Creating Meaningful Outdoor Experiences

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- Cleaning up Great Lakes Areas of Concerns
- Preventing and Controlling Invasive Species
- Reducing Nutrient Runoff that Contributes to Harmful Nuisance Algal Blooms
- Restoring Habitat to Protect Native Species

B-WET Program

Groundswell

GRAND RAPIDS PUBLIC MUSEUM | *Be curious.*

G-GOAL Common Unit | Table of Contents

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G-GOAL Common Unit Introduction

This common unit is intended to provide students with a Meaningful Watershed Educational Experience (MWEE) centered on the Great Lakes Watershed. By the end of the unit, students will implement a stewardship project within their community and will have a better understanding of their role in the Great Lakes Ecosystem.

These units guide students through the four stages of a Meaningful Watershed Educational Experience. The sequence of a MWEE, outlined by the NOAA Bay Watershed Education and Training (B-WET) Program, is:

1. Issue definition and background research
2. Outdoor field activities
3. Stewardship action projects
4. Synthesis and conclusions

Lessons were designed for students in fifth grade through high school. This unit addresses Michigan K-12 Science Standards, developed from the Next Generation Science Standards (NGSS), and Michigan K-12 Social Studies Standards. Place-based examples of these standards will be supplemented with Great Lakes Literacy Principles and with an emphasis on the four major focus areas of the Great Lakes Restoration Initiative (GLRI) Action Plan:

1. Cleaning up Great Lakes Areas of Concern
2. Preventing and controlling invasive species
3. Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
4. Restoring habitat to protect native species

Tips on using the lessons:

- Many of these lessons will require longer than one class period to complete. Each lesson is arranged by important components of a MWEE rather than by traditional class periods. This unit is intended to span across the whole school year, culminating with a community display of student work to share the impact of their stewardship project.

- Student reflection time is intentionally built in throughout many of the lessons. When embarking on a place-based, stewardship-focused unit of study it is crucial to have student buy-in and investment. Dedicating time for students to process the experiences and reflect upon their personal growth and attitude can support these goals.

Best of luck in your work facilitating student-led environmental stewardship!

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Unit Organization and Sequence

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This second step calls for students to get outside and gather information about the issue they've chosen to research. Lessons 5 through 7 are examples of ways to get students outdoors and investigate different focus areas in the Great Lakes Ecosystem. They do not need to be completed in order, and you are encouraged to conduct outdoor field activities related to the issue your students are passionate about.</td></tr>
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Sequence based on:

National Oceanic and Atmospheric Association. (2017). *Meaningful Watershed Educational Experiences (MWEEs) for Students.* Retrieved from https://www.noaa.gov/education/explainers/noaa-meaningful-watershed-educational-experience

Lesson 1: Introduction to Environmental Stewardship and the Great Lakes

Overview

This introductory lesson is intended to encourage students to reflect on the uniqueness of the Great Lakes and on their personal connection to the natural world. This lesson will introduce the term *stewardship* and ask students to discuss their feelings upon starting a Groundswell unit that will culminate in a meaningful stewardship project.

Curriculum Connections

Michigan K-12 Science Standards

- Earth's Systems
    - MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Michigan K-12 Social Studies Standards

- 6 – G1 .3 .3 Explain the different ways in which places are connected and how those connections demonstrate interdependence and accessibility.
- 6 – G5 .1 .3 Identify ways in which human-induced changes in the physical environment in one place can cause changes in other places.

Great Lakes Literacy Principle(s)

#1 - The Great Lakes, bodies of fresh water with many features, are connected to each other and to the world ocean.
#6 - The Great Lakes and humans in their watersheds are inextricably interconnected.

Focus Areas of GLRI Action Plan

N/A

Key Questions

- What is the Great Lakes Ecosystem (GLE)?
- What does it mean to be an environmental steward?
- How are the Great Lakes interconnected?

Student Objectives

- Students will begin to think about their relationship to their natural environment.
- Students will reflect on their personal responsibility to protect the Great Lakes.
- Students will be able to explain how the Great Lakes are connected to each other and to the ocean.
- Students will discuss their pre-existing ideas about stewardship, as well as what they expect the Groundswell project to be like.

Vocabulary

Stewardship
Great Lakes Ecosystem

Materials List and Setup

- Computer
- Projector
- YouTube “Water | Great Lakes in Michigan | Pure Michigan” (0:32) https://tinyurl.com/yc6l4rtg
- YouTube “Long Live Summer: Experience the Lake Effect | Pure Michigan” (0:59) https://www.youtube.com/watch?v=xbtXsORiW_g
- Google map: “Journey to the Atlantic Ocean” https://www.google.com/maps/d/u/0/embed?mid=1QA17L4H_yKYAdyrNAxOQq_bNYarqC7ZT
- Student journals or papers for writing prompt

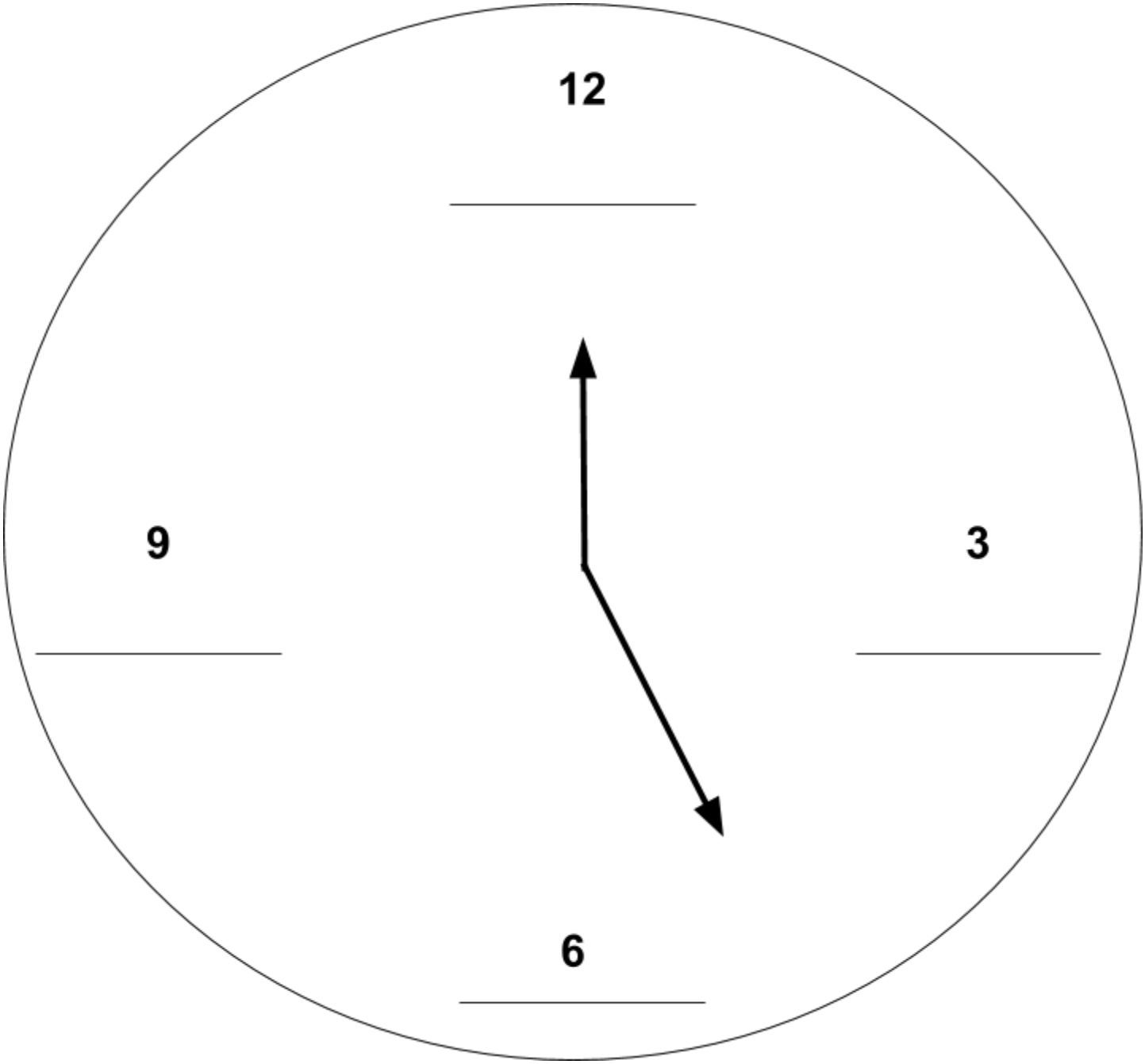
Program Activities

1. Engage:
    a. Materials:
        i. Computer
        ii. Projector
        iii. YouTube “Water | Great Lakes in Michigan | Pure Michigan” (0:32) https://tinyurl.com/yc6l4rtg
        iv. YouTube “Long Live Summer: Experience the Lake Effect | Pure Michigan” (0:59) https://www.youtube.com/watch?v=xbtXsORiW_g
        v. Student journals or papers for writing prompt
    b. Procedures:
        i. Watch the short Pure Michigan videos about the Great Lakes.
        ii. Discuss: How do you feel after watching these? These types of videos are meant to emphasize the special features of our state, most importantly the great fresh water resource of the Great Lakes.
            1. The instructor is encouraged to share a memory about the Great Lakes that is significant to them. Share something that makes you proud to live near the Great Lakes.
        iii. Journal Prompt:
            1. Describe the experiences you’ve had with the outdoors growing up and any memories surrounding the Great Lakes.
            2. What would you say your attitude is toward nature?
2. Explore: Introduce the path water takes as it moves from the Grand Rapids Public Museum (GRPM) in downtown Grand Rapids all the way through to the Atlantic Ocean!
    a. Materials:
        i. Computer
        ii. Projector
        iii. Google map: “Journey to the Atlantic Ocean: https://www.google.com/maps/d/u/0/embed?mid=1QA17L4H_yKYAdyrNAxOQq_bNYarqC7ZT
    b. Procedures:
        i. This Google Map follows the path of a drop of water through the entire journey from falling as precipitation on an urban sidewalk, downtown Grand Rapids, all the way out to the Atlantic Ocean.
        ii. Walk students through the map on a projector. Start with the broad, zoomed out view to show there is an interconnected system all the way from the pavement around us to the Atlantic Ocean! Each stop along the map is numbered and labeled.
        iii. This is intended as an introduction to the interconnectedness of the Great Lakes system. How we treat our water on the ground near our homes or schoos truly impacts the water quality in all of these locations along the journey. We

are connected to the world's oceans, so our personal actions really do matter and have a wide-ranging impact.

3. Explain
    a. Procedures:
        i. How does an understanding of the Great Lakes as a big, connected water body shape the way you think about how you treat the water around you?
        ii. Introduce the following quote to your students from President Jimmy Carter;
            1. "We are stewards of an irreplaceable environment. This is an awesome task as well as a precious gift." - President Jimmy Carter
            2. Environmental stewardship refers to responsible use and protection of the natural environment through conservation and practices that will keep ecosystems functional for the future.
            3. Explain to students that the ultimate goal of this Groundswell unit will be to create a stewardship project that will do just that. They will do something to truly make a difference in their community!
4. Elaborate/Extend:
    a. Materials:
        i. Projector or white board
        ii. Clock Discussion Partners worksheet (1 per student)
    b. Procedures:
        i. Have students talk in small groups, speed-dating style, about the following prompts related to stewardship.
            1. Use the clock partners strategy as a quick way to mix around talking partners.
                a. Before the activity, have students find a partner and write each other's names in the clocks at each of the four time slots--12:00, 3:00, 6:00, and 9:00.
        ii. To get into discussion partners, call out a certain time on the clock and have students quickly group up with that partner to discuss the prompt.
        iii. Reveal each prompt at the appropriate time on the projector or white board.
            1. Do you feel young people can make a difference? Why or why not?
            2. Do you think the Great Lakes ecosystem is worth protecting? Why?
            3. What do you think participating in this Groundswell service project is going to be like?
            4. Have you ever done service in your community before? Who came up with the project? What was the experience like? How will it be different when you have a big role in deciding what the service project will be?
        iv. Circulate the room as students discuss to gauge how the conversations are going.

Clock Discussion Partners



Lesson 2.A: Great Lakes Literacy

Overview

This lesson guides students through a jigsaw-style activity intended to familiarize them with several Great Lakes Literacy Principles. There will be a particular emphasis on how humans and the Great Lakes Ecosystem impact one another.

Curriculum Connections

Michigan K-12 Science Standards

- Ecosystems: Interactions, Energy, and Dynamics
    - MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- Earth's Systems
    - MS-ESS2-2.Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
    - MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.
- Earth and Human Activity
    - MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
    - MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
    - HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Michigan K-12 Social Studies Standards

- 6 – G5 .1 .1 Describe examples of how humans have impacted and are continuing to impact the environment in different places as a consequence of population size, level of consumption, and technology.

Great Lakes Literacy Principle(s)

#2 - Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
#3 - The Great Lakes influence local and regional weather and climate.
#5 - The Great Lakes support a broad diversity of life and ecosystems.
#6 - The Great Lakes and humans in their watersheds are inextricably interconnected.
#8 - The Great Lakes are socially, economically, and environmentally significant to the region, the nation and the planet.

