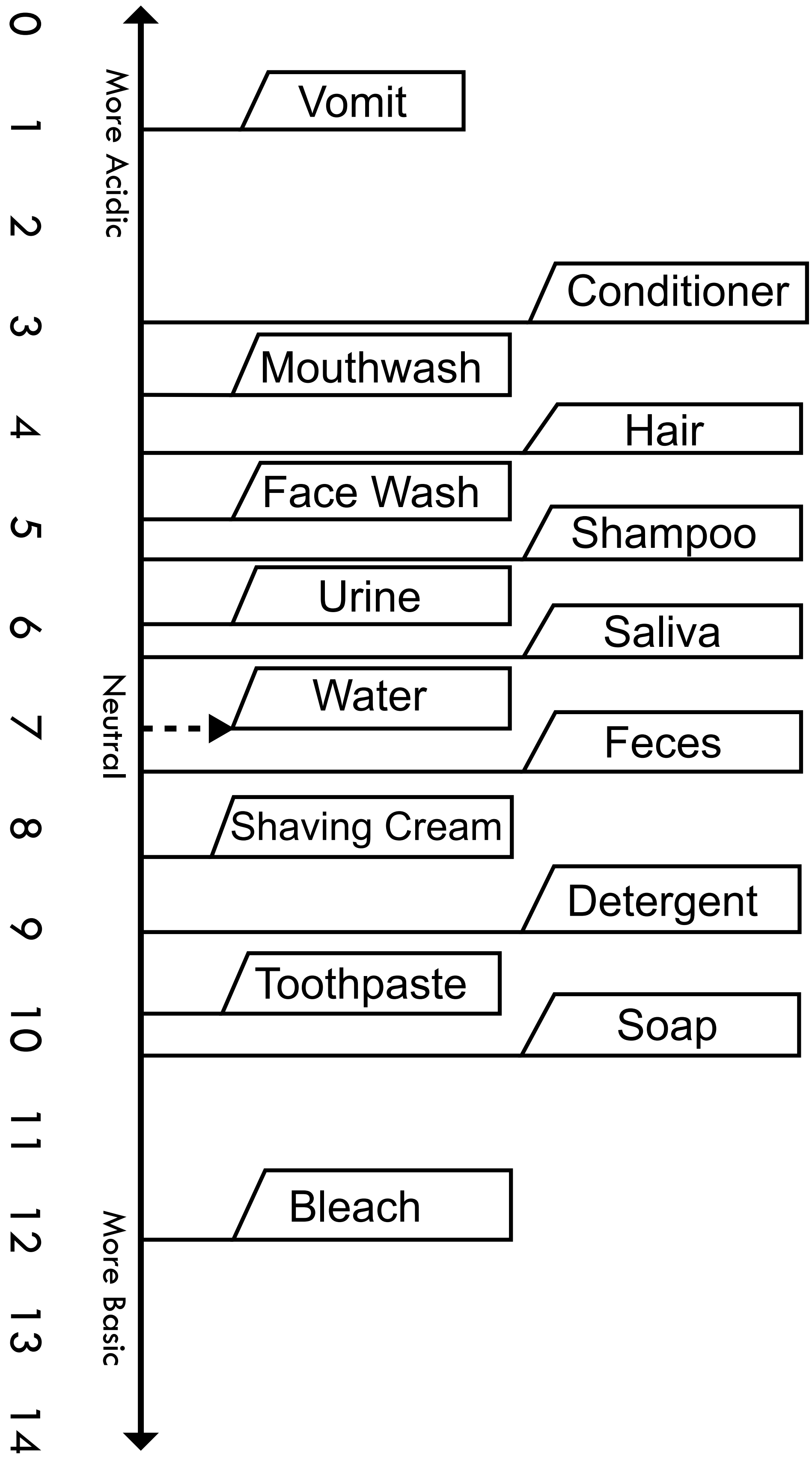






Activity 1

Acidity Chart



Activity 2 Investigating Filters

Educator Preview

Overview:
Youth *investigate* the ability of various filter materials to remove or treat contaminants from a water sample.

Note to Educator:
Please note the longer prep time for this activity. Lead this activity in a room with a sink for easy clean up. Use caution when cutting plastic bottles. In this activity, the water quality features that youth explore include clarity, color, and pH. The pH strips may stain the tabletop, so have youth place their used strips on a paper towel. **Save the charcoal filter demonstrated in this activity for use in Activity 3. Save any materials that can be reused and the *Investigating Filter Materials* chart for use in Activity 4.**

Activity Timing

Introduction:	5 min
Investigate:	40 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Critical Thinking

Activity 2 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ chart paper and markers
- ☐ 1 piece of cheesecloth, 12" x 12"
- ☐ 1 plastic container with lid, 8 oz.
- ☐ 1 roll of paper towels
- ☐ 1 roll of painter's tape
- ☐ 1 rubber band
- ☐ 1 safety glove
- ☐ 1 strainer
- ☐ 1 utility knife
- ☐ 1 vial of food coloring, yellow
- ☐ 2 Tbsp of activated charcoal
- ☐ 8 two-liter bottles

For Materials Table

- ☐ 1 measuring cup, 1/4 cup
- ☐ 1 cup of limestone gravel
- ☐ 2 cups of sand
- ☐ 2 tablespoons
- ☐ 8 half-sheets of paper towel
- ☐ 18 pieces of cheesecloth, 12” x 12”
- ☐ 20 rubber bands
- ☐ 40 cotton balls
- ☐ optional: 60 plastic cups, 8 oz.

For each group of 3

- ☐ 1 Filter Base, p. 37 in this guide
- ☐ 1 foil tray, 12” x 12”
- ☐ 1 measuring cup, 1 cup
- ☐ 1 packet of pH strips
- ☐ 1 Secchi disk
- ☐ 1 water sample from Activity 1

For each youth

- ☐ Engineering Notebook

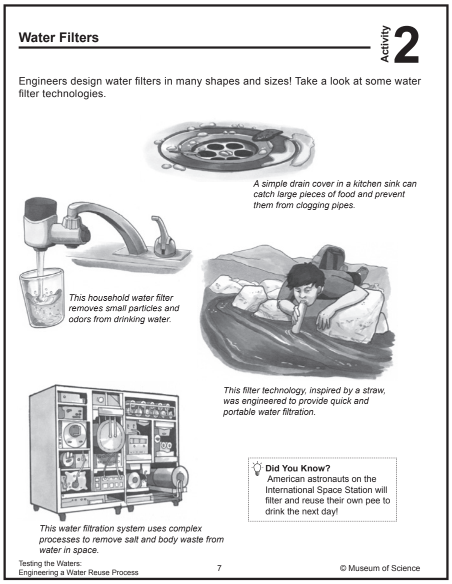
Activity 2 Materials Preparation (40 min)

1. Post the *Engineering Design Process* poster.
2. Make eight Filter Bases using the instructions on *Preparing Filter Bases*, p. 37 in this guide.

3. Create the *Investigating Filter Materials* chart, p. 32 in this guide.
4. Arrange materials on a Materials Table so youth can easily access them.
5. Fill the 8 oz. plastic container halfway with water and add 1-2 drops of yellow food coloring.
6. Using the strainer, rinse the charcoal under running water for approximately 1 minute until the water runs clear.
7. Create a charcoal filter by putting 2 Tbsp of pre-washed charcoal in a square of cheesecloth and tying it closed with a rubber band.

Notebook Pages for Activity 2

Water Filters, p. 7



Water Filters Activity 2

Engineers design water filters in many shapes and sizes! Take a look at some water filter technologies.

A simple drain cover in a kitchen sink can catch large pieces of food and prevent them from clogging pipes.

This household water filter removes small particles and odors from drinking water.

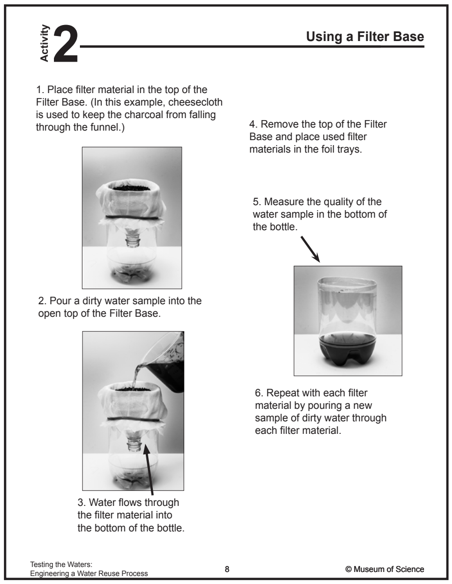
This filter technology, inspired by a straw, was engineered to provide quick and portable water filtration.

