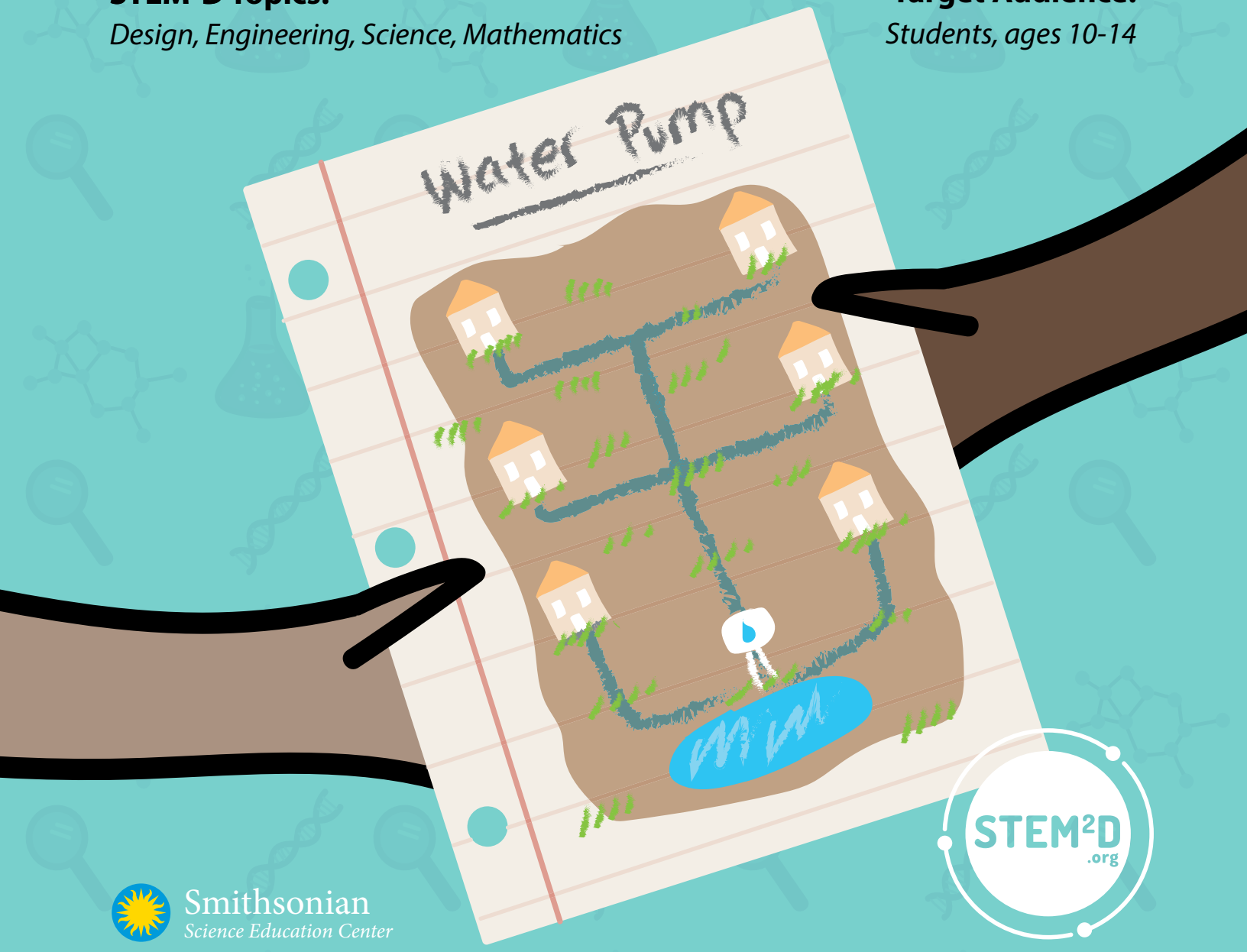
WHERE DOES THE WATER GO?

CALCULATING A NEIGHBORHOOD WATER FOOTPRINT

STEM²D Topics:
Design, Engineering, Science, Mathematics

Target Audience:
Students, ages 10-14



STEM²D .org

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WHERE DOES THE WATER GO? CALCULATING A NEIGHBORHOOD WATER FOOTPRINT is part of the STEM²D Student Activity Series. The content and layout were both developed by the Smithsonian Science Education Center as part of Johnson & Johnson's WiSTEM²D initiative (Women in Science, Technology, Engineering, Mathematics, Manufacturing, and Design), using a template provided by FHI 360 and JA Worldwide. This series includes a suite of interactive and fun, hands-on activities for girls (and boys), ages 5-18, globally.