Focus Areas of GLRI Action Plan

N/A

Key Questions

- What is the Great Lakes Ecosystem (GLE)?
- What does it mean to have Great Lakes Literacy knowledge?

- What do we think about how the Great Lakes influence us and how we influence the Great Lakes?

Student Objectives

- Students will be able to describe 5 of the 8 Great Lakes Literacy Principles.
- In collaborative groups, students will extract key ideas from a piece of text and provide a summary to their group.

Vocabulary

Great Lakes Literacy

Materials List and Setup

- Student journals or paper for writing prompt
- Computer
- Projector
- Great Lakes Literacy Principles and additional materials, listed below. These resources can be printed off or shared digitally with students
    - For simplification, the Great Lakes Literacy principles can be printed in a brochure at http://greatlakesliteracy.net/_downloads/gllp-brochure-web.pdf
- Great Lakes Literacy Challenge Sheet

Great Lakes Literacy Principle 2

1. Great Lakes Literacy Principles. Retrieved from http://greatlakesliteracy.net/principles/2/
2. University of Wisconsin Sea Grant Institute. (2019). *The Formation of the Great Lakes: How they were Made*. Retrieved from https://www.glerl.noaa.gov/educatiohttps://www.seagrant.wisc.edu/resources/the-formation-of-the-great-lakes/how-they-were-made/n/ourlakes/background.html

Great Lakes Literacy Principle 3

1. Great Lakes Literacy Principles. Retrieved from http://greatlakesliteracy.net/principles/3/

Great Lakes Literacy Principle 5

1. Great Lakes Literacy Principles. Retrieved from http://greatlakesliteracy.net/principles/5/
2. The National Wildlife Federation. *The Great Lakes*. Retrieved from https://www.nwf.org/Educational-Resources/Wildlife-Guide/Wild-Places/Great-Lakes
3. NOAA GLERL. *Great Lakes Water Life Photo Gallery*. Retrieved from (https://www.glerl.noaa.gov/seagrant/GLWL/GLWLife.html
4. EPA. (2016). *Great Lakes: Natural Resources: Invertebrates, Insects, and Reptiles*. Retrieved from https://archive.epa.gov/greatlakes/image/web/html/viz_nat3.html

Great Lakes Literacy Principle 6

1. Great Lakes Literacy Principles. Retrieved from http://greatlakesliteracy.net/principles/6/\

Great Lakes Literacy Principle 8

1. Great Lakes Literacy Principles. Retrieved from http://greatlakesliteracy.net/principles/8/
2. Desjardins, J. (2017, Aug 16). The Great Lakes Economy: The Growth Engine of North America. Retrieved from https://www.visualcapitalist.com/great-lakes-economy/
3. Desjardins, J. (2017, Aug 20). If the Great Lakes Region Were a Country, It Would Have the Third Largest Economy in the World. Retrieved from https://www.businessinsider.com/great-lakes-region-economy-infographic-2017-8

Program Activities

1. Engage:
    a. Materials
        i. Student journals or paper for writing prompt
    b. Procedure
        i. Journal or discuss the following prompt: *Great Lakes literacy is an understanding of the Great Lakes' influences on you and your influence on the Great Lakes* (from Great Lakes Literacy Principles brochure)
        ii. Think-pair-share: What do we think about how the Great Lakes influence us and how we do influence the Great Lakes?
            1. Have students create a t-chart in their notes and individually record responses to the questions listed above
            2. Turn and share in small groups
            3. Students report out to the instructor who will compile a list of the class thoughts on a t-chart on poster paper or a whiteboard. *Note: Pick a certain color to record their prior conceptions about this question*
2. Explore: Jigsaw activity to introduce several Great Lakes Literacy Principles
    a. Materials - Print out or share electronically the Great Lakes Literacy Principles and other related resources listed in the materials section, above.
    b. Procedures
        i. Split students up into groups of 5. This will be their core jigsaw group
        ii. Assign each person in the group one of the five Great Lakes Literacy Principles, listed below:
            1. #2- Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
            2. #3 - The Great Lakes influence local and regional weather and climate.
            3. #5 - The Great Lakes support a broad diversity of life and ecosystems.
            4. #6 - The Great Lakes and humans in their watersheds are inextricably interconnected.
            5. #8 - The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.
        iii. Pass out the materials to each student and give them time to read over and annotate their component.
        iv. Have students who were assigned the same literacy principle form expert groups and share their main findings. At this time, they can help each other clarify any confusing points or questions members of the group had.
3. Explain:
    a. Procedures:
        i. Instruct students to return to their original jigsaw groups. Using a stopwatch to facilitate timing, give each group member approximately 90 seconds to deliver the key message/takeaways of their section to the group.
        ii. Jigsaw groups will work together to fill out the Great Lakes Literacy Challenge Sheet.
        iii. You can make this as competitive as you'd like based on your class's preferences. To enhance the accountability of the jigsaw activity, you could give the Great Lakes Literacy Challenge as a quiz that they have to complete in groups, or you can allow them to answer the questions using their materials.
4. Extend/Elaborate:
    a. Procedures:

i. Revisit the t-chart from the beginning of the lesson. Use a different color and have students add further information based on the new information they learned in the jigsaw activity.

**Note: The language of the Great Lakes Literacy Principles may be difficult for some students to digest and understand. Some teachers have found it helpful to get outside and search for examples of the literacy principles in their communities or to have students draw pictures or graphics representing the message of each literacy principle.

Great Lakes Literacy Challenge Sheet

1. How did the Great Lakes form?

2. Sketch or describe the Great Lakes' impact on the four seasons:

Winter:

Spring:

Summer:

Fall:

Great Lakes Literacy Challenge Sheet

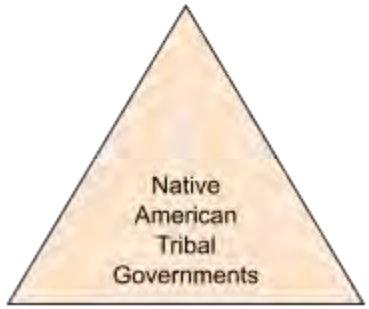
3. Find 6 examples of native species that live in the Great Lakes region. List and draw 3 that live in water and 3 that live on land.

4. List the 6 major types of economies in the Great Lakes region and provide a specific example for each one.

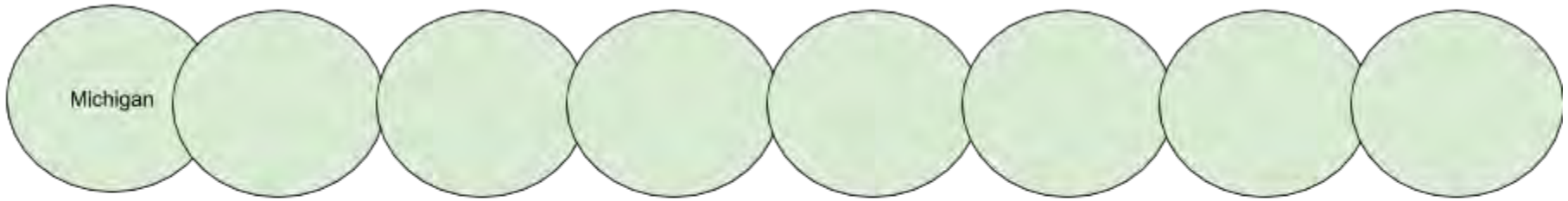
Great Lakes Literacy Challenge Sheet

5. Fill in the blank shapes representing governments whose laws and regulations affect the Great Lakes.

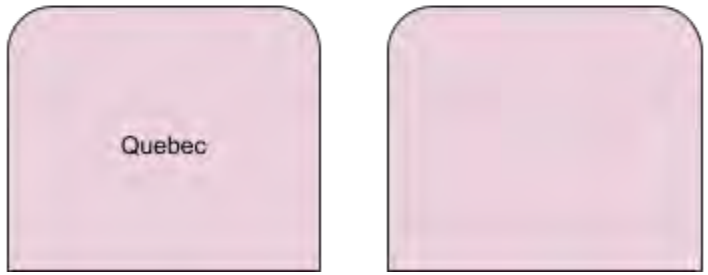
2 countries:



8 states:



2 provinces



Lesson 2.B: Great Lakes Literacy

Overview

In this lesson, students will make predictions about the relative stores of water on Earth's surface, as well as the relative sizes of the Great Lakes. A National Oceanic and Atmospheric Administration (NOAA) hands-on demonstration will help them develop this concept.

Then, students will plot various physical attributes of the Great Lakes on a map template, finding the data from NOAA and Michigan Department of Environmental Quality (MDEQ) online assets. Then, they will be prompted to analyze their map to describe relationships between physical characteristics of the Great Lakes.

They will end this Great Lakes Literacy section of the unit by writing a letter to an administrator or parent about what makes the Great Lakes a resource worth protecting.

Curriculum Connections

Michigan K-12 Science Standards

- Earth's Systems
    - 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
    - 5-ESS2-2. Describe and graph the amounts of saltwater and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
    - MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Michigan K-12 Social Studies Standards

- 6 – G1 .1 .2 Draw a sketch map, or add information to an outline map, of the world or a world region.
- 6 – G1 .2 .3 Use, interpret, and create maps and graphs representing population characteristics, natural features, and land use of the region under study.

Great Lakes Literacy Principle(s)

#1 The Great Lakes, bodies of fresh water with many features, are connected to each other and to the world ocean.
#4 Water makes Earth habitable; fresh water sustains life on land.
#6 The Great Lakes and humans in their watersheds are inextricably interconnected.
#8 The Great Lakes are socially, economically, and environmentally significant to the region, the nation and the planet.

Focus Areas of GLRI Action Plan

N/A

Key Questions

- How much of the Earth's water source is readily available freshwater?
- How much of the Earth's available freshwater do the Great Lakes hold?
- What are identifying physical characteristics of the Great Lakes?
- What causes water to flow through the Great Lakes system?
- What is retention time and how does it relate to the volume of water in a lake?
- What makes the Great Lakes worth protecting?

Student Objectives

- Students will gather information on the physical attributes of the Great Lakes from multiple sources.
- Students will plot physical attributes of the Great Lakes on a map, following symbols from a legend.
- Students will make inferences about relationships between attributes of their mapped data.

Vocabulary

Glossary of Teaching Great Lakes Science (Michigan Sea Grant) https://tinyurl.com/yd5akj97
Groundwater
Retention Time

Materials List and Setup

- The following items will be needed for each student group and one instructor demonstration set:
    - Four 1-liter plastic bottles with the label peeled off
    - Eye dropper/pipette
    - Food coloring (optional)
    - Small cup
    - Measuring tool that reads in mL (a medicine dispenser from a pharmacy works well)
- Chromebook or other device with internet (If your students do not have access to technology, you can print out the Great Lakes maps and information from the following sites:
    - Great Lakes Map (MDEQ) https://tinyurl.com/ydc4uqyt
    - Great Lakes Portal (NOAA's National Weather Service) https://www.weather.gov/greatlakes/michigan
- Great Lakes Mapping student worksheet (1 per student)
- Great Lakes Map Template worksheet (1 per student)

Program Activities

1. Engage: Activity to draw out prior conceptions about physical attributes of the Great Lakes.
    a. Materials: The following items will be needed for each student group and one instructor demonstration set:
        i. Four 1-liter plastic bottles with the label peeled off
            1. Label the bottles as follows:
                a. All of the water on the planet
                b. All of the water in the oceans
                c. All of the freshwater on Earth
                d. All of the freshwater on Earth's surface (easy to get to)
        ii. Eye dropper/pipette
        iii. Food coloring (optional)
        iv. Small measuring cup
        v. Measuring tool that reads in mL (e.g. a medicine dispenser from a pharmacy)
    b. Procedure:
        i. Have students fill the bottled labeled "All of the water on the planet" full with water.
        ii. Then, have them work in their groups to fill the remaining three bottles based on their predictions of how water is distributed on Earth. Encourage them to use precise measurements in making their predictions.
        iii. Check in with each group when they are set with their predictions.
        iv. When all groups have made a prediction, model the correct proportional distribution in front of the class, following the narrative for the bottles demonstration (activity based on NOAA, A Drop in Your Hand, *Hands-on Science with NOAA)*.

v. **Filling the bottles (might be easiest to have this teacher set prepared ahead of the class period)**
    1. Bottle 1: Fill the entire bottle with water. This is the 1-liter that represents all the water on the planet in all of its forms (liquid, solid, gas).
    2. Bottles 2 & 3: Fill an entire bottle – which will be Bottle 2. Remove 30 mL from Bottle 2 and place in Bottle 3. Add a little blue food coloring to Bottle 2…this is the 97% of water held in the oceans. Add a little red food coloring to Bottle 3. This represents the 3% of fresh water on the planet in all forms.
    3. Bottle 4: Measure 1.5 mL of water and pour into the last bottle. Add a little green food coloring. This represents the amount of surface freshwater available.

vi. **Narrative for the bottle demonstration:**
    1. Tell your students you are going to demonstrate how much water is available for people to drink, compared to the total amount found on the planet. Ask them to imagine that Bottle 1 represents this total amount of water (100%). You could ask them how many forms water takes on the planet and get them to identify the three states – liquid, solid, gas.
    2. Bottle 2: Explain that most water found on the planet is in the ocean. This bottle of blue water is the 97% that is in the oceans. Ask if we can drink this water. (Answer being no, since the water is salty.) With adults and older kids you could discuss the energy and money it takes to desalinate sea water (and, for career purposes, that some future engineer could develop a better process than we know of now!)
    3. Bottle 3: This bottle represents the total fresh water available on earth. But 80% of this water is frozen – at the poles, in ice caps, and mountain glaciers.
    4. Bottle 4: This small amount (relative to the 100% Bottle 1 you are holding up for comparison) represents the amount of freshwater that is on the earth's surface – and easy to get to, about 0.006% (USGS. *Where is Earth's Water).* However, much of this water is unsafe for drinking (would you take a drink out of a puddle in a parking lot?) Emphasize this tiny amount compared to ALL the water on the planet.

vii. Of the available freshwater on Earth's surface, the Great Lakes make up a significant portion of it! The five lakes that make up the system—Superior, Michigan, Huron, Erie, and Ontario—compose the largest freshwater system on Earth and contain approximately one fifth of the world's freshwater supply.

c. Transition into the activity: *As a whole, the Great Lakes are enormous! We will next examine what makes each individual lake unique. Let's make a quick prediction:*
    i. Pull up a map of the United States and zoom in on a view of the Great Lakes. Have students use their prior knowledge or predictions to rank the sizes of the Great Lakes. Explain that you want them to rank the sizes by how much water each lake holds (its volume).