This water filtration system uses complex processes to remove salt and body waste from water in space.

Did You Know? American astronauts on the International Space Station will filter and reuse their own pee to drink the next day!

Testing the Waters: Engineering a Water Reuse Process 7 © Museum of Science

Using a Filter Base, p. 8

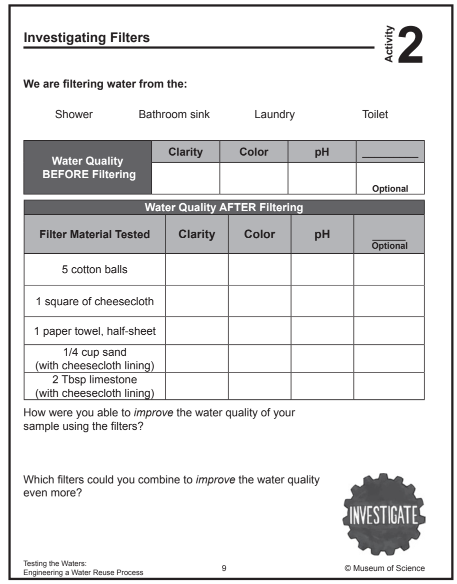


Activity 2 **Using a Filter Base**

1. Place filter material in the top of the Filter Base. (In this example, cheesecloth is used to keep the charcoal from falling through the funnel.)
2. Pour a dirty water sample into the open top of the Filter Base.
3. Water flows through the filter material into the bottom of the bottle.
4. Remove the top of the Filter Base and place used filter materials in the foil trays.
5. Measure the quality of the water sample in the bottom of the bottle.
6. Repeat with each filter material by pouring a new sample of dirty water through each filter material.

Testing the Waters: Engineering a Water Reuse Process 8 © Museum of Science

Investigating Filters, p. 9



Investigating Filters Activity 2

We are filtering water from the:

Shower Bathroom sink Laundry Toilet

Water Quality BEFORE Filtering	Clarity	Color	pH	________
				Optional

Water Quality AFTER Filtering				
Filter Material Tested	Clarity	Color	pH	____ Optional
5 cotton balls				
1 square of cheesecloth				
1 paper towel, half-sheet				
1/4 cup sand (with cheesecloth lining)				
2 Tbsp limestone (with cheesecloth lining)				

How were you able to *improve* the water quality of your sample using the filters?

Which filters could you combine to *improve* the water quality even more?

INVESTIGATE

Testing the Waters: Engineering a Water Reuse Process 9 © Museum of Science

Chart for Activity 2

Investigating Filter Materials				
Water Location	Quality Before Filtering*			Which Filter Materials Worked Best?
	Clarity	Color	pH	
Bathroom sink				*Write detailed responses in this column, (e.g., limestone improves the pH, cotton balls improved the clarity, etc.)*
Laundry				
Shower				
Toilet				

* If your group is using a fourth criteria for water quality, add a column accordingly.

Activity 2 Investigating Filters

Youth will learn:
- Engineers design filters to treat water.
- Different filter materials remove different types of contaminants from water.
- Engineers use the *investigate* step to learn more about ways they can solve their problem.

Tip

Replay the *Special Report* video from 4:05 to 4:15 to remind youth about water filters in the reuse process.

Tip

If groups have a different sample from the last activity, they can re-measure the quality or copy the data from *Water in the Home*, p. 4 in their Engineering Notebooks.

Tip

Since one water sample (e.g., shower) may be tested by more than one group, consider having those groups test half of the filter materials and share their data to save time.

Investigate (5 min)

1. Show youth the model water samples from Activity 1. Have them think back to when they *investigated* water quality by asking:
   - **What is the problem we are trying to solve?** *We need to reuse water instead of wasting it, so we need to engineer a process for reusing water.*
   - **Why can't we reuse any of these water samples?** *Because all of the water was waste water, which cannot be reused.*
2. Tell youth that today they will *investigate* different filters to *improve* the water quality of their samples so that they can be reused.
3. Have youth turn to *Water Filters*, p. 7 in their Engineering Notebooks, and read about some filter technologies used to treat water. Some of these technologies may be new to youth, and some they may be familiar with already.

Investigate Filter Materials (40 min)

1. Show youth the different filter materials they will be investigating today (cheesecloth, cotton balls, limestone, paper towels, and sand).
2. Explain that they will work in groups to test how well each material removes contaminants from one of the water samples. Assure groups that they will eventually get to combine multiple filters, but for now they will test each filter separately. Ask:
   - **Why do you think it might be useful to test each filter separately for now?** *If we test each filter by itself, we can see how much it might impact our final designs.*
3. Have youth turn to *Using a Filter Base*, p. 8 in their Engineering Notebooks, to review the testing instructions. Make sure youth understand they will:
   - First, record the water quality (clarity, color, and pH) of their sample in the "Before Filtering" section on

> **Tip**
>
> Have youth use the plastic cups to save their cleaned water samples for comparison to the original.

> **Tip**
>
> Youth can use the rubber bands to secure filter materials in the filter base.

> **Tip**
>
> Youth can manipulate the filter materials by folding and layering them. Encourage them to be creative!

> **Tip**
>
> Successful filters make the water quality better (neutral pH, high clarity, and colorless).

> **Tip**
>
> Different filter materials have different expected results:
> - Limestone balances the pH.
> - Cheesecloth, cotton balls, paper towel, and sand all remove particles and may slightly improve color.

Investigating Filters, p. 9 in their Engineering Notebooks.
- Place a filter material in the top of the Filter Base and pour 1/2 cup of their water sample over the filter. (Note that before placing any loose materials; e.g., sand, limestone; into the base, youth should first put down a piece of cheesecloth as a liner.)
- Measure and record the water quality of the sample in the base.
- Place used filter materials into the foil trays, and repeat this procedure for all the filter materials.

4. Split youth into groups of 3. Distribute one water sample from Activity 1 to each group. Be sure water from each location gets tested.
5. Invite groups up to the Materials Table to collect one Filter Base, a foil tray, and their filter materials.
6. Remind youth that they will test each filter material separately, so they should only pour 1/2 cup of the polluted water sample into the water filter for each test.
7. As youth are working, ask:
   - **How is this filter material affecting the quality of the water? Does it improve the pH, the color, and/or the clarity?**
   - **Is one filter material working better than the others to clean your water sample?**
8. Once groups have tested all of the filter materials, call groups back together and have them share out which filter was most successful at treating their water sample.
9. Record the whole group's data on the *Investigating Filter Materials* chart. For the "Which Filter Materials Worked Best?" column, add detailed notes about which materials worked best for treating different features (clarity, color, pH, etc.). Ask:
   - **What worked well with the filter materials? What problems did you notice with the filter materials?** *Accept all answers.*
   - **Was anyone able to remove the color from the water in their samples?** *Most groups will have some residual color left in their samples, particularly the yellow food coloring.*

Reflect (10 min)

1. Explain that some filters need more time to treat the water. Bring out the plastic container of yellow water and the charcoal filter bag. Let youth know that there is charcoal inside the cheesecloth bag. Place the charcoal filter into the yellow water and explain that they will check on this filter at the end of the next activity. Consider taking a picture of the

sample so that you can compare the results in Activity 3.

2. Congratulate youth on their engineering work so far. Ask:
   - **Which steps of the Engineering Design Process did we use today?** *We* investigated *different filter materials.*
   - **How do filters help us solve our problem of being able to reuse water?** *Now we can treat the waste water so that it is clean enough to be reused.*
3. Tell youth that in the next activity, they will use their knowledge of water quality and filtering to reorder the pipes in a home so that water can be reused.
4. Have youth clean up by rinsing the limestone with the strainer and setting it aside for use in later activities. Discard the remaining used filter materials.
5. Discard the water samples that youth created in Activity 1, using the strainer to prevent any contaminants from going down the drain.
6. Wipe out any remaining contaminants from the inside of the Filter Bases and rinse them in the sink.
7. Save the *Investigating Filter Materials* chart for the next activity. Save the Filter Bases, aluminum trays, and clean filter materials for Activity 3.

