

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).



PLAN

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

Testing a Process, p. 16

Testing a Process Activity **4**

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								

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

How can you improve your process?

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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.

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.

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?**

- **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


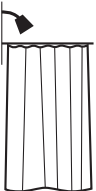


If you have the space, consider saving groups' final water samples or taking pictures so they can compare them to their *improved* samples in the next activity. Be sure to label them, cover them with plastic wrap to prevent evaporation, and store them in an area where the water will not spill.

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	<input type="checkbox"/> 1/2 gallon of water <input type="checkbox"/> 2 drops yellow food coloring
 Shower	<input type="checkbox"/> 1/2 gallon of water <input type="checkbox"/> 1 tsp soap <input type="checkbox"/> 1 tsp soil <input type="checkbox"/> 2 Tbsp vinegar <input type="checkbox"/> 30+ pieces of thread, 1-2" long
 Laundry	<input type="checkbox"/> 1/2 gallon of water <input type="checkbox"/> 1 tsp detergent <input type="checkbox"/> 1 tsp tea leaves <input type="checkbox"/> 1 Tbsp soil
 Bathroom Sink	<input type="checkbox"/> 1/2 gallon water <input type="checkbox"/> 1 tsp soap <input type="checkbox"/> 2 blobs toothpaste, pea sized

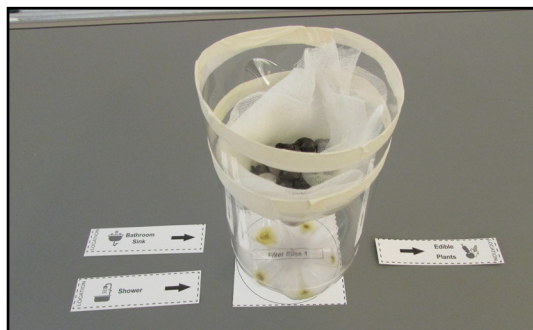
Prepare two jars of each water mixture.

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.