Design and illustrations by Sofia Elian

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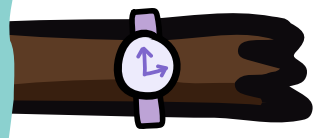
ACTIVITY DESCRIPTION

In this water conservation activity, students will have fun as they work in teams to calculate the water usage of the different households on Sunnybrook Circle, an imaginary neighborhood. They will discover, using the information and materials provided for them, if the water district has enough water to meet the demands or if water restrictions need to be put in place. Students will design and build a "pumping station" to meet the challenge of moving the water they need from the reservoir to their house. In addition to problem-solving, decision-making and creativity, students use interpersonal skills needed in STEM²D careers such as presenting ideas, negotiating, organizing and working as a collaborative team.



ESTIMATED TIME:

This activity typically takes 1 hour to complete and should be done in one session.

STUDENT DISCOVERIES

Students will:

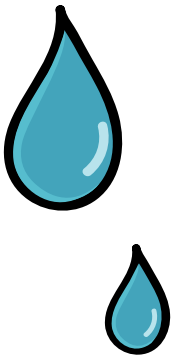
- Participate in a team-based learning experience.
- Learn how STEM²D—science, technology, engineering, mathematics, manufacturing, and design—subjects are used in water conservation.
- Build important STEM²D skills, ssuch as estimation, decision-making, and problem-solving.
- Consider STEM²D concepts including, volume, conservation, and energy.
- Become aware of their own water footprint and how they can help conserve water.

- Recognize that STEM^{2}D offers diverse and exciting career opportunities, including those connected with sourcing, delivering, purifying, and conserving water.
- Have fun experiencing STEM^{2}D.

GETTING READY

Materials: Suggested materials preparation prior to the activity with students.

- Activity Leader Checklist
- Tell My Story form
- 1 Student Assessment Handout per student
- 1 Gallon water jug, filled with water



For each team (four students each):

- 1 Clear plastic bag containing:
  - 1 Plastic syringe (60 ml)
  - 5 Lengths of airline tubing (30 cm each)
  - 4 Connectors
  - 1 Three-way valve
  - 2 Beakers (1000 ml each)
  - 1 Measuring tape
  - 1 Graduated cylinder (100 ml)
- 1 Sunnybrook Circle Household Description card
- 2 Sheets of white construction paper (30 cm x 45 cm)
- Crayons or colored markers
- 2 Water Usage Estimate forms
- 2 US Department of Interior Water Usage Scale sheets
- 2 Water Footprint sheets
- 4 Clear plastic cups to hold the colored discs separated by color
- Colored plastic discs, green, blue, yellow, and red
  - 50 green = 1 gallon each
  - 20 blue = 10 gallons each
  - 20 yellow = 50 gallons each
  - 10 red = 100 gallons each
- Certificates (optional), 1 per student
- Camera (optional)

Estimated Materials Cost:
Activity leaders can expect to spend no more than $250 (assuming crayons or colored markers are available) in material costs when completing this activity with 24 students organized into six teams of four students each.

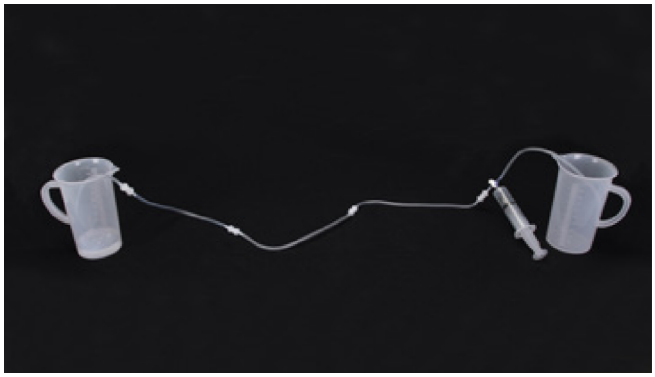
ACTIVITY LEADER PREPARATION

1. Read **Spark WiSTEM²D.** This is essential reading for all volunteers interested in working with youth, as it provides important background knowledge about STEM²D, strategies for engaging female students, and tips for working with groups of students. Download at STEM²D.org.

2. Review the **Activity Leader Checklist** for details and specific steps for planning and preparing to implement this activity.