Sustainability Tip

Just as youth are learning about water reuse, you can reuse some of the materials in later activities. Rinse and set aside the limestone, charcoal, filter bases, and aluminum trays to be reused.

Preparing Filter Bases:

1. Using a safety glove, cut bottle in half with a utility knife.

2. Place painters tape over cut edges.

3. Remove cap.

4. Save bottom for catching water.

5. Stack top of bottle upside-down inside bottom of bottle. This is the Filter Base.

Filter Base

Using a Filter Base:

1. Place filter material in the top of the Filter Base. (In this example, cheesecloth is used to keep the charcoal from falling through the funnel.)

2. Pour dirty water sample into open top of the Filter Base.

3. Water flows through filter material into the bottom of the bottle.

4. Remove top of the Filter Base and place used filter materials in the foil trays.

5. Measure the quality of the water sample in the bottom on the bottle.

6. Repeat with each filter material by pouring a new sample of dirty water through each filter material.

Activity 3 Order Up!

Educator Preview

Overview

Youth apply what they learned about water quality to reconfigure a model house to reuse as much water as possible.

Note to Educator:

In this activity, youth reference the *Water in the Home* diagram from Activity 1 and reconfigure the way the pipes are placed so that they can reuse the water. They will use straws to represent the model pipes and tape them in place to *create* a map of the new layout.

Activity Timing

Introduction:	5 min
A Greywater Process:	35 min
Reflect:	10 min
	50 min

21st Century Skill Highlight

Critical Thinking
Collaboration

Tip

Place the *Mapping Greywater* pages in plastic sheet protectors before aligning and attaching them together to use again in the future.

Activity 3 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Investigating Filter Materials* chart from Activity 2
- ☐ plastic container with lid, 8 oz., with yellow water and charcoal filter from Activity 2
- ☐ 4 rolls of painter's tape
- ☐ 16 sheets of copy paper
- ☐ 40 straws, color 1
- ☐ 40 straws, color 2
- ☐ 40 straws, color 3

For each group of 3

- ☐ *Mapping Greywater*, pp. 43–45 in this guide
- ☐ 1/2 stick of modeling clay
- ☐ 1 pair of scissors
- ☐ optional: 2 sheet protectors

For each youth

- ☐ Engineering Notebook

Activity 3 Materials Preparation (30 min)

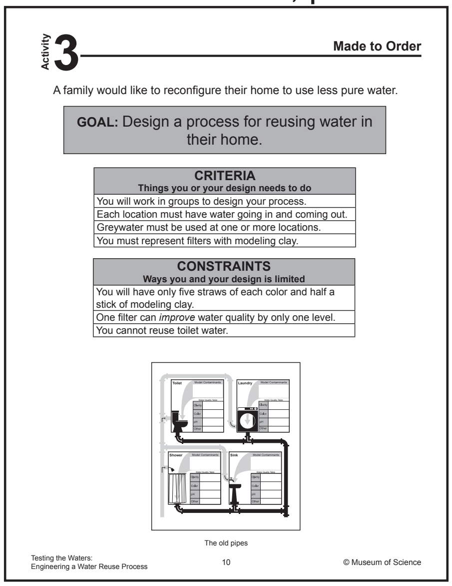
1. Post the *Engineering Design Process* poster.
2. Fill in the "After Use" water quality sections on the *Mapping Greywater* pages, pp. 43–45 in this guide, by using the data on *Water in the Home,* p. 4 in youth's Engineering Notebooks.
3. Make copies of both pages of *Mapping Greywater* and tape the two pages together to make one larger sheet for each group (see p. 40 in this guide).

Activity 4 Pre-Preparation (15 min)

Youth will need a total of 16 Filter Bases over the course of this unit (only 8 are needed for Activity 3, but 16 are needed for Activities 4–6). Making Filter Bases can be time consuming, so consider preparing them ahead of time. Follow the instructions on *Preparing Filter Bases*, p. 37 in this guide.

Notebook Page for Activity 2

Made to Order, p. 10


Activity 3 Made to Order

A family would like to reconfigure their home to use less pure water.

GOAL: Design a process for reusing water in their home.

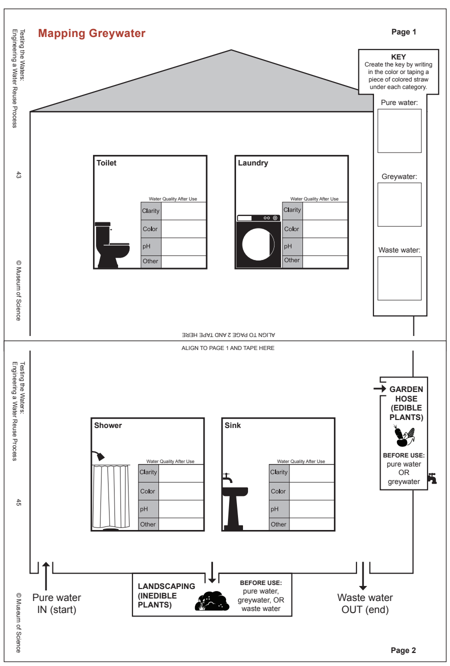
CRITERIA Things you or your design needs to do
You will work in groups to design your process.
Each location must have water going in and coming out.
Greywater must be used at one or more locations.
You must represent filters with modeling clay.

CONSTRAINTS Ways you and your design is limited
You will have only five straws of each color and half a stick of modeling clay.
One filter can *improve* water quality by only one level.
You cannot reuse toilet water.

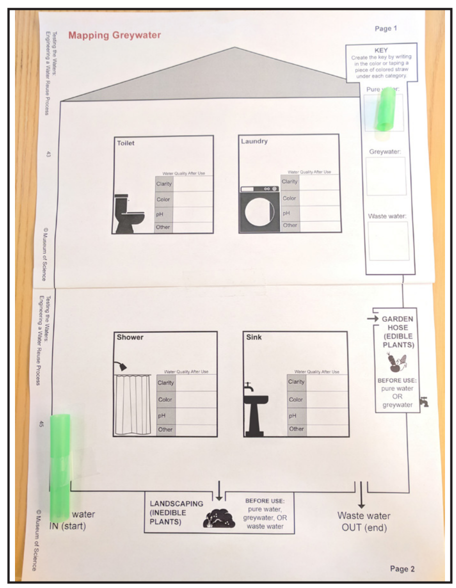
The old pipes

Testing the Waters: Engineering a Water Reuse Process 10 © Museum of Science

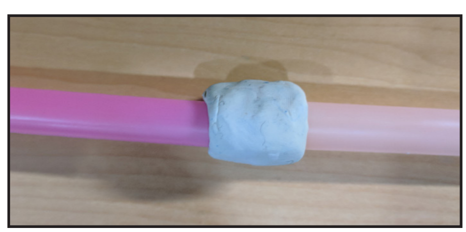
Mapping Greywater Examples



Pages taped together with water quality values filled in



Example: straws modeling pure water pipes are taped on pages



Modeling clay represents a filter.

Youth will learn:
- Water quality determines the order water can be reused for specific locations.
- There can be multiple solutions to the same problem.

Tip

Replay the *Special Report* video from 3:25 to 4:05 to remind youth of how pipes deliver water to and from different areas. Consider bringing youth to an area where you can see pipes connected to a sink or toilet.

Tip

If youth are unfamiliar with the terms *edible* and *inedible*, provide some examples, e.g., carrots, lettuce, apple trees (edible); flowers, grass, trees (inedible). Edible plants become inedible when they are watered with waste water, so it is important to know which plants will be used for food and which will be used for decoration.

Introduction (5 min)

1. Congratulate youth on the excellent engineering work they have done so far. Ask:
   - **What did we *investigate* in the last activity?** *How different filter materials can improve water quality in different ways.*
2. Have youth turn to *Water in the Home*, p. 4 in their Engineering Notebooks. Ask:
   - **Why were we not able to reuse any of this water?** *Because all of the water was waste water after it had been used.*
3. Tell youth that today they will use what they learned about water quality to change the flow of water in the home on p. 4 so that the water can be reused.