2. Explore:
    a. Materials
        i. Great Lakes Mapping student worksheet (1 per student)
        ii. Great Lakes Map Template (1 per student)
        iii. Chromebook or other device with internet (If your students do not have access to technology, you can print out the Great Lakes maps and information from
            1. Great Lakes Map (MDEQ) https://tinyurl.com/ydc4uqyt

2. Great Lakes Portal (NOAA's National Weather Service) https://www.weather.gov/greatlakes/michigan

b. Procedure:
   i. Students will follow the directions to map physical characteristics of the Great Lakes onto the map outline.

3. Explain:
   a. Students will answer the map analysis questions on their worksheet independently or in small groups.
   b. Discuss answers as a class. Share this quote to explain the concept of retention time:
      i. A well-known scientist named Jack Valentine was involved in Great Lakes science during the development of Areas of Concern. He tells a story to explain retention time. When his great-great-great-great grandfather was working hard one day and saw Lake Superior, he jumped in to cool off. The retention time for water in the lake is so long that his sweat is probably still in Lake Superior!

4. Elaborate/Extend:
   a. Materials:
      i. Copies of Great Lakes System Profile graphic (1 per student)
   b. Procedure:
      i. Distribute the graphic and use it as a visual to explain how water movement through the Great Lakes is a classic example of watershed dynamics, showing how water flows from areas of high elevation to low elevation.

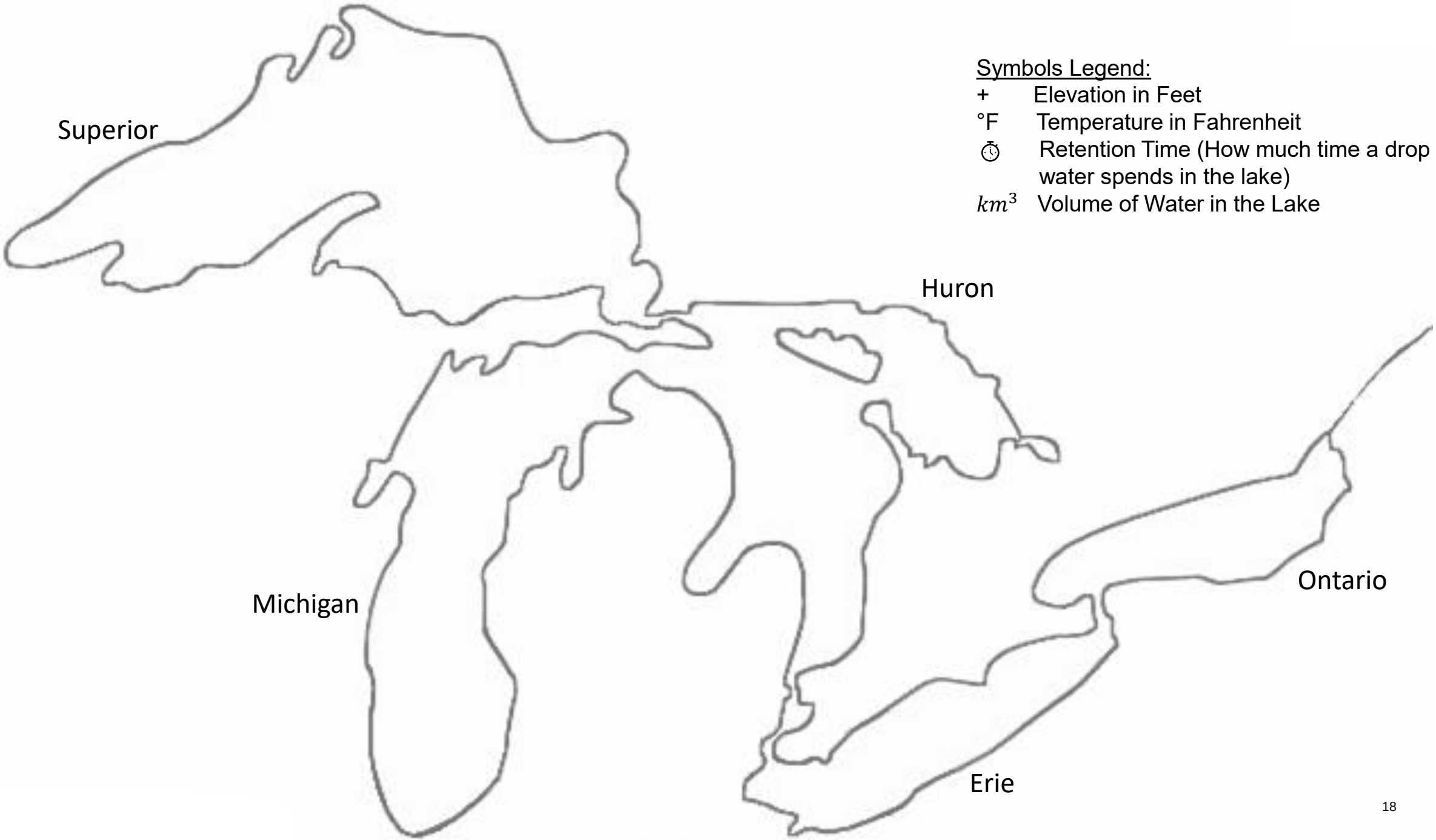
5. Evaluate:
   a. Materials:
      i. Materials for students to write a letter or email
      ii. Worksheets/resources from lessons 1-3 to reference
   b. Procedure:
      i. Instruct students to compose a letter to the principal or their caregivers to explain what they've learned about the Great Lakes Ecosystem and why it is worth protecting.
      ii. Criteria: Students must use at least three specific examples they've learned in lessons 1-3 to support their message that the Great Lakes Ecosystem is worth protecting.

References

Domske, H. M. (2006).Great Lakes overview [PowerPoint slides]. Retrieved from http://www.coexploration.org/mm/cosee/coseeglintrotogl/index.html

NOAA. *A Drop in Your Hand - Water Stewardship from NOAA Education.* Retrieved from http://www.noaa.gov/sites/default/files/atoms/files/Drop_in_your_hand%28NOAA%29.pdf

USGS. *How Much Water is There on Earth?* Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth



Symbols Legend:

+ Elevation in Feet

°F Temperature in Fahrenheit

⏱ Retention Time (How much time a drop of water spends in the lake)

km^3 Volume of Water in the Lake

Great Lakes Mapping

Directions: Creating your map

1. From the MDEQ Great Lakes Map website, https://tinyurl.com/ydc4uqyt, find the following characteristics of each Great Lake and record it on that lake on the map. Make sure to follow the symbols legend!
    a. Elevation
    b. Retention Time (i.e. How much time a drop of water spends in the lake)
    c. Volume of Water in the Lake
2. From the NOAA Great Lakes Portal website, https://www.weather.gov/greatlakes/michigan, find the current temperature of each Great Lake and record it on that lake on the map.

Directions: Analyzing the map data

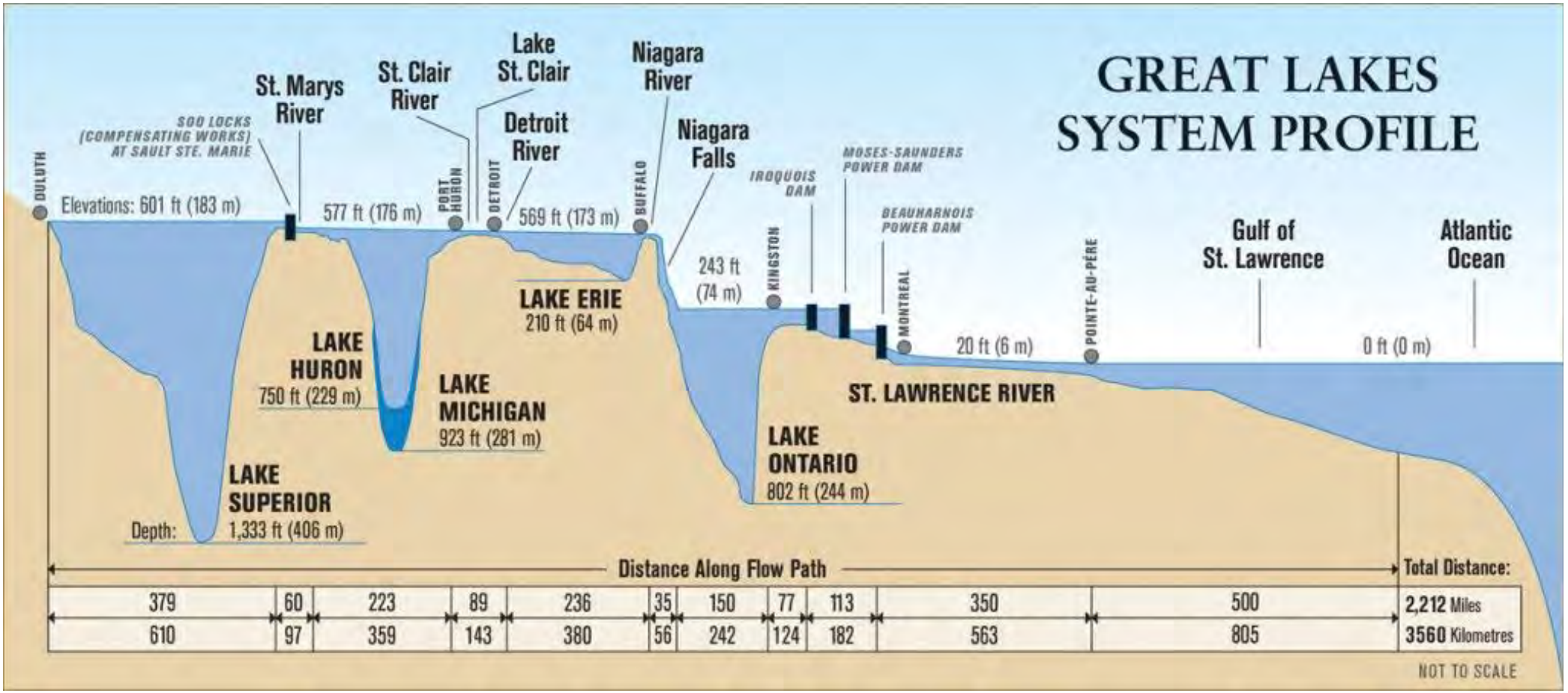
1. We know that in a watershed, gravity causes water to flow from areas of higher elevation to areas of lower elevation. The same movement applies to water moving between the Great Lakes. **Using this concept, draw arrows on your map in red demonstrating the direction of water flow within the Great Lakes.**

2. Which lake has the largest volume? The smallest volume?

3. Which lake has the longest retention time? The shortest retention time?

4. How would you define the relationship between retention time and volume?

5. Based on what your map data show, what factor(s) do you think impact the temperatures of each of the Great Lakes?



Great Lakes System Profile graphic, courtesy of Michigan Sea Grant, *The Great Lakes Basin,* map/poster.

Lesson 3: Issue Selection

Overview

This lesson plan provides methods to prepare students to attend the River City Water Festival. It also includes reflective activities to help students process the information they learned from community experts. By the end of this lesson, students will have gone through a decision-making process to identify the Great Lakes issue they would like to address with a stewardship project.