3. See the **STEM²D Student Activities Overview** for additional information.

4. Prepare in a plastic bag all the materials needed for the Pump Station.



Engineering design Pump Station using the materials provided for this activity.

STEP-BY-STEP ACTIVITY:

WHERE DOES THE WATER GO? CALCULATING A NEIGHBORHOOD WATER FOOTPRINT

Welcome and Introductions (10 minutes maximum with this age group)

- Greet the students.
- Tell the students your name and your organization/company. Talk about your educational and career path. Use the **Tell My Story** form as a basis

for your remarks. Be prepared to describe your job or a typical day, and provide information about your background including:

  - Your education – focus on secondary and post-secondary classes and courses
  - Current work projects
  - Interests and hobbies

- Why you love STEM²D, and how your work is connected.
- Write your introduction ideas here.

TIPS FOR STARTING CONVERSATIONS:

Conversation Starters are provided throughout and include questions designed to introduce students to the activity topics. Use the questions—modify them, or add others—to engage your students.

- Ask the students or any volunteers helping today to introduce themselves.
- Use Conversation Starters to learn more about the students and their interests.
- Discuss the opportunities that exist in the local community to support students as they develop their interests and personal experiences.
- Tell the students that your career is only one of the many careers available in STEM²D – science, technology, engineering, mathematics, manufacturing, and design.
- Explain that STEM²D careers are **high-demand**, **high-growth careers** and are predicted to remain in demand over the next 10 years.
- Some STEM²D careers do not require a college degree and offer young people exciting, high-paying opportunities. Stress the importance of gaining mathematics skills and engineering practices to succeed in any STEM²D career.

CONVERSATION STARTERS: *CAREER PLANNING*

- When you consider your future, what are you most excited about?
- Do you see yourself working with others, for a large company, with your friends, for yourself? Why or why not?
- What does the perfect work day look like to you? Are you outdoors? Are you working alone, or with others? Do you solve problems? Do you fix or build things?

Instructions (40 minutes)

- Divide the students into teams of four. You may want teacher input into the grouping for inclusion and diversity for this activity.
- Direct the students' attention to the gallon of water placed in the front of the room.
- Ask the students how many gallons of water they think they use in a day.
- Go through each direct water usage category on the Water Usage Estimate Form and try to reach a class average estimate for each of the following:
    - Brushing teeth
    - Washing hands and face
    - Shower/Bath
    - Toilet flush
    - Dishwasher
    - Clothes washer
    - Drinking
- Ask the students to think of "indirect ways" water is used in their lives and homes which are not being calculated. Ideas may be: water for cooking, water in foods, and food production.
- Have them fill out their Water Usage Estimate Form. They may work in pairs or as a team. They should be prepared to share their estimates, so a class average can be calculated for each category.
- Hand out the US Department of Interior Water Usage Scale.
- Discuss the estimated average used by the DOI (Department of the Interior) to determine water usage.
- How close did the class numbers come to the DOI numbers?

- If there is a large number difference, ask the students to explain why this may be.

Calculating the Water Usage of the Springbrook Neighborhood

- Hand out one Sunnybrook Circle Household Description card to each team.
- Hand out 2 sheets of white construction paper to each team.
- Hand out 2 Water Footprint Sheets to each team.
- Each team should:
    - Read their Sunnybrook Circle Household Description card.
    - On a sheet of construction paper, draw the house as they imagine it on Springbrook Circle with the house number included.

Students will estimate how much water pets require.

    - On a second sheet of construction paper, draw the face of each family member and pets and/or other water usages mentioned. Leave space for recording the estimated number of gallons of water that each person or pet and other usage requires in one day.

See example on next page:

			
Gallons of Water	**Gallons of Water**	**Gallons of Water**	**Gallons of Water**
Total Number of Gallons of Water needed for one day for this Household			

  - Use the Department of the Interior Water Usage Scale and the Water Footprint Sheets to estimate the water usage for each family member, pet or usage and record that number under each face, pet or use.
  - Add up the total number of gallons of water needed for the household and put at the bottom of the construction paper.

- J&J volunteers should visit each team as they work and ask open-ended questions that will lead them to problem-solving:
  - What challenges are you having in estimating the amount of water your household would use?
  - Did your household have any usages that were not on the DOI sheet? How did you estimate the amount of water used?
  - Do you agree with the number of gallons the Department of the Interior says are used for each category?
  - Do you think there is any unnecessary use of water?
- When all the Teams have estimated the total gallons of water their household needs for a day, they need to consider the problem of getting the water to their household by designing a pump station to get the raw water from the reservoir where it is stored (beaker 1) to the water district (beaker 2) where it is purified before coming through the water mains to the households.
- Students may need to be introduced to the terms "criteria" and "constraints" in order to better contextualize the "pump station" challenge.