A Greywater Process (35 min)

1. Have youth turn to *Made to Order*, p. 10 in their Engineering Notebooks, to review their challenge. Have a volunteer read the criteria and constraints aloud.
2. Show youth one of the taped *Mapping Greywater* pages, straws, and modeling clay. Explain they will use straws as model pipes and modeling clay as model filters.
3. Assign one straw color to indicate each water quality (pure, grey, and waste).
4. Remind youth that the water may not immediately qualify as greywater. Ask:
   - **How can we improve the water quality?** *We can use filters to improve the pH, color, and clarity.*
5. Remind youth they can use *How Clean Does It Need to Be?*, p. 6 in their Engineering Notebooks, to review the criteria for pure water, greywater, and waste water.
6. Split youth into groups of 3. Pass out a taped set of *Mapping Greywater* pages to each group.
7. Remind groups record the colors of the straw in the key on their *Mapping Greywater* pages.
8. Let youth gather their materials (i.e., straws, modeling clay, tape, and scissors) and begin designing their water reuse

> **Tip**
>
> Encourage groups to be creative with the way they design their greywater process. The process can be arranged in a straight line, branches, or even in a loop.

> **Tip**
>
> If youth have questions about when greywater is used, let them know its usage can vary depending on region, local regulations, plant species, and/or personal preference. Encourage them to look up the local legislation regarding greywater.

> **Tip**
>
> Take a picture of the "before" stage of the yellow water to compare it to the "after" results.

> **Tip**
>
> The charcoal filter may take anywhere from 24-48 hours to remove color from the water sample.

processes. Encourage them to discuss a *plan* with their group before they start cutting straws and securing them in place with painter's tape.

9. As groups are working, move around the room and ask:
    - **Why is it important to know the water quality of the samples?** *So you know if the water is safe to reuse.*
    - **How are you ordering your process for reusing water?**
    - **In how many locations have you been able to reuse water?**
    - **Can you think of other ways you could order the water flow?**

Reflect (10 min)

1. When youth have finished, gather them together to share and compare their processes for reusing water. Ask:
    - **What similarities do you notice between your processes? What differences do you notice?** *We both started with shower, but we only reused the sink water and they reused sink and shower water.*
    - **How can you *improve* your water reuse process?** *We can increase the number of times water is reused.*
    - **Why do you think it is important to reuse water in a particular order?** *Order is important because some locations require cleaner water than others.*
    - **Is the process of reusing water a technology?** *Yes. It is solving the problem of not having enough water by ordering the flow of water so it can be reused.*
    - **Which steps of the Engineering Design Process did we use today?** *We* investigated *why order is important, we* planned *how to order the flow of water, we* created *a process for reusing water in the home.*
2. Remind youth how they talked about how some filters take time to treat the water.
3. Bring out the plastic container of yellow water with the charcoal filter. Ask:
    - **What do you notice about the quality of the water now?** *The water sample should be less yellow than it was before. If you took a picture in Activity 2, compare the color in the picture and in the sample.*
    - **How can you use this filter material in your water reuse process?** *Accept all answers.*
4. Let youth know that next time they will begin designing a process for reusing water in a water-scarce environment like a home in the American Southwest or a research lab in space.

Mapping Greywater

KEY

Create the key by writing in the color or taping a piece of colored straw under each category.

Pure water:

Greywater:

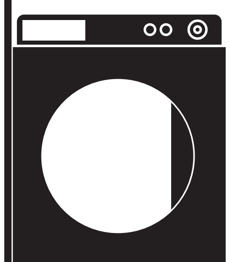
Waste water:

Toilet

Water Quality After Use

Clarity	
Color	
pH	
Other	

Laundry

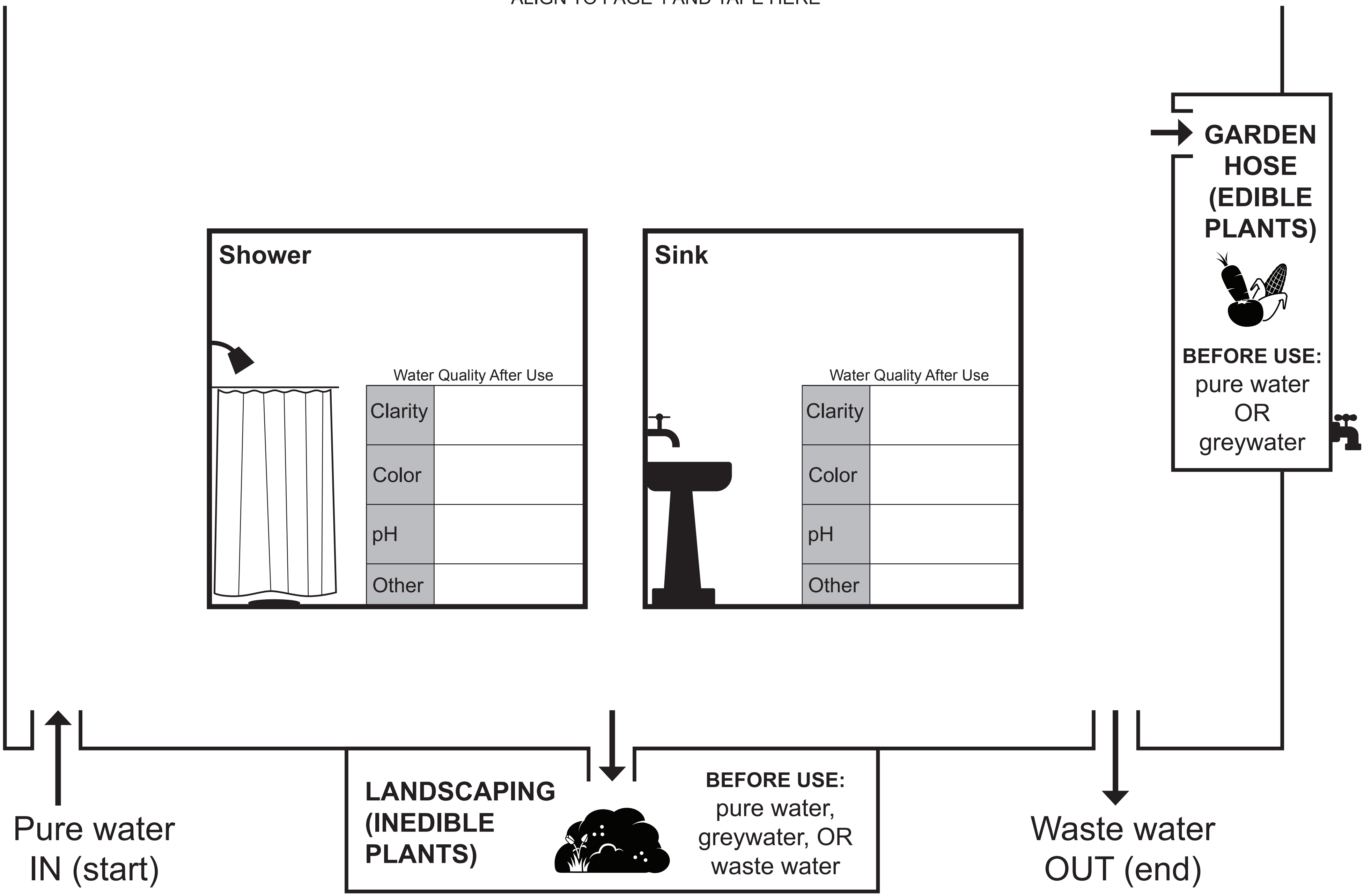


Water Quality After Use

Clarity	
Color	
pH	
Other	

ALIGN TO PAGE 2 AND TAPE HERE

ALIGN TO PAGE 1 AND TAPE HERE



Shower

Water Quality After Use	
Clarity	
Color	
pH	
Other	

Sink

Water Quality After Use	
Clarity	
Color	
pH	
Other	

Page 2

Create a Process

Overview

Youth work in groups to *plan*, *create*, and *test* a water reuse process for an extreme environment.