Curriculum Connections

Michigan K-12 Science Standards

- Ecosystems: Interactions, Energy, and Dynamics
    - MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
    - MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
    - MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
    - HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- Biological Evolution: Unity and Diversity
    - HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- Earth's Systems
    - 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
    - MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- Earth and Human Activity
    - 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
    - MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Michigan K-12 Social Studies Standards

- 6 – G5 .1 .1 Describe examples of how humans have impacted and are continuing to impact the environment in different places as a consequence of population size, level of consumption, and technology.
- 6 – G5 .1 .3 Identify ways in which human-induced changes in the physical environment in one place can cause changes in other places.

Great Lakes Literacy Principle(s)

#5 - The Great Lakes support a broad diversity of life and ecosystems.
#6 - The Great Lakes and humans in their watersheds are inextricably interconnected.
#7 - Much remains to be learned about the Great Lakes
#8 - The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.

Focus Areas of GLRI Action Plan

- Cleaning up Great Lakes Areas of Concern
- Preventing and controlling invasive species

- Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
- Restoring habitat to protect native species

Key Questions

- What are the areas of concern in the Great Lakes?
- What issues do I personally feel most interested in and connected to?
- What issue do we want our stewardship project to address?

Student Objectives

- After participating in station activities with community experts, students will be able to describe focus areas for Great Lakes restoration.
- Students will reflect on which issues in the Great Lakes they feel most passionate about.
- Students will use criteria-based decision making to identify which issue they want their stewardship project to address.

Vocabulary

Invasive species
Algae bloom
Nutrient runoff
Criteria

Materials List and Setup

- River City Water Festival reflection card
- Issue Selection Grid

Program Activities

1. Engage:
    a. Procedure:
        i. Before heading to the River City Water Festival (RCWF), prepare your students by giving them an idea of what the day will look like and reminding them of the purpose.
        ii. You have been building Great Lakes Literacy so far, uncovering the special attributes of the Great Lakes and understanding why they are a resource worth protecting. At the RCWF, you will hear from local community experts who will explain what is being done in this area to improve the Great Lakes Ecosystem in four major areas. These areas have been identified by the Great Lakes Restoration Initiative. That initiative encourages all groups to focus on stewardship projects in the following areas because they will have the largest impact:
            1. Cleaning up Great Lakes Areas of Concern
            2. Preventing and controlling invasive species
            3. Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
            4. Restoring habitat to protect native species
2. Explore:
    a. Procedure:
        i. Attend the River City Water Festival, using the knowledge you gained at the Summer Institute to co-facilitate each station along with the community expert.
3. Explain:
    a. Materials:
        i. River City Water Festival reflection card
    b. Procedure:

i. Students will complete a River City Water Festival reflection card. They can fill out this card at the RCWF, on the bus ride back to school, or when you get back to class. They should do this reflection promptly while their memory of the RCWF is still fresh.

4. Elaborate/Extend:
    a. Materials:
        i. Issue Selection Grid
    b. Procedure:
        i. The Issue Selection Grid will be used to decide what Great Lakes issue your class stewardship project will address. Keep in mind, you are trying to decide on an ISSUE, not a project or solution yet! Explain that this method is called Criteria-Based Decision Making.
        ii. Through whole group discussion, decide what criteria you will use to select an issue. Definition of criteria: Standards that can be used to judge or decide something. You will narrow down to the three most important criteria for your class.
            1. Example criteria: How interesting is the issue to you? How many people does the issue affect? How much do you already know about the issue?
        iii. Students will work in groups or individually to score each box in the grid with a ranking of 1-5, with a 5 indicating that the criterion is fully met, and a 1 meaning the criterion is not met at all.
        iv. Students will add up the scores and record them in the "Totals" row.
        v. The instructor may collect these grids, calculate class totals, and present the highest-scoring issue at the next class meeting.

**If your class is not participating in the local River City Water Festival, consider how you might arrange for speakers to visit your class to share what is being done in your community to improve watershed health. You may also select media, such as a documentary or video clips, to transmit information about the four focus areas of the GLRI action plan (Cleaning up Great Lakes Areas of Concern; preventing and controlling invasive species; reducing nutrient runoff that contributes to harmful/nuisance algal blooms; restoring habitat to protect native species).

Directions: Use the table below to decide which Great Lakes issue you want to address with your project.

- As a class, decide on the criteria that you will use to rate each issue.
- Score every box with a ranking of 1-5, with a 5 indicating that the criterion is fully met.
- Add your scores in the bottom row, circle the winner, and report your results.

	Issues, Challenges, or Opportunities			
Definition of criteria: *Standards that can be used to judge or decide something*	1 Cleaning up Great Lakes Areas of Concern (or Toxic Substances)	2 Preventing and controlling invasive species	3 Reducing nutrient runoff that contributes to harmful/nuisance algal blooms	4 Restoring habitat to protect native species
Criterion 1:				
Criterion 2:				
Criterion 3:				
Totals:				

River City Water Festival Reflection

What issue or topic was the most interesting to you? What about it was interesting?

Describe something you learned today that shocked or surprised you.

What Great Lakes issue do you personally feel the most passionate about or think is the most important? Why?

Lesson 4: Background Research

Overview

This lesson will walk students through the process of conducting background research. Student groups will follow provided guidelines to generate research questions around a Great Lakes issue. Then, they can conduct online research within a list of provided websites to answer the questions they've created. This lesson should conclude with student groups presenting their findings in some way to a real audience.

Curriculum Connections

Michigan K-12 Science Standards

- Ecosystems: Interactions, Energy, and Dynamics
    - MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
    - MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
    - MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
    - HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- Biological Evolution: Unity and Diversity
    - HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- Earth and Human Activity:
    - 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
    - MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Michigan K-12 Social Studies Standards

- 6 – G5 .1 .1 Describe examples of how humans have impacted and are continuing to impact the environment in different places as a consequence of population size, level of consumption, and technology.
- 6 – G5 .1 .3 Identify ways in which human-induced changes in the physical environment in one place can cause changes in other places.

Great Lakes Literacy Principle(s)

#5 - The Great Lakes support a broad diversity of life and ecosystems.
#6 - The Great Lakes and humans in their watersheds are inextricably interconnected.
#7 - Much remains to be learned about the Great Lakes.

Focus Areas of GLRI Action Plan

a. Cleaning up Great Lakes Areas of Concern
b. Preventing and controlling invasive species
c. Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
d. Restoring habitat to protect native species

Key Questions

- How do you generate research questions about an issue?
- What constitutes a high-quality, relevant research question?

- What do we need to learn about the issue we've chosen to understand it more fully?

Student Objectives

- Students will follow guidelines to generate a list of relevant research questions for their chosen Great Lakes issue.
- Students will conduct background research with a variety of sources to gain a more complete understanding of the Great Lakes issue they have chosen.
- Students will present their findings to an authentic audience.

Materials List and Setup

- Student journal or paper for written reflection
- Generating Research Questions handout
- Student technology with internet to research
- Materials for students to share out their findings (posters, slideshow, etc)

Program Activities

1. Engage:
    a. Materials:
        i. Student journal or paper for written reflection
        ii. Generating Research Questions handout
    b. Procedure:
        i. Introduce the task for the day. *We have chosen _____ as the Great Lakes issue our class will address. Today, your task is to do research about this topic.*
        ii. Prompt students to do a written reflection to pull out their prior conceptions of the topic before researching. You can guide them to think about what was presented at River City Water Festival as well. *What do you already know or think you know about the topic?*
        iii. Distribute the Generating Research Questions handout and guide students through the instructions.
        iv. Have students work in small groups to generate at least 8 research questions.
        v. When they are done, have them check with you to ensure their questions are relevant.
2. Explore:
    a. Materials:
        i. Student technology with internet to conduct research
        ii. See the Appendix for a list of useful website links related to each Great Lakes Restoration Initiative Area of Concern
    b. Procedure:
        i. To answer questions they generated around the class issue, students will need to do some online research. Prompt them to explore at least 4 different resources (websites or print materials you may have available) to gather information.
        ii. If you'd like, have students record the source(s) they used to answer each question.
        iii. As a general rule, websites that end in gov, edu, and org will be higher quality than websites that end in com or net. You can have students peruse the websites that are listed in the Appendix section of the lesson plan to ensure they access accurate and appropriate information.
3. Explain:
    a. Materials:
        i. Student-generated list of research questions
        ii. Materials for students to share out their findings (posters, slideshow, etc)

b. Procedure:
    i. As students research, they will answer the minimum of 8 questions that they generated during the engage phase.
    ii. Have student groups share out their findings so that the whole class gets a full understanding of the issue. You may choose to bring in the principal or other school staff as an audience for student presentations, or students could create posters of their questions/answers to display in the hallways of the school to inform other students.

4. Elaborate/Extend:
    a. Procedure:
        i. Depending on the capacity for your community partner to assist your class, you may encourage students to direct any remaining questions they were unable to answer to your community partner (via email, phone call, in person).

Appendix

Cleaning up Great Lakes Areas of Concern

- https://www.glri.us/sites/default/files/glri-action-plan-2.pdf
- http://www.regions.noaa.gov/great-lakes/index.php/great_lakes-restoration-initiative/toxics/
- https://www.epa.gov/greatlakes/restoring-great-lakes
- https://www.epa.gov/great-lakes-aocs
- https://www.epa.gov/greatlakes/contaminated-sediment-great-lakes
- http://greatlakesmapping.org/great_lake_stressors/1
- https://www.cbc.ca/news/canada/5-chemical-threats-to-the-great-lakes-1.1055139
- https://psmag.com/environment/what-it-takes-to-make-the-great-lakes-areas-of-concern-less-concerning

Preventing and controlling invasive species

- https://www.nwf.org/Educational-Resources/Wildlife-Guide/Threats-to-Wildlife/Invasive-Species
- https://www.invasivespeciesinfo.gov/whatis.shtml
- https://www.glri.us/sites/default/files/glri-action-plan-2.pdf
- https://www.epa.gov/greatlakes/invasive-species-great-lakes
- https://www.nature.org/ourinitiatives/regions/northamerica/areas/greatlakes/explore/great-lakes-aquatic-invasive-species.xml?gclid=EAIaIQobChMIwPnx3oHF3AIVmoSzCh2XQAqvEAAYASAAEgJGEvD_BwE
- http://www.regions.noaa.gov/great-lakes/index.php/great_lakes-restoration-initiative/invasive-species/
- https://greatlakes.org/campaigns/keeping-invasive-species-out/
- http://www.glfc.org/invasive-species.php
- http://www.iiseagrant.org/NabInvader/great_lakes.html
- https://www.nwf.org/Our-Work/Waters/Great-Waters-Restoration/Great-Lakes

Reducing nutrient runoff that contributes to harmful/nuisance algal blooms

- https://www.glri.us/sites/default/files/glri-action-plan-2.pdf
- https://cees.iupui.edu/research/algal-toxicology/bloomfactors
- https://oceanservice.noaa.gov/hazards/hab/
- http://www.noaa.gov/what-is-harmful-algal-bloom
- https://www.epa.gov/nutrientpollution/harmful-algal-blooms
- https://www.cdc.gov/habs/index.html
- https://oceanservice.noaa.gov/facts/nutpollution.html
- https://www.epa.gov/nutrientpollution/problem
- https://www.epa.gov/nutrientpollution/sources-and-solutions

Restoring habitat to protect native species

- https://www.glri.us/sites/default/files/glri-action-plan-2.pdf
- https://www.epa.gov/wetlands/why-are-wetlands-important
- https://www.fisheries.noaa.gov/coastal-wetlands-too-valuable-lose
- https://www.biologicaldiversity.org/campaigns/protecting_native_plants/
- https://www.worldwildlife.org/habitats/wetlands
- https://www.fisheries.noaa.gov/national/habitat-conservation/great-lakes-habitat-restoration
- https://www.audubon.org/content/why-native-plants-matter
- https://www.glc.org/work/habitat
- http://www.miseagrant.umich.edu/lessons/lessons/by-broad-concept/life-science/habitat-restoration/
- https://earthjustice.org/the-wild/wildlife/habitat

Generating Research Questions

Background research is important for helping you understand the Great Lakes issue you've identified and gather ideas to design a stewardship project.

Directions:
You can follow the steps below to generate a list of important questions you need to answer through online research.

1. Identify the keywords in the topic. Brainstorm additional keywords and concepts you might need to search. Use the Great Lakes Issue statement as a place to start identifying keywords. Here is an example of an Atlantic Ocean concern:
    a. **Issue:** Plastic pollution is harming wildlife that lives in the Atlantic Ocean

    In this example, keywords would be:
    - Plastic
    - Pollution
    - Wildlife
    - Atlantic Ocean

2. Use the following question stems and the keywords you came up with to create research questions. The goal is to use the question stems (why, how, who, what, when, where) with your keywords. Ask why things happen, ask how things happen, ask what causes things to happen, etc.
    a. **Question Stems:**
        i. What
        ii. When
        iii. Where
        iv. How
        v. Does
        vi. Why
        vii. Which
    b. **Research Question Examples:**
        i. Which species are harmed by plastic pollution?
        ii. When did plastic pollution start becoming such a problem in the Atlantic Ocean?
        iii. What are people doing to solve the issue of plastic pollution?