Note that the criteria (goals) for this activity are:

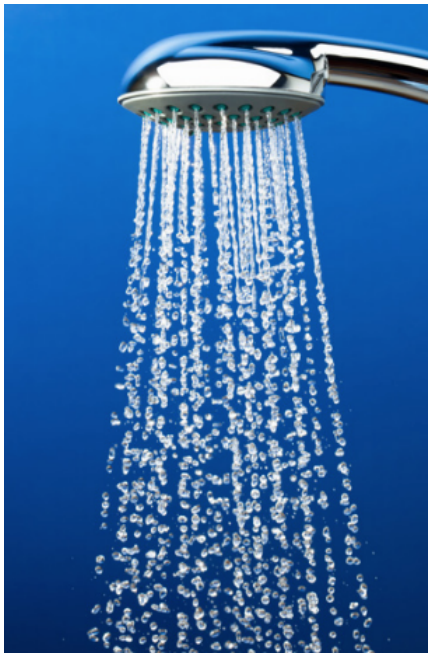
a. Students must move the amount of water that is needed for their household from one bucket to another bucket

(1 gallon = 1 ml)

The constraints (limits) for this activity are:

a. The buckets must be 100 cm away

b. Use only the materials provided in the plastic bag



A 5-minute shower uses approximately 25 gallons of water

- All the materials they need are in the plastic bag marked Pump Station. This is an exercise in engineering design so there is no one "right way" to prepare the setup. See the materials list for all the items that should be in each Pump Station bag.
- Once the students have the pump station working, they must pump in milliliters, the number of gallons their household needs from the reservoir to the Water District. For example, if the students with Household Number 1167 have estimated that their house needs 290 gallons of water a day, that means the students have to pump 290 ml of water from the reservoir (beaker 1) to the Water District (beaker 2).
- After they have pumped the water, they can now go to the Water District (managed by a J&J volunteer) and receive colored discs representing the number of gallons needed for their household. Four clear plastic cups should be filled with the colored discs as follows:
    - 50 green = 1 gallon each
    - 20 blue = 10 gallons each
    - 20 yellow = 50 gallons each
    - 10 red = 100 gallons each
- Altogether, the colored discs equal 2,250 gallons of water. Tell students that the four cups filled with colored discs represent the water available for the neighborheed. Students will see the number of gallons of water (colored discs) decreasing in the clear plastic cups.
- Discussion: Was there enough water to go around? A 10% cut in water would be 2,025 gallons and a 20% cut would be 1,800 gallons, which could cause a water shortage. What if the available water supply was cut by 10%? 20%?
- Discuss what water usage restrictions might be needed for there to be enough water for the neighborhood in the future.
- Discuss the Pump Station design challenges in getting water from where it is stored to where it is needed.
- Because most of our freshwater comes from underground, ask the students about the energy that might be needed to bring it to the surface.

- Have each team pick one person to report out the work of their team, their household and the number of gallons of water used in a day. Report any unnecessary use of water that might come under a restriction.
- As a class discuss any patterns they see in the water usage.
- Tally how many gallons each household thinks they can conserve.
- Give positive feedback after each team presentation and encourage the other teams to applaud their work.
- This is a good time to take pictures of each team.
- Ask to have the Household pictures displayed around the room for others to see and compare the water usage.

Student Reflection (10 minutes)

- Distribute the Student Handout. Have the students reflect on this activity by answering the following questions:
    - What did you learn from this activity?
    - Was it fun? What made it fun?
    - Are there ways you feel you could help conserve more water?
    - How might you encourage water conservation in your community?
    - What was your biggest challenge in completing the activity?
    - Think back to the pumping station. What did you learn about moving water from one place to another?
- After a few minutes ask the students to share their thoughts. If time permits, have the students discuss their response to the following question:
    - Before this activity, have you ever thought about how much water a household uses each day?
    - Were you surprised by the amount of water people use?
    - Were you surprised by the amount of energy it takes to move water from where it is stored in a reservoir or underground to where it is needed for household use?
- Thank the students for participating
- This is a great time to present each student with a certificate that has been prepared ahead of time with each student name and signed by the Johnson and Johnson volunteer.