Note to Educator:

Please note the longer prep time for this activity. Lead this activity in a room with a sink for easy prep and clean up. Have paper towels on hand in case of spills. The pH strips may stain the tabletop, so place used strips on a paper towel. **Be sure to save any materials that can be reused, the water samples, and groups' designs for use in the next activity.**

Activity Timing

Introduction:	10 min
Plan:	5 min
Create and Test:	40 min
Reflect:	5 min
	60 min

21st Century Skill Highlight

Critical Thinking
Collaboration
Creativity

Activity 4 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Extreme Environments* chart, p. 48 in this guide
- ☐ *Investigating Filter Materials* chart, from Activity 3
- ☐ 1 bottle of soap
- ☐ 1 bottle of vinegar
- ☐ 1 cup of soil
- ☐ 1 roll of masking tape
- ☐ 1 roll of paper towels
- ☐ 1 safety glove
- ☐ 1 spool of thread
- ☐ 1 strainer
- ☐ 1 Tbsp detergent
- ☐ 1 teaspoon
- ☐ 1 tube of toothpaste, travel size
- ☐ 1 utility knife
- ☐ 1 vial of food coloring, yellow
- ☐ 1 youth-made water reuse process, from Activity 2
- ☐ 2 tablespoons
- ☐ 2 tea bags, black tea
- ☐ 8 two-liter bottles
- ☐ 8 jars, 1/2 gallon
- ☐ 8 sheets of copy paper
- ☐ optional: 1 roll of plastic wrap

For the Materials Store

- ☐ 1 measuring cup, 1/4 cup
- ☐ 2 cups of activated charcoal
- ☐ 2 cups of limestone gravel
- ☐ 4 cups of sand
- ☐ 8 craft sticks
- ☐ 18 pieces of cheesecloth, 12" x 12"
- ☐ 18 half-sheets of paper towel
- ☐ 20 rubber bands
- ☐ 60 plastic cups, 8 oz.
- ☐ 80 cotton balls

For each group of 3

- ☐ *Water Reuse Plan*, p. 53 in this guide
- ☐ 1 foil tray, 12" x 12"
- ☐ 1 measuring cup, 1 cup
- ☐ 1 packet of pH strips
- ☐ 1 pair of scissors
- ☐ 1 permanent marker
- ☐ 1 Secchi disk
- ☐ 2 Filter Bases

For each youth

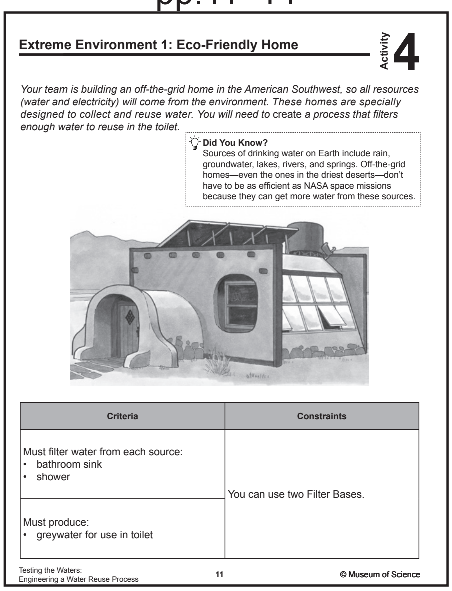
- ☐ Engineering Notebook

Activity 4 Materials Preparation (45 min)

1. Post the *Engineering Design Process* poster.
2. Follow the instructions on *Preparing Filter Bases*, p. 37 in this guide, to make eight more Filter Bases (for a total of 16) if not previously assembled.
3. Post the *Investigating Filter Materials* chart from Activity 3.
4. Create and post the *Extreme Environments: Water Quality* chart, p. 48 in this guide.
5. Prepare new water samples using the recipes on *Water Samples for Final Challenge*, p. 52 in this guide. Use the masking tape and a permanent marker to label them.
6. Using the strainer, rinse the charcoal under running water until the water runs clear (approximately 1 minute).
7. Arrange the water samples and the materials on a table to make a Materials Store. Place the tablespoons with the limestone and charcoal and the 1/4 cup with the sand on the table.
8. Make a copy of *Water Reuse Plan*, p. 53 in this guide, one for each group.

Notebook Pages for Activity 4

Extreme Environments, pp.11–14



Extreme Environment 1: Eco-Friendly Home — Activity 4

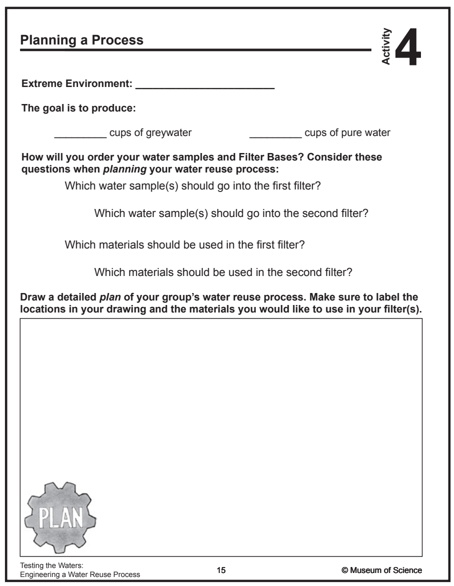
Your team is building an off-the-grid home in the American Southwest, so all resources (water and electricity) will come from the environment. These homes are specially designed to collect and reuse water. You will need to create a process that filters enough water to reuse in the toilet.

Did You Know?
Sources of drinking water on Earth include rain, groundwater, lakes, rivers, and springs. Off-the-grid homes—even the ones in the driest deserts—don't have to be as efficient as NASA space missions because they can get more water from these sources.

Criteria	Constraints
Must filter water from each source: • bathroom sink • shower	You can use two Filter Bases.
Must produce: • greywater for use in toilet	

Testing the Waters: Engineering a Water Reuse Process — 11 — © Museum of Science

Planning a Process, p. 15



Planning a Process — Activity 4

Extreme Environment: ____________________

The goal is to produce:

________ cups of greywater ________ cups of pure water

How will you order your water samples and Filter Bases? Consider these questions when *planning* your water reuse process:

Which water sample(s) should go into the first filter?

Which water sample(s) should go into the second filter?

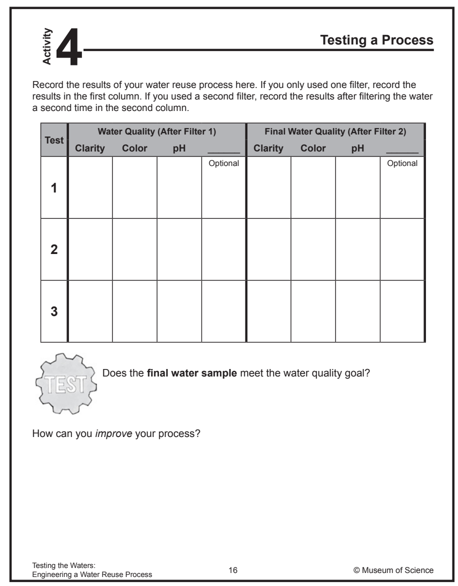
Which materials should be used in the first filter?

Which materials should be used in the second filter?

Draw a detailed *plan* of your group's water reuse process. Make sure to label the locations in your drawing and the materials you would like to use in your filter(s).

Testing the Waters: Engineering a Water Reuse Process — 15 — © Museum of Science

Testing a Process, p. 16



Activity 4 — Testing a Process

Record the results of your water reuse process here. If you only used one filter, record the results in the first column. If you used a second filter, record the results after filtering the water a second time in the second column.

Test	Water Quality (After Filter 1)				Final Water Quality (After Filter 2)			
	Clarity	Color	pH	____ Optional	Clarity	Color	pH	____ Optional
1								
2								
3								

Does the **final water sample** meet the water quality goal?

How can you *improve* your process?

Testing the Waters: Engineering a Water Reuse Process — 16 — © Museum of Science

Chart for Activity 4

Extreme Environments: Water Quality Before Filtering*			
Water Location	**Clarity**	**Color**	**pH**
Bathroom Sink			
Laundry			
Shower			
Space Toilet			

* If your group is using a fourth criteria for water quality, add a column accordingly.

Activity 4 Create a Process

Youth will learn:
- Using the steps of the Engineering Design Process can help guide them to a successful solution.
- Engineers use what they learn in the *identify* and *investigate* steps to inform their design decisions.

Tip

Replay the *Special Report* video from 3:45 to 6:30 to remind youth how engineers at Arcosanti designed a process to reuse water.

Tip

Remember that youth are creating a *process*, or series of steps completed in a certain order, to reuse water.

Tip

A space toilet is different from a toilet on Earth because solid waste is disposed of separately, while liquid waste is collected for reuse.