3. Throw out irrelevant questions. You can always find more information to research, but some questions just don't have anything to do with the issue and stewardship project you will create.
    a. Relevant Questions = questions that **will** help you gather information on your Great Lakes issue and understand how to solve it.
    b. Irrelevant Questions = questions that **will not** help you gather information on your Great Lakes issue and understand how to solve it.

Lesson 5: Outdoor Research to Inventory Invasive Plants in Study Site

Overview

If your class has chosen to focus on the GLRI focus area of preventing and controlling invasive species, this lesson would be a good option for getting outdoors and doing field work. The activities included will encourage student groups to become experts in identifying a certain species of invasive plant and will give them an opportunity to apply their knowledge and attempt to identify those invasive plants outdoors at a chosen study site.

Curriculum Connections

Michigan K-12 Science Standards

- Ecosystems: Interactions, Energy, and Dynamics
  - MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- Biological Evolution: Unity and Diversity
  - HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- Earth and Human Activity
  - 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
  - MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Great Lakes Literacy Principle(s)

#5 - The Great Lakes support a broad diversity of life and ecosystems.

Focus Areas of GLRI Action Plan

- Preventing and controlling invasive species

Key Questions

- What are the identifiable characteristics of local invasive plants?
- Are there invasive plants in our study site?

Student Objectives

- Students will conduct online research to create an identification tool for local invasive plants.
- Students will present their findings to their class and, ideally, to a community expert who is knowledgeable about plants.
- Students will use the identification tool they have created to identify and tag invasive plants in their study site.

Vocabulary

Invasive Species
Distribution

Materials List and Setup

- Student technology with internet to research invasive plant characteristics
  - A list of botany websites and resources for plant identification can be found at the end of the lesson plan in Supplementary Materials.

- Technology to present student slideshows
- Flagging tape or pin flags (available at your local hardware store)

Program Activities

1. Engage:
    a. Procedure:
        i. Reach out to a local plant expert in your area who is familiar with invasive species. Ask them what invasive plants are troublesome in your study site (school yard, park, field). If you do not have a study site with invasive plants identified, you can ask them to recommend a spot near your school known to have several types of invasive plants.
        ii. Split students into groups based on the numbers of invasive plant species at the study site.
2. Explore:
    a. Materials:
        i. Student technology with internet to research invasive plant characteristics
            1. A list of botany websites and resources for plant identification can be found at the end of the lesson plan in Supplementary Materials.
    b. Procedure:
        i. Students will use technology to locate information and identifying characteristics of their assigned invasive plant. Helpful websites are listed in the Supplementary Materials section at the end of this lesson plan.
        ii. Students should develop a slideshow with the following information:
            1. Slide 1: Common Name and Scientific Name
            2. Slide 2: The top 3 unique, identifying characteristics (use photos to demonstrate)
            3. Slide 3: Seasonal pictures of your plant (fall, winter, summer, and spring)
            4. Slide 4: Distribution map of where it is found in the United States
            5. Slide 5: What are the harmful effects of this plant?
3. Explain:
    a. Materials:
        i. Projector to present student slideshows
    b. Procedures:
        i. Student groups will present their slideshow to the class. If there is a knowledgeable community partner available, invite them to your classroom for student presentations of their identification guides. The community expert can give feedback and offer advice on identification for when students head out to the field.
4. Elaborate/Extend:
    a. Materials:
        i. Flagging tape or pin flags (available at your local hardware store)
        ii. Student-created identification guides printed out (1 per student group)
    b. Procedure:
        i. Print out class-created invasive plant identification guides that include all of the plants the class researched.
        ii. At the study site, direct student groups to use the identification guides to locate and mark (with flagging tape or pin flags) any invasive plants they find.
5. Evaluate:
    a. If there is a community partner available to come to your study site, they can provide an authentic evaluation of student learning by confirming correct identification and ideally helping the class report their findings to the appropriate agency to come remove/treat the invasive plants.

Supplementary Materials
Borland, K., Campbell, S., Schillo, R. & Higman, P. (2009). *A Field Identification Guide to Invasive Plants in Michigan's Natural Communities.* Retrieved from https://mnfi.anr.msu.edu/invasive-species/InvasivePlantsFieldGuide.pdf Michigan Natural Features Inventory *Best Control Practice Guides* http://mnfi.anr.msu.edu/invasive-species/best-control-practice-guides.cfm Midwest Invasive Plant Network *Plant Identification traits, photos, distribution maps* https://www.mipn.org/plantlist/ Midwest Invasive Species Information Network *Invasive Species Fact Sheets* http://www.misin.msu.edu/facts/ *Report Occurrences* - Students can contribute their data to the map about where they found certain invasive species. http://www.misin.msu.edu/report/ National Invasive Species Information Center *Invasive Plants information, tells history and method of invasion into U.S.* https://www.invasivespeciesinfo.gov/plants/main.shtml University of Michigan Herbarium https://michiganflora.net/

Lesson 6: Outdoor Research to Investigate Patterns of Stormwater Runoff

Overview

If your class has chosen to focus on the GLRI focus area of reducing nutrient runoff, this lesson would be a good option for getting outdoors and making observations to gather data about your study site. Students will explore the concepts of nonpoint source pollution and stormwater runoff as they note the features of their study site on a map.

Curriculum Connections

Michigan K-12 Science Standards

- Earth's Systems
  - 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
  - MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- Earth and Human Activity
  - MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
  - MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Michigan K-12 Social Studies Standards

- 6 – G5 .1 .1 Describe examples of how humans have impacted and are continuing to impact the environment in different places as a consequence of population size, level of consumption, and technology.
- 6 – G5 .1 .3 Identify ways in which human-induced changes in the physical environment in one place can cause changes in other places.

Great Lakes Literacy Principle(s)

#6 - The Great Lakes and humans in their watersheds are inextricably interconnected.

Focus Areas of GLRI Action Plan

- Reducing nutrient runoff that contributes to harmful/nuisance algal blooms

Key Questions

- How is stormwater moving on our school grounds?
- What might be the implications of nonpoint source pollution for our watershed?

Student Objectives

- A student will be able to describe the problem of stormwater unoff and how nonpoint source pollutants can be harmful to the watershed as a whole.
- Students will analyze patterns of stormwater flow on their study site and note their observations on a map, following a legend.

Vocabulary

Algae Bloom
Eutrophication
Nonpoint Source Pollution
Nutrient Runoff
Runoff

Sedimentation
Stormwater Runoff

Materials List and Setup

- Video Fifteen to the River: Explaining Stormwater Runoff by West Michigan Environmental Action Council https://www.youtube.com/watch?v=GrBEEjijxaY
- Investigating Patterns of Stormwater Runoff worksheet (1 per person)
- Clipboards (1 per person)
- Whiteboard and dry erase markers
- Document Camera/projector
- Student-created maps of study site or printouts of satellite Google maps image of site/copies of a map of the site (one per pair) of students

Notes:

- Before doing this lesson, it's recommended that you spend some time developing expectations for outside learning with your students.
- This lesson will be best if your students have some background knowledge of runoff and nonpoint source pollution. The stormwater runoff video does a good job of briefly explaining this concept in the context of Grand Rapids. Other informational videos and websites can be found in the References section of this lesson.
- It would be a good pairing to do this lesson after you have done a general assessment of your study site and even had students create maps of the study site. Student-created maps would work best for this lesson as they would be easiest for students to annotate with the pollutant and stormwater infrastructure legends on their worksheet.

Program Activities

1. Engage:
    a. Materials
        i. Video *Fifteen to the River: Explaining Stormwater Runoff* by West Michigan Environmental Action Council https://www.youtube.com/watch?v=GrBEEjijxaY
        ii. Investigating Patterns of Stormwater Runoff worksheet (1 per person)
        iii. Whiteboard and dry erase markers
    b. Procedure
        i. Start by showing the 2-minute video about stormwater runoff. Tell students to pay specific attention to the types of pollutants that are commonly carried by stormwater. Make sure to emphasize that in Grand Rapids, it takes only 15 to 30 minutes for stormwater to reach the Grand River.
        ii. Distribute the Investigating Patterns of Stormwater Runoff worksheet to each student. Explain that today we will look at the study site and make observations on a map of how stormwater is moving through the site and what potential pollutants it may pick up on its journey through the watershed. If necessary, explain which stream or body of water stormwater enters before it makes its way to the Grand River.
        iii. Explain the Study Site Legend of Surface Features to students; give them time to look at each icon and allow them to ask for clarification if they are unsure what they mean. Let them know they will be locating these items on their site assessment map.
            1. *Note: These icons represent predominantly urban infrastructure features. Use the space in the worksheet below the legend to*

brainstorm what other icons need to be added, such as agricultural fields.

iv. Then, create a class list of pollution sources that could be on our school grounds. Work together as a group to come up with icons for these sources; the instructor can note the icons on a whiteboard. Students will record notes on the blank space on the front side of their worksheet labeled Pollution Sources Legend.

1. Examples of pollutants: oil, excess sediment/soil, animal waste, trash, fertilizer, pesticides, salt.

2. Explore
    a. Materials
        i. Investigating Patterns of Stormwater Runoff worksheet (1 per person)
        ii. Clipboards (1 per person)
        iii. Student-created maps of study site or printouts of satellite Google maps image of site/Copies of a map of the site (one per pair) of students
    b. Procedure
        i. Explain that students will use the legend they just made, as well as the urban infrastructure legend that was given to them, to analyze how stormwater runoff travels on their section of the school grounds.
        ii. Go over the directions on the worksheet with students.
        iii. Give students a guideline of how long they will have outside and where to meet at the end of that time.
        iv. Let students know that each group will present their map and explain it to the class when we come back in, being prepared to answer any questions.
3. Explain
    a. Materials
        i. Document Camera/projector
    b. Procedure
        i. Students will select one map from their group to present.
        ii. Call student groups up to present under the document camera, and challenge each group with a question to answer about what they observed about patterns of stormwater runoff or clarifications of features of their maps.
4. Extend/Elaborate
    a. Materials
        i. Investigating Patterns of Stormwater Runoff worksheet
    b. Procedure
        i. Student will complete the "Digging Deeper" questions on the back of the worksheet.
        ii. Collect the worksheets as their exit ticket and review their responses to the digging deeper section to gauge their attainment of the learning objectives.
        iii. Many of the websites and videos linked below can provide further information on the consequences of nonpoint source pollution entering waterways through stormwater runoff, such as nutrient loading and algal blooms.

References

Lesson adapted from:
Nature Works Everywhere. (2016). *Urban Runoff: Design a School Stormwater Management Plan*.

Retrieved from https://www.natureworkseverywhere.org/resources/urban-runoff/

Groundswell Michigan. (2017, Jan 26). *Communities for Clean Water: Managing Excess Nutrients* [Video File]. Retrieved from https://www.youtube.com/watch?time_continue=1&v=Q9iwqF4_-4Y

Groundswell Michigan. (2017, Jan 26). *Communities for Clean Water: Managing Excess Sediment* [Video File]. Retrieved from https://www.youtube.com/watch?v=HQ6NTWxSMb4

Groundswell Michigan. (2017, Jan 26). *Communities for Clean Water: Managing Pathogens* [Video File]. Retrieved from https://www.youtube.com/watch?v=Kg7j9BnGTHU

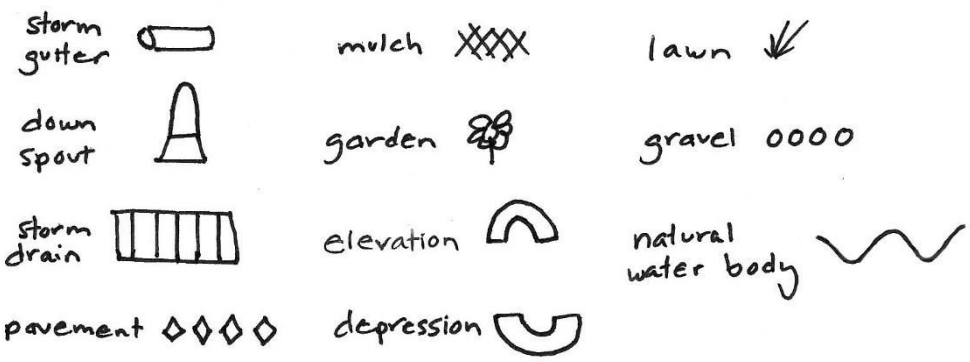
Groundswell Michigan. (2017, Jan 26). *Communities for Clean Water: Watersheds and NonPoint Source Pollution* [Video File]. Retrieved from https://www.youtube.com/watch?v=j6AeuKl4Fwg

USGS. *Nitrogen and Water*. Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/nitrogen-and-water?qt-science_center_objects=0#qt-science_center_objects

USGS. *Runoff: Surface and Overland Water Runoff*. Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/runoff-surface-and-overland-water-runoff?qt-science_center_objects=0#qt-science_center_objects

Investigating Patterns of Stormwater Runoff

Study Site Legend of Surface Features:



(Legend from Nature Works Everywhere. (2016). Urban Runoff: Design a School Stormwater Management Plan. Retrieved from https://www.natureworkseverywhere.org/resources/urban-runoff/)

Pollution Sources Legend:

1. Mark the high points on the site with the elevation icon from the legend.
2. Where are the low points where water would collect on your site? Indicate where they are located using the depression icon from the legend.
3. Use arrows, like the one below, to mark the paths rainwater would travel on your site.