EXTENDED LEARNING

Here are a few ways to extend the learning:

1. Design a study to find out how much water is used in different ways within the school.
2. Are there ways your school can help conserve water?
3. Research from where your local water district receives its water. Is that an unlimited resource or could there be a shortage in the future?
4. Research the global water issue. How does it impact your life?
5. Students can play the game "Aquation: The Freshwater Access Game" found here for free https://ssec.si.edu/aquation. This game introduces students to the challenges of moving freshwater worldwide to where it is most needed.

VOCABULARY:

ESTIMATE: An approximate calculation or judgment of the value, number, quantity, or extent of something

DEPARTMENT OF INTERIOR: The United States Department of the Interior (DOI) The United States federal executive department of the U.S. government responsible for the management and conservation of most federal land and natural resources among other responsibilities

WATER FOOTPRINT: A measurement of the amount of water used to produce each of the goods and services we use and humanity's appropriation of freshwater in volumes of water consumed and/or polluted

RESERVOIR: A large natural or artificial lake used as a source of water supply.

ACTIVITY LEADER REFLECTION

After the activity, take a few minutes to reflect on the following:

- What went well and what could be improved?
- What would you do differently next time?
- How comfortable did you feel leading the discussions? Do you have a better understanding of the STEM²D concepts?
- How useful was the information presented in the **Spark WiSTEM²D** to implementing this activity?
- Will you volunteer for this type of experience again?

Resources and References

- US Department of Interior:
  https://water.usgs/gov/edu/ga-home-percapita.html

Smithsonian Science for the Classroom™

How Can We Provide Freshwater to Those in Need? is part of a new curriculum series developed by the Smithsonian Science Education Center. It is aligned to a subset of 5th grade NGSS performance expectations, with a focus on engineering design. In this module, students will explore the topic of water scarcity and the various ways humans have attempted to get water from where it is (such as groundwater) to where it is needed.

South Sudanese children get the daily ration of water

ACTIVITY LEADER CHECKLIST:

DID YOU . . .

- ☐ Read Spark WiSTEM²D? This is essential reading for all volunteers interested inworking with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students. Download at www.STEM2D.org.

- ☐ Visit the implementation site and observe the young people? (optional) If visiting, take note of the following:
  - ☐ How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
  - ☐ What does the site do to make each student feel important and at ease?
  - ☐ How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - ☐ How can you engage the site representative in your presentation?
- ☐ Meet with and finalize the logistics with the Site Representative?
  - ☐ Confirm the date, time, and location of the activity?
  - ☐ Confirm the number of students attending? Knowing this will help you decide how to group the students into teams, as well as the appropriate materials to purchase.
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the Tell My Story Form, which will prepare you to talk about your educational and career path with the students?
  - ☐ If teams are needed for this activity, please ask the teacher in advance to organize the students into teams.
- ☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:
  - ☐ Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
- ☐ Obtain the required materials (see the Materials and Estimated Materials Costs sections) and, if asked for in the Getting Ready section, photocopy the Student Handouts and Materials Testing Sheets. In addition:
  - ☐ Organize the materials to ensure each team has everything listed in the Materials section—keep in mind some materials are shared among the teams.
- ☐ Prepare the space? Specifically:
  - ☐ Make sure tables and chairs are arranged to accommodate teams of students.
  - ☐ Bring a camera, if desired, to take photographs.
- ☐ Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- ☐ Have fun!

Tell My Story Form

This form will help volunteers serving as activity leaders prepare to talk about their **STEM²D** interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM²D? _____

_____

_____

What do you hope young people, especially females, will get out of this activity? _____

_____

FUN FACT

Share a little about your background. Ideas:

- Share a memory from childhood where you first had your spark or interest in STEM.
- Detail your journey; highlight what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most?

_____

_____

How did you know you wanted to pursue a STEM²D career?