Introduction (10 min)

1. Let youth know that today they will start the final design challenge: designing a process to reuse water in an extreme environment.
2. Ask youth to think back to the *Special Report* video they watched in Prep Activity 2. Ask:
   - **How do the engineers help solve the problem of water scarcity in an extreme environment?** *They reuse water, they use filters to clean the water and use the water in a certain order.*
3. Tell youth that they will work in groups to *create* and *test* a process for reusing water in an extreme environment, just like the engineers in the video.
4. Display the *Investigating Filter Materials* chart and review the results. Ask:
   - **How can we use this information to help create water reuse processes?** *We can use the information to decide which filter materials might work best to filter the different water samples from each extreme environment.*
5. Have groups turn to *Extreme Environments*, pp. 11–14 in their Engineering Notebooks, and review the extreme environments that groups may choose for their engineering design challenge.
6. Show youth the jars with the water samples you prepared. Explain that they will be ordering and filtering the water from up to four locations: bathroom sink, shower, laundry, and space toilet.
7. Ask for volunteers to come up and measure the water quality (clarity, color, pH, etc.) of each sample. Record their measurements on the *Extreme Environments: Water Quality Before Filtering* chart.

Plan (5 min)

1. Split youth into groups of 3.
2. Have groups choose one of the *Extreme Environments*, pp.

11–14 in their Engineering Notebooks.

3. Hold up one of the water reuse processes groups made from Activity 3 to remind youth that in a water reuse process, both the filter materials and the order that the water flows through the filters are important factors in producing water that is clean enough to be reused.
4. Explain that youth will create a model process on their table tops using the cards from the *Water Reuse Plan* page. They can arrange the water locations in any order they choose, but their process should meet the criteria listed for their extreme environment in their Engineering Notebooks. Ask:
   - **How can we test if the water is clean enough to reuse?** *We can look at clarity, color, pH, etc.*
   - **How will we know which locations the water can be reused at?** *We can test the sample and check the* How Clean Does It Need to Be? *page in our Engineering Notebooks.*
5. Remind youth that although they will have multiple water locations to think about, they will only have two Filter Bases. Youth can use multiple filter materials in each Filter Base, and combine water from multiple locations to send through the Filter Bases.
6. Have groups cut out Location cards and Filter Base cards from the *Water Reuse Plan* page and order the cards on the table to *plan* their water reuse processes. Encourage them to record their ideas on *Planning a Process*, p. 15 in their Engineering Notebooks.

Tip

If youth have struggled with previous lessons or concepts, consider starting them with Extreme Environment 1. Once they are successful, they can select a more challenging extreme environment to engineer for.

Create and Test (40 min)

1. After youth have finished their *plans*, have them gather materials from the Materials Store and begin engineering their process for water reuse using their plan as a guide. Note that the order is not linear; in fact, sometimes two different water sources must go through the same filter.
2. When groups are ready to *test* their process, have them label plastic cups with the name of each water location they will include in their filtering process, then come to the Materials Store. Stir the samples with a craft stick and then pour 1/2 cup of water into their labeled cups.
3. When groups *test* their designs, remind them that they need to record the quality of their final water sample on *Testing a Process*, p. 16 in their Engineering Notebooks.
4. As groups are working, ask:
   - **How have you ordered your water locations?**
   - **Is your process working like you thought it would?**

Tip

Youth can place the Filter Bases directly on top of the Filter Base cards, if they choose.

Tip

Groups can refer to *How Clean Does It Need to Be?*, p. 6 in their Engineering Notebooks, to review the criteria for pure water, greywater, and waste water.

- **Are you meeting the criteria of your Extreme Environment?**
- **How might you *improve* your process?**

5. Let youth know when there are 10 and 5 minutes remaining.

Reflect (5 min)

1. Have youth reflect on the Engineering Design Process. Ask:
   - **Which steps of the Engineering Design Process did you use today?** *We* planned, created*, and* tested *our processes for reusing water.*
2. Let groups know they will get to *improve* their water reuse process in the next activity.
3. Remind youth that after they *improve* their designs, they will get a chance to present their water reuse process and demonstrate the importance of reusing water in extreme environments on Earth and in space.
4. Have youth clean up by rinsing the charcoal and limestone with the strainer and setting them aside for use in later activities. Discard the remaining used filter materials.
5. Have youth rinse their Filter Bases and place them in their tray with their *Water Reuse Plan* cards. Have groups label their tray for next time using a permanent marker and masking tape.
6. Save groups' design components in a safe location so youth can *improve* them in the next activity. Be sure to save the jars with the water samples and the *Extreme Environments* chart for youth to reference while they *improve* their designs.

Tip

Some groups may want to use the charcoal in their processes and let the filter work overnight. Be sure to label their designs, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

Tip

If you have the space, consider saving groups' final water samples or taking pictures so they can compare them to their *improved* samples in the next activity. Be sure to label them, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

Sustainability Tip

To reinforce the idea of sustainability, you can reuse some of the materials in later activities. Rinse and set aside the limestone, charcoal, filter bases, and aluminum trays to be reused.

Water Samples for Final Challenge Groups will share these samples to *test* their water reuse process, 1/2 cup at a time	
Water Location	**Mixtures**
Space Toilet	☐ 1/2 gallon of water ☐ 2 drops yellow food coloring
Shower	☐ 1/2 gallon of water ☐ 1 tsp soap ☐ 1 tsp soil ☐ 2 Tbsp vinegar ☐ 30+ pieces of thread, 1-2” long
Laundry	☐ 1/2 gallon of water ☐ 1 tsp detergent ☐ 1 tsp tea leaves ☐ 1 Tbsp soil
Bathroom Sink	☐ 1/2 gallon water ☐ 1 tsp soap ☐ 2 blobs toothpaste, pea sized

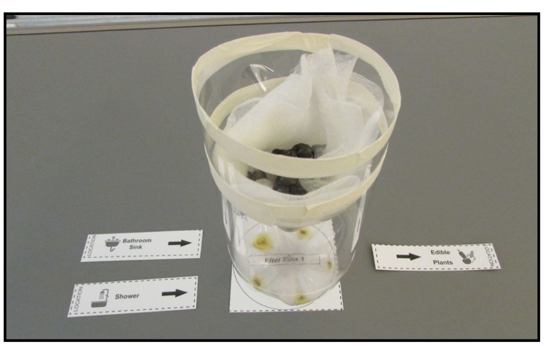
Prepare two jars of each water mixture.

Prepare each mixture in a separate 1/2 gallon jar

Stir well before distributing.

Note: Shaking the jars increases the amount of bubbles in the sample.

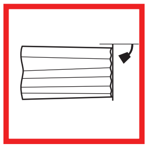
There are 8 cups in a half gallon, so if several groups choose the same scenario, you may need to make an extra jar of the water samples listed in that scenario.

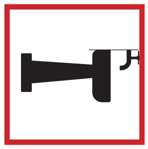


Example Water Reuse Process on Table Top (step one of a process)

Water Reuse Plan

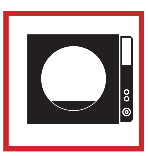
Cut out the boxes and arrange these cards on the table to plan *your water reuse process.*


Shower


Bathroom Sink

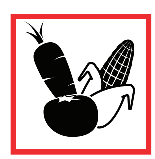
Filter Base 1


Toilet


Laundry

Filter Base 2

Edible Plants



Improve a Process

Overview:

Youth will *improve* their water reuse processes to better meet the criteria for their extreme environment.