4. Identify any storm drains on your site. Indicate where they are located using the storm drain symbol from the legend.
5. Identify any sources of nonpoint source pollution you find on your site. Indicate where they are located using the appropriate symbols from the legend.
6. Label the surface types on your site using symbols from the legend (e.g. lawn, gravel, pavement, dirt, mulch).
7. Mark any other special features of your site: storm gutters, bodies of water, etc.

Digging Deeper

1. Look again at the stormwater map you have created of your site. Circle the location where you think stormwater runoff is the most polluted. **Explain why you chose this area.**

2. Describe where these pollutants will travel beyond your site and the impact of how they may cause damage.

3. What do you think could be done to decrease stormwater runoff on your study site?

Lesson 7: Outdoor Water Quality Research

Overview

Students will work through stations to complete chemical and physical tests on water samples from their study stream or river. This laboratory-based investigation will allow students to collect and analyze data. Ultimately, they will use their water quality results to decide whether or not their study site could support various native species.

Note: The data on native species habitat requirements are based off of fish found in the Grand River.

**This lesson is a modified version of the Grand River Water Quality Lab, developed by the Grand Rapids Public Museum. If you would like to have GRPM science education staff deliver this program for your class, you can visit grpm.org/schools to submit a group scheduling reservation.

Curriculum Connections

Ecosystems: Interactions, Energy, and Dynamics

- MS-LS2-4.Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Earth's Systems

- 5-ESS2-1.Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Earth and Human Activity

- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Michigan K-12 Social Studies Standards

- 6 – G5 .1 .3 Identify ways in which human-induced changes in the physical environment in one place can cause changes in other places.

Great Lakes Literacy Principle(s)

#5 The Great Lakes support a broad diversity of life and ecosystems.
#6 The Great Lakes and humans in their watersheds are inextricably interconnected.

Focus Areas of GLRI Action Plan

- Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
- Restoring habitat to protect native species

Key Questions

- How can I assess the health of a watershed?
- How do chemical and physical properties of water impact organisms that live in a river?
- What are the habitat requirements for various native fish in Michigan?

Student Objectives

- Students will be able to explain how chemical and physical indicators provide information about water quality.
- Students will be able to use water quality data to predict whether or not the river could support various aquatic organisms.
- Students will be able to safely perform scientific laboratory procedures such as using a pipette, filling test tubes to a specific volume, following chemical testing procedures, and interpreting results.

Vocabulary

Dissolved Oxygen
Eutrophication
Nitrate
pH
Phosphate
Sediment
Turbidity
Water Quality
Watershed

Materials List and Setup

- Water sample from study stream/river
- Water sampling materials (for testing temperature, pH, nitrates, phosphates, dissolved oxygen (D.O.), turbidity). This lesson is based off of the LaMotte tablet test kit.
    - Earth Force Low Cost Water Monitoring Kit
    - Earth Force Standard Water Monitoring Kit
- Data collection tables--Lake Sturgeon, Northern Pike, Yellow Perch, Bluegill, Brook Trout, Common Carp (1 per student; split class into 6 groups of students each assigned to a fish species)
- Station instructions (1 copy for each station, front and back with big idea and directions; preferably laminated)
- Data Analysis Chart (1 per student)
- Calculator
- Computer and projector or document camera
- Protective goggles
- Labeled waste containers

Program Activities

1. Engage:
    a. Materials:
        i. Protective goggles
        ii. Data collection tables
    b. Procedure:
        i. Cover laboratory safety instructions.
        ii. Introduce question to investigate: How can we test if our habitat is healthy for native fish species?
        iii. Split class into 6 groups/Assign species to each group and pass out the data collection tables
2. Explore:
    a. Materials:
        i. Water sample from study stream/river
        ii. Water sampling materials (for testing temperature, pH, nitrate, phosphate, D.O., turbidity) This lesson is based off of the LaMotte tablet test kit.
        iii. Data collection tables--Lake Sturgeon, Northern Pike, Yellow Perch, Bluegill, Brook Trout, Common Carp (1 per student; split class into 6 groups of students each assigned to a fish species)
        iv. Station instructions (1 copy for each station, front and back with big idea and directions; preferably laminated)
        v. Protective goggles
        vi. Labeled waste containers

b. Procedure:
    i. Cover directions for the data collection stations.
        1. Students will read the big idea information and then follow the station directions. They will record the water quality data on their data collection tables. *Students will spend about 8-10 minutes at each station.*
    ii. Students rotate through six data-collection stations and record results in their own data collection tables.
        1. Stations cover: temperature, dissolved oxygen, pH, turbidity, phosphate, nitrate.

3. Explain:
    a. Materials:
        i. Data Analysis Chart (1 per student)
        ii. Calculator
        iii. Computer and projector or document camera
    b. Procedure:
        i. Instructor pools class data and calculates averages for each water quality measurement. Fill in the class average in the first column of the data analysis chart.
        ii. In their groups, students will determine whether each organism could live in the study stream/river, based on the levels of chemical and physical habitat requirements. For an easy way to visually process the data, have students color code cells of the chart green and red (green cells are when the physical or chemical requirement of their fish is met with the class data, red when it is not).
4. Elaborate:
    a. Procedure:
        i. Discuss trends you find in the data.
        ii. Clean up all materials. *Waste containers can be poured down the drain with the water running.*

Supplementary Materials

EPA. (2001). *Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VIII*. Retrieved from https://www.epa.gov/sites/production/files/documents/rivers8.pdf

Fondriest Environmental Learning Center. (2019). *Environmental Measurements: Parameters*. Retrieved from https://www.fondriest.com/environmental-measurements/parameters/

GLISA. *Climate: Fish and Wildlife*. Retrieved from http://glisa.umich.edu/climate/fish-and-wildlife

USGS. *National Water Information System: Web Interface*. Retrieved from https://waterdata.usgs.gov/nwis

USGS. *Nitrogen and Water*. Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/nitrogen-and-water?qt-science_center_objects=0#qt-science_center_objects

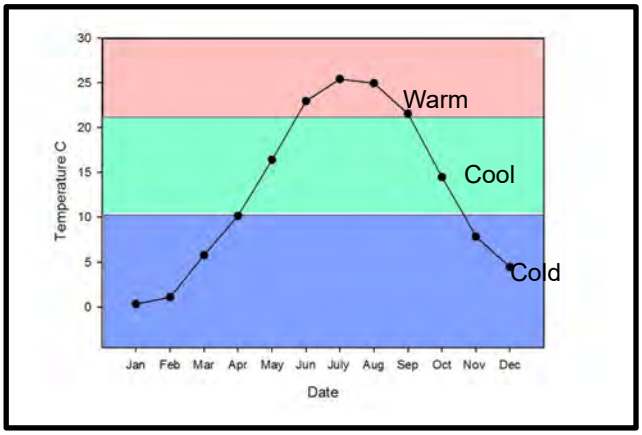
USGS. *Runoff: Surface and Overland Water Runoff*. Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/runoff-surface-and-overland-water-runoff?qt-science_center_objects=0#qt-science_center_objects

Station Instructions

1. Temperature

Big Idea:

- Water temperature is a physical property expressing how hot or cold water is. Temperature is an important factor to consider when assessing water quality.
- In addition to its own effects, temperature influences several other parameters and can alter the physical and chemical properties of water.
- Temperature fluctuations can also affect the behavior choices of fish, such as moving to warmer or cooler water, changing feeding habits and movement.

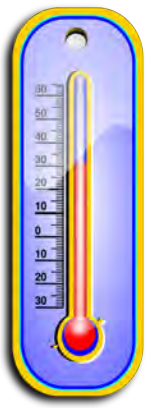


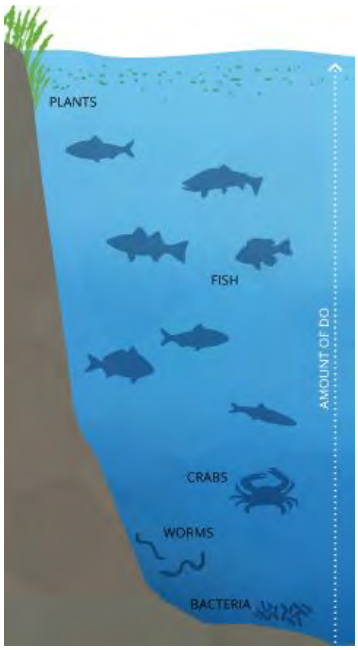
Average Monthly Grand River Water Temperature

Graph created based on data from USGS. *National Water Information System: Grand River Near Eastmanville, MI.* Retrieved from https://waterdata.usgs.gov/usa/nwis/uv?04119400

1. Temperature

1. Use the digital thermometer and place in the beaker of water for 1 min.
2. Record the measurement in ℃ on your fish sheet.





2. Dissolved Oxygen

Big Idea:

- Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. They need oxygen to survive, just like we do!
- When there is a lot of oxygen dissolved in the river, the organisms there can survive and be healthy.
- When rivers are damaged or polluted, it can lower the amount of dissolved oxygen available.

Image from Fondriest Environmental, Inc. (2013). *Fundamentals of Environmental Measurements: Dissolved Oxygen.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/

2. Dissolved Oxygen

1. Submerge the small tube into the water sample and fill with water.
2. Drop two of the DO test tablets into the tube.
3. Screw the cap on the tube - be sure there is no air in the tube.
4. Mix by inverting until dissolved. This will take 2 minutes.
5. Wait 3 more minutes for color to develop.
6. While you wait, find the preferred dissolved oxygen level for your fish species from the graphic to the right and record that in your data table
7. Compare your test tube to the chart and record the water sample's dissolved oxygen level in your data table.
8. Dispose of test in WASTE container.

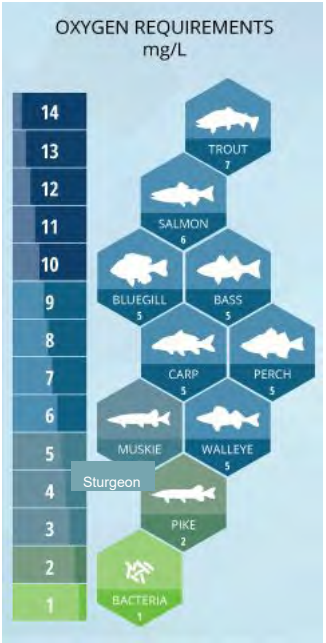


Image from Fondriest Environmental, Inc. (2013). *Fundamentals of Environmental Measurements: Dissolved Oxygen.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/

3. pH

Big Idea:

- pH is a number between 0 and 14 defining how acidic or basic a body of water is. A pH of 0 means that the water is very acidic, and a pH of 14 means that the water is very basic.
- If the pH of water is too high or too low, the aquatic organisms living within it will die. pH can also make certain chemicals and heavy metals in the water toxic to some species.
- Most aquatic creatures prefer a pH range of 6.5-9.0, though some can live in water with pH levels outside of this range.
- Waste from industrial factories, farms, and mining or construction sites can move the pH to unsafe levels.

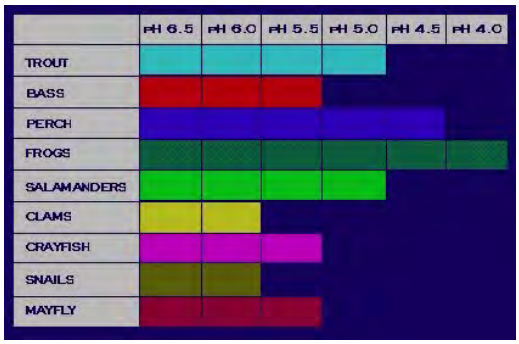


Image from Safe Drinking Water Foundation. (2017). *TDS and pH*. Retrieved from https://www.safewater.org/fact-sheets-1/2017/1/23/tds-and-ph

3. Measure Grand River pH

1. Fill the Test tube to the 10mL line with the water sample.
2. Add one pH test tablet.
3. Cap and mix by inverting until the tablet is dissolved.
4. Compare the color of the sample to the pH color chart.
5. Record your results.
6. Dispose of your sample in the WASTE container.