_____

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why to the students.*

_____

_____

What your current position entails. *Be sure to include how you use STEM²D on a typical work day.*

_____

_____

WATER FOOTPRINT SHEET

House Number_____ Family Name_____

USAGE	ESTIMATED GALLONS
Brushing Teeth 	
Washing Hands and/or Face 	
Shower 	
Bath 	
Toilet Flush 	
Dishwasher 	
Dishes by Hand 	
Clothes Washer 	
Drinking 	
Outdoor Watering (hose) 	
Pets 	
Other	

WATER FOOTPRINT SHEET

House Number_____ Family Name_____

USAGE	ESTIMATED GALLONS
Brushing Teeth 	
Washing Hands and/or Face 	
Shower 	
Bath 	
Toilet Flush 	
Dishwasher 	
Dishes by Hand 	
Clothes Washer 	
Drinking 	
Outdoor Watering (hose) 	
Pets 	
Other	

US DEPARTMENT OF INTERIOR
WATER USAGE SCALE

WATER USAGE	ESTIMATED AMOUNT IN GALLONS
Brushing Teeth 	.5
Washing Hands and/or Face 	1
Shower 	25 (5 minutes)
Bath 	40
Toilet Flush 	4
Dishwasher 	15
Dishes by Hand 	30
Clothes Washer 	35
Drinking 	.25
Outdoor Watering (hose) 	2 Gallons/minute
Pets 	
Other	

SUNNYBROOK CIRCLE
HOUSEHOLD DESCRIPTIONS

1164 SUNNYBROOK CIRCLE
THE ENRICO SANCHEZ FAMILY

Enrico and his wife, Maria, have five children ages 3, 6, 8, 11, and 14. They live in a newly built, energy efficient home. Enrico is the mechanical engineering instructor at the local vocational school and Maria also works there full-time as the school librarian. Maria's mother takes care of 3-year-old Susanna at their home during the day while the other children are in school. Maria washes two loads of clothes every day and runs the dishwasher after each meal.

1165 SUNNYBROOK CIRCLE
MS. SILVIA CORBEIL

Silvia lives by herself in her ranch style home. Her husband passed away last year. She owns the most property on the circle which has a small barn for her horse. There is plenty of room for the horse, Wave, and her German shepherd, Rex to run. Silvia volunteers most days for a few hours for Meals on Wheels. She doesn't use the dishwasher and washes clothes every two days.

1166 SUNNYBROOK CIRCLE
THE RAMESH SABETIASHRAF FAMILY

Ramesh and his wife, Rhianna, have two children who are 9 and 12 and they live in a 2-story house. Ramesh is a chemical engineer for Johnson & Johnson and works in his lab every day. Rhianna works from home as a computer programmer. Their two boys are very active in sports and have turned their backyard into a small soccer field which they keep green by watering it for 20 minutes a day. Rhianna uses the washing machine and dish washer daily.

1167 SUNNYBROOK CIRCLE
THE HAK CHEN FAMILY

Hak, Lee, and Kim Chen are all adults living in a small, modest home that has a huge vegetable garden in the back and flower gardens and shrubs all around the house. Kim Chen is the gardener. She waters her gardens and plants for half an hour each day. The clothes washer and dishwasher are used every other day. Lee, who is physically disabled works from home writing articles for a science journal. Kim loves being at home assisting Lee. Hak is a pharmacist at the local CVS drugstore.

1168 SUNNYBROOK CIRCLE
THE WESTON WASHINGTON FAMILY

Weston and his wife, Debra, and their daughter, Ella, live in the oldest 2 story house on the circle. They have been doing a lot of remodeling and have added a large patio and kidney-shaped swimming pool in the back of the house. Ella is in the 6th grade and loves swimming. Weston is a high school mathematics teacher and Debra teaches music at Ella's middle school. The kitchen is still under construction and as yet, doesn't have a dishwasher. A load of clothes is washed daily and the pool requires 10 minutes of water from the hose each day to keep up with evaporation on sunny days. The Washington's have 2 Scottie dogs, Mosely and Matti.

1169 SUNNYBROOK CIRCLE
THE BOYD BRIGGS FAMILY

Boyd and Karen Briggs are both retired living a peaceful life in their brick-front ranch home with their tabby cat, Missy. They take care of their little grandson, Nicholas, during the day so their daughter can work at the local nursing home. Boyd loves to tinker with old car which requires his clothes to be washed daily. Karen has lots of potted plants in their sunroom and also outside on the patio. The patio has a small fish pond filled with goldfish where Missy sits for hours hoping to catch one.

WHERE DOES THE WATER GO? CALCULATING A NEIGHBORHOOD WATER FOOTPRINT

Student Handout

Think about the activity. Record your answers to the questions using phrases or pictures in the space provided.

What did you learn from this activity?

Was it fun? What made it fun?

Are there ways you feel you could help conserve more water?

How might you encourage water conservation in your community?

What did you learn about moving water from one place to another?

What was your biggest challenge in completing the activity?

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