Note to Educator:

Lead this activity in a room with a sink for easy cleanup. Have paper towels on hand in case of spills. The pH strips may stain the tabletop, so place used strips on a paper towel. Encourage groups to focus on *improving* their processes. Make sure to provide encouragement and reinforce their identities as successful engineers. **Be sure to save any materials that can be reused, the water samples, and groups' designs for the next activity.**

Activity Timing

Introduction:	5 min
Plan:	5 min
Improve:	35 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Critical Thinking
Collaboration

Activity 5 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Extreme Environments* chart from Activity 4
- ☐ Remaining materials from Activity 4
- ☐ 1 measuring cup, 1/4 cup
- ☐ 1 roll of masking tape
- ☐ 1 roll of paper towels
- ☐ 1 strainer
- ☐ 2 tablespoons
- ☐ 8 craft sticks
- ☐ 8 jars, 1/2 gallon, with water samples
- ☐ 35 sheets of copy paper
- ☐ optional: 1 roll of plastic wrap

For each group of 3

- ☐ 1 foil tray, 12" x 12"
- ☐ 1 packet of pH strips
- ☐ 1 pair of scissors
- ☐ 1 permanent marker
- ☐ 1 Secchi disk
- ☐ 1 set of *Water Reuse Plan* cards
- ☐ 2 Filter Bases

For each youth

- ☐ Engineering Notebook

Activity 5 Materials Preparation (20 min)

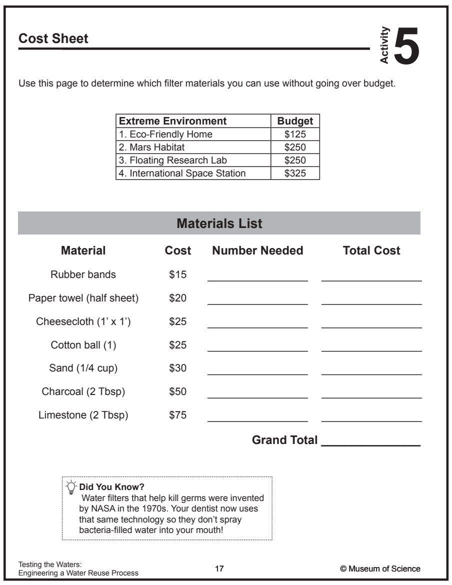
1. Post the *Engineering Design Process* poster.
2. Post the *Extreme Environments* chart from Activity 4 for youth to reference in this activity.
3. Create a Materials Store with the materials remaining from Activity 4.

Activity 5 Materials Preparation (continued)

4. Make copies of the Engineering Showcase invitations, p. 59 in this guide, for youth to share with family and friends.
5. Optional: Prepare more water samples in the jars using the recipes on *Water Samples for Final Challenge*, p. 52 in this guide.
6. Optional: Make a new copy of the *Water Reuse Plan* cards, p. 53 in this guide, if the first copies were damaged by water.

Notebook Pages for Activity 5

Cost Sheet, p. 17



Cost Sheet — Activity 5

Use this page to determine which filter materials you can use without going over budget.

Extreme Environment	Budget
1. Eco-Friendly Home	$125
2. Mars Habitat	$250
3. Floating Research Lab	$250
4. International Space Station	$325

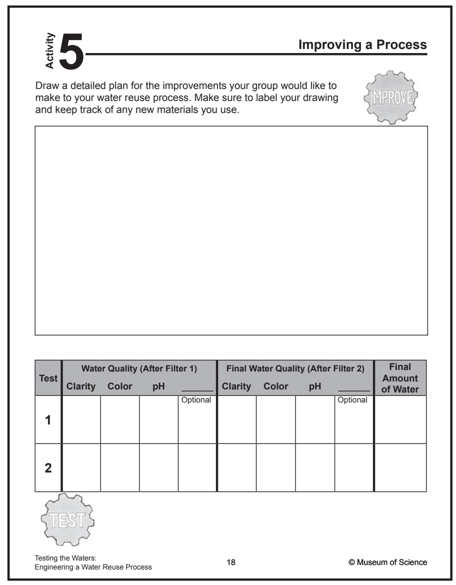
Materials List

Material	Cost	Number Needed	Total Cost
Rubber bands	$15		
Paper towel (half sheet)	$20		
Cheesecloth (1' x 1')	$25		
Cotton ball (1)	$25		
Sand (1/4 cup)	$30		
Charcoal (2 Tbsp)	$50		
Limestone (2 Tbsp)	$75		
		Grand Total	

Did You Know?
Water filters that help kill germs were invented by NASA in the 1970s. Your dentist now uses that same technology so they don't spray bacteria-filled water into your mouth!

Testing the Waters: Engineering a Water Reuse Process 17 © Museum of Science

Improving a Process, p. 18



Activity 5 — **Improving a Process**

Draw a detailed plan for the improvements your group would like to make to your water reuse process. Make sure to label your drawing and keep track of any new materials you use.

Test	Water Quality (After Filter 1)				Final Water Quality (After Filter 2)				Final Amount of Water
	Clarity	Color	pH	____ Optional	Clarity	Color	pH	____ Optional	
1									
2									

Testing the Waters: Engineering a Water Reuse Process 18 © Museum of Science

Improve a Process

Youth will learn:

- The *improve* step allows engineers to reflect upon and alter their original designs.

Tip

Remind youth that they can *improve* by lowering the cost of the process, decreasing the amount of materials they use, or by increasing the quality and/or amount of the water they produce for their final product.

Tip

For some youth, the introduction of the budget may be distracting and too challenging. Encourage these youth to improve their designs in other ways. See suggestions above.

Tip

If youth are having trouble *improving* their designs, encourage them to ask another group for advice.

Introduction (5 min)

1. Congratulate youth on their engineering work so far.
2. Have groups volunteer to share their results, discuss problems, or give advice from the last activity. Ask:
   - **Which scenario did you choose and were you able to meet your goal(s)?**
   - **What is working well in your water reuse process?**
   - **Did your design work the way you *imagined* it would?**
   - **What challenges did you encounter?**
   - **How can you rearrange the process to get more water or to *improve* the quality of the water?**
3. Let youth know that today they will *improve* their water reuse process to make it work better and be more cost efficient. Some groups may have thought of ways to *improve* during the last activity. Today, all groups should continue to work on those improvements.
4. Remind youth that the *improve* step is an important part of the Engineering Design Process. Let youth know that they should *test* all the changes they want to make today before they share their final design with visitors in the next activity.

Planning Improvements (5 min)

1. Tell youth that one way to *improve* their process is to make sure it is not too expensive. Explain that each extreme environment now includes a budget as an additional constraint.
2. Youth can find their budget and the costs of materials on *Cost Sheet*, p. 17 in their Engineering Notebooks.
3. Tell groups that they will now *plan* how they will *improve* their process for reusing water. They should use the data they gathered from their tests last time to choose at least one part of their process to *improve,* and account for the budget.
4. Have youth split into the same groups as the last activity.
5. Give groups 5 minutes to record their *improved* designs on *Improving a Process*, p. 18 in their Engineering Notebooks.

Improve (35 min)

1. When groups have completed their *plans*, have them collect

the materials they need from the Materials Store and begin *improving* their designs.

2. Encourage groups to *test* their designs as they *improve.* Let groups know that they can record new testing data on *Improving a Process,* p. 18 in their Engineering Notebooks.
3. As groups work, rotate among them and ask questions like:
   - **How are you *improving* your design?**
   - **Are your improvements working out the way you thought they would?**
   - **What else can you do to *improve* your design?**
4. As youth finish *testing* and *improving*, congratulate them on their engineering work.
5. Let groups that are still working know when there are 10 and 5 minutes remaining.

Tip

Groups can refer to p. 6 and p. 8 in their Engineering Notebooks to review the procedures for testing water quality and using a Filter Base.

Reflect (10 min)

1. Call groups back together and have them gather around the *Engineering Design Process* poster. Ask:
   - **Which steps of the Engineering Design Process did you use as you were engineering your water reuse processes?** *We* planned *how we wanted to change our design, we* created *and* tested *our designs to* improve *them.*
2. Tell youth that in the next activity, they will prepare a presentation to share their designs and the different ways they used greywater. Ask:
   - **Which steps of the Engineering Design Process do you think you will use to prepare a presentation?** Communicate.
3. Have youth discard used filter materials (except charcoal) and their final water samples, then rinse their Filter Bases and place them in their tray with their *Water Reuse Plan* cards. Have groups relabel their tray if needed.
4. At the end of the session, hand out *Engineering Showcase* invitations for youth to share with family and friends.
5. Save the jars with the water samples and groups' design components in a safe location so youth can share them in the next activity.

Tip

Some groups may want to use the charcoal in their processes and let the filter work overnight. Be sure to label their designs, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

Sustainability Tip

Consider saving materials for when you teach this activity in the future. Rinse and set aside the limestone, charcoal, filter bases, and aluminum trays. Once dry, store any loose materials in airtight containers.

You're Invited...

ENGINEERING SHOWCASE

WHERE:

WHEN:

WHAT:

Come support your local water resource engineers as they present a process for reusing water!

Activity 6

Engineering Showcase

Educator Preview

Overview

Youth *communicate* their ideas about designing a water reuse process in the Engineering Showcase.

Note to Educator:

Lead this activity in a room with a sink for easy cleanup. Have paper towels on hand in case of spills. The pH strips may stain the tabletop, so have youth place their used strips on a paper towel. The Engineering Showcase is an opportunity for youth to share the engineering work they have completed over the course of the unit. Invite parents, peers, and other staff members to come and see what youth have engineered.