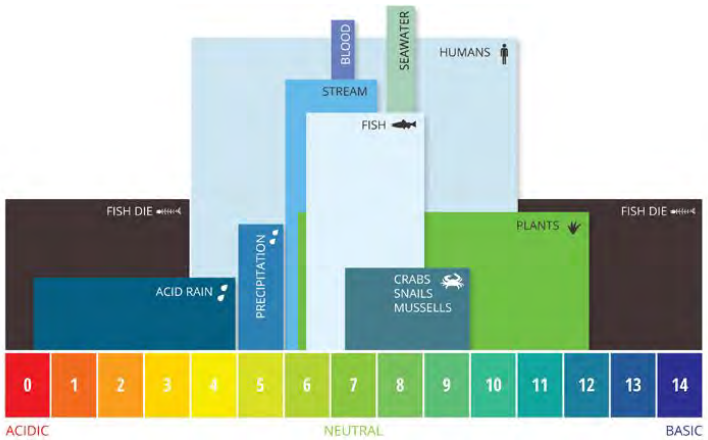
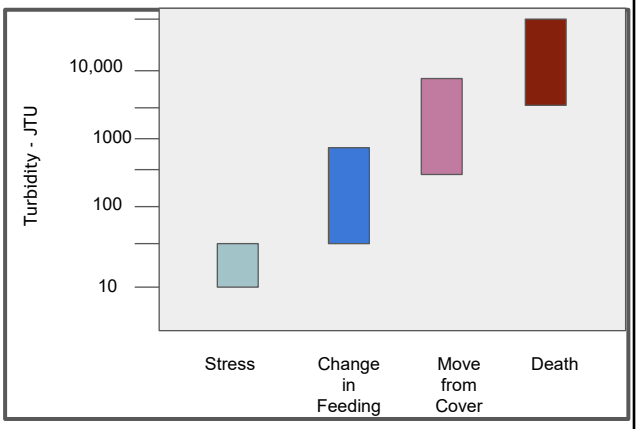


Image from Fondriest Environmental, Inc. (2013). *pH of Water*. Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/

4. Turbidity

Big Idea:

- Turbidity is a measure of how clear the water is.
- The greater the amount of sediment in the water (silt, sand, algae, or fine organic matter) the murkier it appears and the higher the turbidity is.
- By measuring turbidity, you can make conclusions about your species' health and whether or not it will survive and thrive in the body of water it is in.

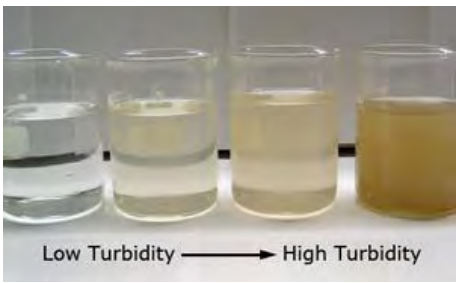


Effects of Turbidity on Fish Behavior

Image from Fondriest Environmental, Inc. (2014). *Turbidity, Total Suspended Solids and Water Clarity.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

4. Turbidity Procedure:

1. Fill the jar to the turbidity fill line located on the outside of the kit label.
2. Hold the Turbidity Chart on the top edge of the jar.
3. Looking down into the jar, compare the appearance of the secchi disk icon in the jar to the chart.
4. Record your result as Turbidity in JTU.



Images from The Hudson River Education and Stewardship Program. *Turbidity.* Retrieved from https://steinhardtapps.es.its.nyu.edu/nyuhudson/?page_id=168

5. Nutrients - Phosphate

Big Idea:

- Animals and plants that live in the water need phosphate. It is a nutrient they use to grow. However, too much phosphate in the water can be harmful.
- Too many nutrients in the water can cause algal blooms which can block sunlight and reduce the amount of oxygen in the water that organisms need.
- Human and animal waste and pollution from runoff can put too much phosphate into the river.

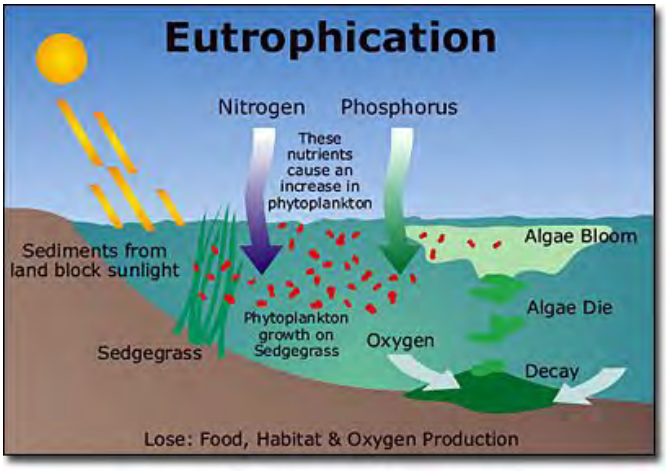


Image from Delaware Estuary Water Clarity. (2017). *What's The Problem in the Estuary?* Retrieved from https://www.delawareestuarywaterclarity.org/problem/

5. Phosphate

1. Fill a test tube to the 10 mL line.
2. Add one Phosphorus Test Tab.
3. Cap and Mix until dissolved.
4. Wait 3 min for the color to appear.
5. Compare the color to the sample chart.
6. Record your results.
7. Dispose of sample in WASTE container.

Have you ever seen water like this? This type of algae overgrowth can result from too many nutrients in the water.

Image from National Geographic. (2014). *Big Data Arrives on a Small Lake in Vermont.* Retrieved from https://blog.nationalgeographic.org/2014/12/19/big-data-arrives-on-a-small-lake-in-vermont/

6. Nutrients - Nitrate

Big Idea:

- Animals and plants that live in the water need nitrate. It is a nutrient they use to build protein. However, these plants and animals only need a very small amount in the water.
- Too many nutrients in the water can cause algal blooms which can block sunlight and reduce the amount of oxygen in the water that organisms need.
- Sewage and waste from animals and farms can create unsafe levels of nitrates in our river.

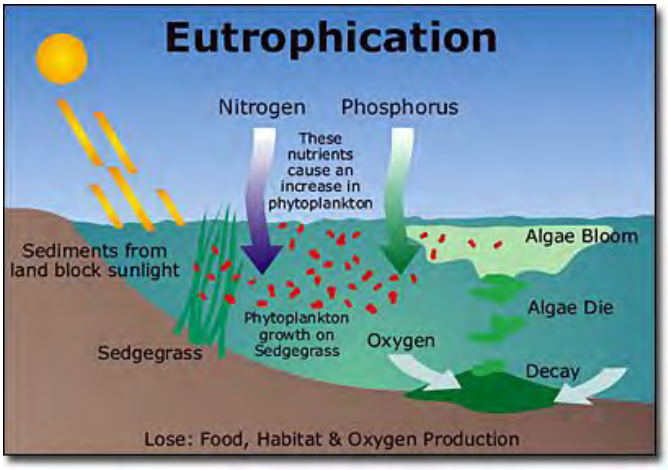


Image from Delaware Estuary Water Clarity. (2017). *What's The Problem in the Estuary?* Retrieved from https://www.delawareestuarywaterclarity.org/problem/

6. Nitrate

1. Fill a test tube to the 5 mL line.
2. Add one Nitrate Test Tab and cover with the protective sleeve.
3. Cap and Mix for 2 min.
4. Wait 3 min for the color to develop.
5. Remove from sleeve.
6. Compare the color to the sample chart.
7. Record your results.
8. Dispose of sample in WASTE container.

Have you ever seen water like this? This type of algae overgrowth can result from too many nutrients in the water.

Image from National Geographic. (2014). *Big Data Arrives on a Small Lake in Vermont.* Retrieved from https://blog.nationalgeographic.org/2014/12/19/big-data-arrives-on-a-small-lake-in-vermont/

Lake Sturgeon

Indicator	Preferred Range	Collected Data
Temperature	8-14 Celsius	
Dissolved Oxygen		
Turbidity	<40JTU	
pH	6.5-9	
Nitrate	<10ppm	
Phosphate	<3ppm	

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Lake Sturgeon

Acipenser fulvescens

Lake sturgeon (*Acipenser fulvescens*) are the largest indigenous fish found in the Great Lakes Basin and represent an important biological component of the Great Lakes fish community that can serve as an indicator of the overall Great Lakes' ecosystem's health and diversity. Lake sturgeon populations have been greatly impacted since the late 1800s, with almost all populations dramatically reduced or extirpated as a result of overfishing, habitat loss, dam construction and pollution.

Lake sturgeon can reach lengths of more than eight feet with weights of over 200 pounds. Their bodies are heavy and torpedo-shaped, with young sturgeon being angular (5-sided), but adults being rounded. Lake sturgeon do not have scales, but instead host "armor" in the form of boney, shell-shaped plates, or scutes, arranged in five rows – two on each side and one along the back running the length of the body.

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Northern Pike

Indicator	Preferred Range	Collected Data
Temperature	24 - 26 Celsius	
Dissolved Oxygen		
Turbidity	<40JTU	
pH	6.5-9	
Nitrate	<10ppm	
Phosphate	<3ppm	

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Northern Pike

Esox lucius

Common Name(s): Common pike, jack, jackfish

Description: The back of a northern pike is generally a dark green, fading to a light green on its sides and a cream white on the belly. There are very distinctive light-colored oval shaped spots against the darker color on the sides. The cheeks are fully scaled, as well as the upper half of the gill cover. The lower jaw protrudes with the underside containing five or less large sensory pores on each side, making the head consist of one fourth of the length of the entire fish. The rounded fins have distinctive dark markings.

Feeding Habits: Young fish eat primarily insects and insect larvae, waterfleas, and copepods. Adult northerns eat almost entirely fish, such as sunfish, perch, and even smaller northern pike, but are also known to eat frogs, crayfish, mice, muskrats, ducklings, and other shore birds. This is one of the most fearsome predators in freshwater.

Range: The whole of the northern United States, stretching down to Nevada , east through Maryland, plus Texas, Arkansas, Alaska, and all of Canada.

Habitat: Northern pike can live in almost any freshwater streams, rivers, ponds and lakes. They prefer slow-moving water with heavy vegetation. These fish grow larger in cooler waters, but live in warmer waters as well.

Typical Size: This species grows up to 3-4 feet in length and over 30 pounds. Fish that weigh over 10 pounds are fairly common in larger lakes and bodies of water. A typical catch is about 5 pounds.

World Record: 55 pounds, 1 ounce (Source - IGFA)

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Yellow Perch

Indicator	Preferred Range	Collected Data
Temperature	17 - 25 Celsius	
Dissolved Oxygen		
Turbidity	<40JTU	
pH	4.5 - 8	
Nitrate	<10ppm	
Phosphate	<3ppm	

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Yellow Perch

Perca flavescens

Description: The yellow perch sides are golden yellow to brassy green with six to eight dark vertical saddles with a white to yellow belly. Yellow perch have many small teeth, but no large canines. The gill cover contains one or more sharp spines.

Feeding Habits: Adults feed on aquatic insects, larger invertebrates, and other small fish.

Range: The yellow perch is a widespread species in the northern United States and in Canada. Although it occurs in nearly every U.S. state today it is sparsely distributed in the South.

Habitat: The yellow perch is found in lakes, ponds, and slow moving rivers. It prefers clear water with moderate vegetation and lots of sand or gravel bottoms.

Typical Size: Yellow perch range from 1 ounce to 1 pound with some fish known to exceed 2 pounds. Rarely are they longer than 12 inches in length.

World Record: 4 pounds, 3 ounces (Source - IGFA)

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Bluegill

Indicator	Preferred Range	Collected Data
Temperature	25 - 30 Celsius	
Dissolved Oxygen		
Turbidity	<40JTU	
pH	6.5-9	
Nitrate	<10ppm	
Phosphate	<3ppm	

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Bluegill

Lepomis macrochirus

Common Name(s): Bream, sun perch, blue sunfish, copperbelly

Description: Bluegills may be distinguished from other sunfish by the dark spot at the base of the dorsal fin and the solid black gill flap. They also have 6-8 vertical bars on their sides, and a relatively small mouth. The spiny dorsal fin usually has 10 spines and is broadly connected to the soft dorsal. The anal fin has three spines.

Feeding Habits: Small mouth size limits the size of food particles ingested and almost dictates a diet of insects and similar small organisms. While insects remain the staple food item for adults, crayfish, snails, small fish, and fish eggs are also consumed.

Range: Bluegills appear to have been native to the eastern half of the United States, southeastern Canada and northeastern Mexico. Today, as a result of countless intentional introductions, bluegill are found throughout the US and northern Mexico.

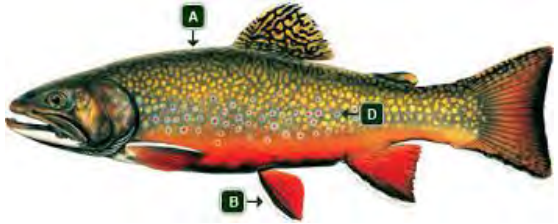
Habitat: The bluegill enjoys warm, shallow lakes with rooted vegetation. During mid-day, they go to deeper waters of shallow lakes or beneath the shade of trees or brush.

Typical Size: An adult bluegill can reach a size of about 12 inches in length although the average is 8 inches. A good size bluegill can reach 2 pounds in size. They live an average of 4-6 years.

World Record: 4 pounds, 12 ounces (Source - IGFA)

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

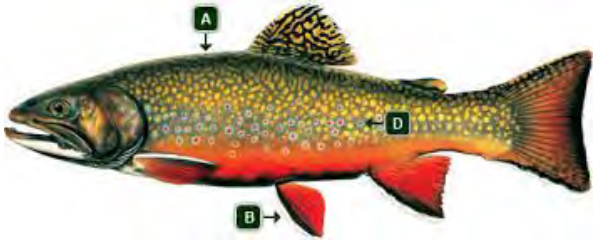
Brook Trout



Indicator	Preferred Range	Collected Data
Temperature	11 - 16 Celsius	
Dissolved Oxygen		
Turbidity	<40JTU	
pH	5.5-9	
Nitrate	<10ppm	
Phosphate	<3ppm	

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Brook Trout



Salvelinus fontinalis

Common Name(s): Speckled trout, spotted trout, mountain trout, char

Description: With an olive back covered by wormlike markings, fiery spotted flanks, and white-trimmed fins, the brook trout is one of the most colorful fish in freshwater.