Activity Timing

Introduction:	5 min
Preparing:	15 min
Showcase:	30 min
Reflect:	10 min
	60 min

21st Century Skill Highlight

Collaboration
Communication

Activity 6 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ chart paper and markers
- ☐ Remaining materials from Activity 5
- ☐ 1 measuring cup, 1/4 cup
- ☐ 2 tablespoons
- ☐ 8 craft sticks
- ☐ 8 jars, 1/2 gallon, with water samples
- ☐ 60 plastic cups, 8 oz.

For each youth

- ☐ Engineering Notebook

For each group of 3

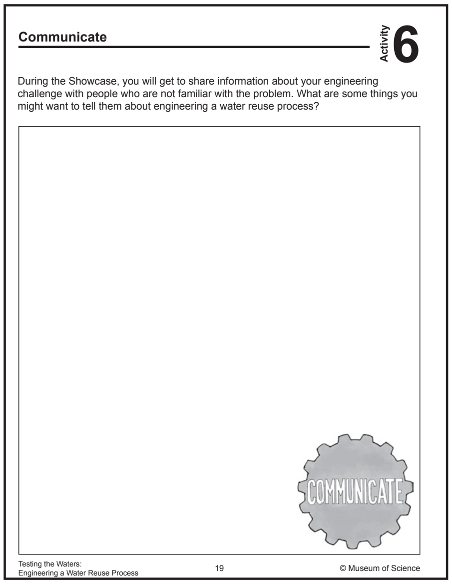
- ☐ 1 foil tray, 12” x 12”
- ☐ 1 measuring cup, 1 cup
- ☐ 1 packet of pH strips
- ☐ 1 pair of scissors
- ☐ 1 Secchi disk
- ☐ 1 set of *Water Reuse Plan* cards
- ☐ 2 Filter Bases

Activity 6 Materials Preparation (15 min)

1. Post the *Engineering Design Process* poster.
2. Create a Materials Table with the materials remaining from Activity 5.
3. If needed, prepare more water samples in the jars using the recipes on *Water Samples for Final Challenge*, p. 52 in this guide.
4. Invite people from the community, including families and friends of youth, to the Engineering Showcase.

Notebook Pages for Activity 6

Communicate, p. 19

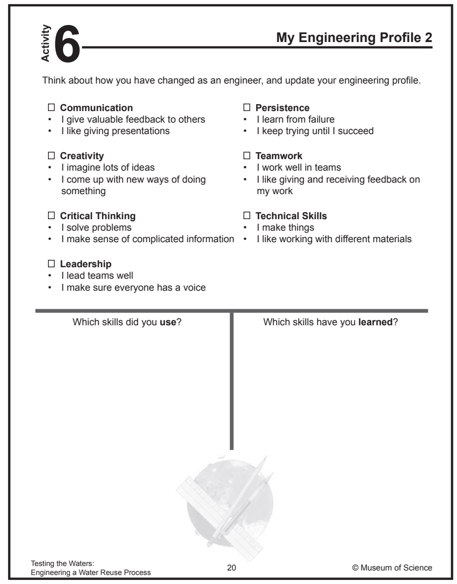


Communicate Activity **6**

During the Showcase, you will get to share information about your engineering challenge with people who are not familiar with the problem. What are some things you might want to tell them about engineering a water reuse process?

Testing the Waters: Engineering a Water Reuse Process 19 © Museum of Science

My Engineering Profile 2, p. 20



Activity **6** **My Engineering Profile 2**

Think about how you have changed as an engineer, and update your engineering profile.

- ☐ **Communication**
  - I give valuable feedback to others
  - I like giving presentations
- ☐ **Creativity**
  - I imagine lots of ideas
  - I come up with new ways of doing something
- ☐ **Critical Thinking**
  - I solve problems
  - I make sense of complicated information
- ☐ **Leadership**
  - I lead teams well
  - I make sure everyone has a voice
- ☐ **Persistence**
  - I learn from failure
  - I keep trying until I succeed
- ☐ **Teamwork**
  - I work well in teams
  - I like giving and receiving feedback on my work
- ☐ **Technical Skills**
  - I make things
  - I like working with different materials

Which skills did you **use**?	Which skills have you **learned**?

Testing the Waters: Engineering a Water Reuse Process 20 © Museum of Science

Activity 6 Engineering Showcase

Activity Guide

Youth will learn:

- *Communicating* with others is an important part of the Engineering Design Process.
- As engineers, they have valuable knowledge to share about the problem they have solved.

Introduction (5 min)

1. Guide youth to review the Engineering Design Process poster and point out the *communicate* step. Remind youth that today they will be *communicating* to others about the water reuse processes they engineered. Ask:
   - **What are the important ideas you think we should present?**
   - **What are some ideas you have about how to successfully *communicate* your work?**

Tip

Instead of giving youth a structure for their group presentation, have them come up with creative ideas of their own. They may want to show a video, or act out different roles in their presentations. As long as they have the inclination and the time, allow them to structure their own presentation.

Preparing the Presentation (15 min)

1. Explain that the Showcase will be split into three parts.
   - First, there will be a whole-group presentation where volunteers explain what they learned about water quality, filter materials, and order, and why these ideas are important for water reuse.
   - Then, they will split into groups and explain their water reuse process. Volunteers from each group will share their designs with the guests, demonstrate the process, and answer any questions they might have.
   - Finally, visitors will have time to explore the designs, speak with groups informally, and ask questions about their water reuse process.
2. The first part of the Showcase will need volunteers to talk about specific things. Write down some possible roles on the board for groups to review:
   - Describe and demonstrate the problem
   - Describe how water reuse and water treatment can help solve the problem
   - Explain the design challenge and the Engineering Design Process
   - Describe and demonstrate how they *investigated* water quality, filter materials, and the order of locations
3. Encourage youth to add topics to the list. Have youth decide who would like to present and assign them roles. Tell youth that they can prepare notes for their group's presentation on

Tip

The presentations should be a time for youth who enjoy presenting, or those who would like to work on this skill, to take a lead role. It is not necessary for all youth to present, though everyone should take part in preparing for the presentation.

Communicate, p. 19 in their Engineering Notebooks.

4. While volunteers are practicing their roles, give groups time to reassemble their water reuse processes or make any other final preparations for the presentation.
5. As groups are preparing, rotate among them and provide support. The process of sharing should be fun and exciting, not stressful!

Engineering Showcase (30 min)

1. When youth are ready, invite guests into the room and explain that they will see a presentation first, and then they will have time to explore the designs and speak with the water resource engineers.
2. Have the volunteers explain the engineering challenge to the visitors.
3. Give each group a few minutes to share their design and demonstrate it by *testing* their process. As groups are *testing*, ask questions like:
   - **What are some things you *investigated* to help you solve this problem?**
   - **What did you test that worked really well? What didn't work so well?**
   - **How did the Engineering Design Process help you reach this final design?**
4. After all groups have shared, allow visitors to walk around to see the water reuse processes and ask the engineers any additional questions they have about the designs.
5. At the end of the Showcase, be sure to congratulate your group on doing a great job with the *communicate* step of the Engineering Design Process and on being water resource engineers. Have youth thank the audience members before concluding the presentation.

Reflect (10 min)

1. Have youth discard used filter materials (except charcoal) and their final water samples, then rinse their Filter Bases and place them in their trays.
2. Remind youth that there is always room for improvement and encourage them to think about what they would do if they had more time with the challenge.
3. Encourage youth to reflect on the Engineering Design Process. Ask:
   - **Which steps of the Engineering Design Process were most helpful to you?**
   - **Can you *imagine* other problems you might solve using the Engineering Design Process?**

4. Congratulate groups on their excellent engineering work.
5. Give youth time to complete *My Engineering Profile 2*, p. 20 in their Engineering Notebooks. Giving youth time to record their thoughts will help them reflect on and wrap up the experiences they had throughout the unit.
6. Gather youth as a group. Ask:
   - **What are you most proud of doing as part of this engineering group?**
   - **Are there other water conservation problems you would like to solve as a water resource engineer?**
   - **Why do you consider yourself an engineer?**

Sustainability Tip

Consider saving materials for when you teach this activity in the future. Rinse and set aside the limestone, charcoal, filter bases, and aluminum trays. Once dry, store any loose materials in airtight containers.