Feeding Habits: In streams they prefer aquatic insects that live under the rocks and along the stream bottom. Land insects, like ants and beetles, that fall into the water are readily eaten, as are small crayfish. They will eat other small fish and minnows but only when they are easy to catch.

Range: The brook trout is native to northeastern North America. Primarily from the Great Lakes, north to the Hudson Bay and east to the Atlantic and Arctic Coasts. They are also located in the Appalachians southeast of the Great Lakes to the northeastern corner of Georgia. Brook trout have also been introduced to higher elevations in the western United States.

Habitat: Brook trout inhabit clear, cold mountain streams and lakes. They prefer a water temperature of 57-61 degrees. They are rarely found in water that is warmer than 68 degrees and if temperatures exceed 77-80 degrees it is fatal.

Typical Size: The average brook trout is 10-12 inches in length and weigh 4-6 pounds. They are slow growing and short lived fish, rarely making it past 8 years.

World Record: 14 pounds, 8 ounces (Source - IGFA)

Image from Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/

Common Carp

Indicator	Preferred Range	Collected Data
Temperature	29 - 32 Celsius	
Dissolved Oxygen		
Turbidity	<40JTU	
pH	6.5 - 9	
Nitrate	<10ppm	
Phosphate	<3ppm	

Image from Michigan DNR. (2019). *Common Carp and Suckers.* Retrieved from https://www.michigan.gov/dnr/0,4570,7-350-79135_79218_79614_82671---,00.html

Common Carp

Cyprinus carpio

Description: The common carp is a heavy-bodied minnow with barbels on either side of the upper jaw. Typically, color varies from brassy green or yellow, to golden brown, or even silvery. The belly is usually yellowish-white. Common carp may live in excess of 47 years and weigh over 75 pounds. The all-tackle world record was landed in 1987 from Lac de St. Cassien, France, and weighed in at 75 pounds 11 ounces.

Life History: Although carp are generally considered a nuisance by North American anglers, they are highly prized as sportfish in Europe, as they are often excellent fighters. A growing number of anglers in the US are becoming interested in carp as a sportfish. Although flavor varies with the quality of the water from which fish were captured, their sheer abundance has made them an important food fish in some areas.

Distribution: Common carp are native to temperate portions of Europe and Asia. They were first introduced into North America in 1877.

Image from Michigan DNR. (2019). *Common Carp and Suckers.* Retrieved from https://www.michigan.gov/dnr/0,4570,7-350-79135_79218_79614_82671---,00.html

Data Analysis Chart

Directions:

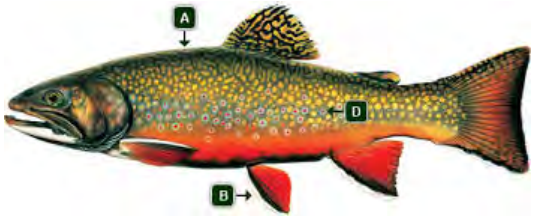
- Use the physical and chemical water quality data you gathered today to determine whether or not each fish species could live in the study stream/river.
- Record the class averages for each water quality indicator in the class data column on the left
- To analyze your data, color code the white cells of the chart green or red (green cells indicate that the water quality would fall within the preferred range for each fish, red indicates when it does not).

Class Data:	Preferred Range for Sturgeon	Preferred Range for Perch	Preferred Range for Pike	Preferred Range for Trout	Preferred Range for Bluegill	Preferred Range for Carp
Temperature (℃) _____	(8-14)	(17-25)	(24-26)	(11-16)	(25-30)	(29-32)
Dissolved Oxygen _____	(4)	(5)	(2)	(7)	(5)	(5)
pH _____	(6.5-9)	(6.5-9)	(6.5-9)	(6.5-9)	(6.5-9)	(6.5-9)
Turbidity _____	<40JTU	<40JTU	<40JTU	<40JTU	<40JTU	<40JTU
Nitrate _____	<10ppm	<10ppm	<10ppm	<10ppm	<10ppm	<10ppm
Phosphate _____	<3ppm	<3ppm	<3ppm	<3ppm	<3ppm	<3ppm

EPA. (2001). *Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VIII*. Retrieved from https://www.epa.gov/sites/production/files/documents/rivers8.pdf

Lake Sturgeon

Brook Trout



Yellow Perch

Bluegill

Common Carp

Northern Pike

Images from:
Wisconsin DNR. (2016). *Game Fishes of Wisconsin.* Retrieved from https://dnr.wi.gov/topic/fishing/species/
Michigan DNR. (2019). Common Carp and Suckers. Retrieved from https://www.michigan.gov/dnr/0,4570,7-350-79135_79218_79614_82671---,00.html

Lesson 8: Brainstorming Solutions

Overview

Students will use what they've learned so far about their chosen issue to begin brainstorming potential stewardship projects. This lesson walks the class through the design process and encourages them to work collaboratively to develop an idea of how they might address their watershed issue.

Curriculum Connections

Michigan K-12 Science Standards

- Ecosystems: Interactions, Energy, and Dynamics
  - MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
  - HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- Biological Evolution: Unity and Diversity
  - HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
- Earth and Human Activity
  - MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
  - HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- Engineering Design
  - 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
  - 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
  - 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.

Great Lakes Literacy Principle(s)

N/A

Focus Areas of GLRI Action Plan

Could address any of the following areas depending on the issue you've selected and the partner you bring in:

- Cleaning up Great Lakes Areas of Concern
- Preventing and controlling invasive species
- Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
- Restoring habitat to protect native species

Key Questions

- How might we solve the issue we've identified?
- How can we use the design process to develop an idea?
- How would our solution work?
- How would our solution benefit the Great Lakes Watershed?

Student Objectives

- Students will brainstorm potential solutions for the identified issue.
- Students will utilize the design process to collaboratively develop an idea.
- Students will explain how their solution would benefit the Great Lakes Watershed.
- Students will write a letter to a community partner, explaining their project and requesting help.

Vocabulary

Design Process
Prototype

Materials List and Setup

- Student journal or paper for reflective writing
- Design/prototype materials (legos, pipe cleaners, straws, scrap paper, markers, rubber bands, wheels, etc.)
- Design process PowerPoint: **https://tinyurl.com/ybfkxq5u**
- Sticky Notes (each student group should have a big stack)
- Pens/markers/pencils
- Design Plan worksheet (1 per group)
- Community Partner Letter template (1 per student)

Program Activities

1. Engage:
    a. Materials:
        i. Student journal or paper for reflective writing
    b. Procedure:
        i. Start class with the following writing prompts:
            1. *Think back to what we have done so far for our Groundswell project this year. How are you feeling at this point in the project?*
            2. *What do you think is the most important thing we've learned or discovered so far?*
        ii. Students should share their answers with a talking partner. The instructor can then have a few pairs report our their thoughts to the class.
        iii. Instructor should guide a conversation to specifically define the class issue and give the local/community connection that the student project may work to address.
            1. Example: If your GLRI Action Plan focus area is preventing and controlling invasive species, make sure that students understand they will be addressing that issue in the study site (maybe on the school grounds, at a local park, along a streamside).
2. Explore:
    a. Materials:
        i. Design process PowerPoint: https://tinyurl.com/ybfkxq5u
        ii. Sticky Notes (each student group should have a big stack)
        iii. Pens/markers/pencils
        iv. Design Plan worksheet (1 per group)
    b. Procedure: Group brainstorming activity--Reference the design process PowerPoint to guide students through each stage of brainstorming and prototyping.
        i. Split students into groups of 3-7 people
        ii. Cover rules for the brainstorm:
            1. This brainstorm will help us answer the question "How might we try to tackle or solve this issue?"

2. Collaboration is key here; make sure to build off of your classmates' ideas, don't shoot down the thoughts of others, go for quantity at first, don't speak over others.

iii. Review the four phases of the design process with students. Concise explanations of each phase are:
   1. **Gather:** We have already worked on this phase! This is when you get out into the community and see examples of the issue firsthand. Gather information about what exactly the problem is.
   2. **Generate:** Brainstorm with a group of people to think about possible ideas and designs! Dream big!
   3. **Make:** Choose one idea and build a rough model of it, called a prototype, to see if you can bring our idea to life!
   4. **Share:** Use your prototype to share your ideas with other people and then think about what you could change to make it even better!

iv. Generate ideas:
   1. Student groups will generate ideas on sticky notes and place them on an open wall space, on a poster board, or on their table. Encourage them to brainstorm as many ideas as they can and to write one idea per sticky note. Give them approximately five minutes for this initial brainstorm.

v. Select favorite ideas
   1. Have the group read all of the brainstormed ideas together aloud.
   2. Each group member will vote on their top 2-3 favorite ideas using a colored marker.
   3. The group will identify which idea has the most votes. This is the idea they will select to flesh out further.

vi. Groups will flesh out their favorite idea by filling out the design plan worksheet.

3. Explain:
   a. Materials:
      i. Design/prototype materials (legos, pipe cleaners, straws, scrap paper, markers, rubber bands, wheels, etc)
   b. Procedure:
      i. Make:
         1. Groups quickly create a prototype or visual to use in explaining their idea to the class.
      ii. Share:
         1. Present out to the class with their prototype. They will read from their design plan worksheet to explain what their solution is, how it will work, and how it will address the Great Lakes Watershed issue the class has chosen.
4. Elaborate/Extend:
   a. Materials:
      i. Community Partner Letter template (1 per student)
   b. Procedure:
      i. Students will use the template to draft letters explaining their progress in the Groundswell project and the ideas they brainstormed during today's lesson; they will also ask the partner to come in to help them develop the details of their project.
      ii. In setting up meetings with the community partner, the instructor can forward student letters to them, giving student work a real audience.

How Might We...

Group Brainstorming Activity

(Inspired by OpenIDEO, Brainstorm in a Box)

How Might We Solve Our Issue?

Let's recap:

- ❑ We have settled on an issue in our community
- ❑ We have dived deeper to learn more about this issue

Now we will:

- ❑ Try to answer the question "How Might we try to tackle or solve this issue?"
- ❑ We will do this with a group brainstorming activity

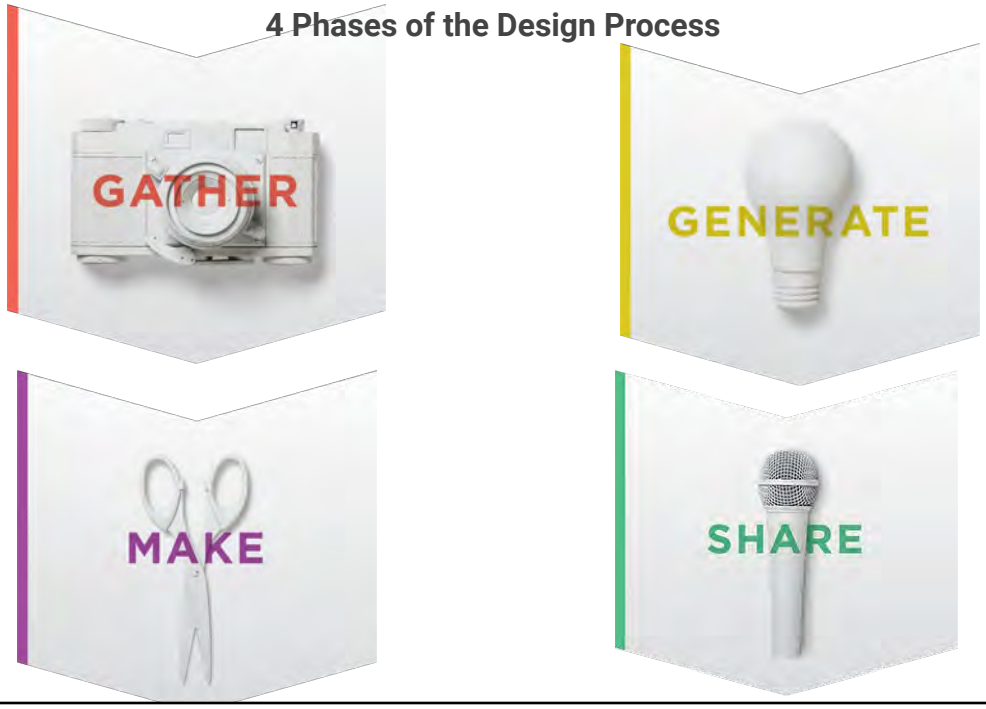
Materials:

- ❑ Post-it notes
- ❑ Pens/markers/pencils
- ❑ A large open wall or whiteboard
- ❑ Open minds and creativity!

Rules for this activity:

- ❑ Build off of your classmates' ideas
- ❑ Go for quantity at first!
- ❑ Don't speak over others
- ❑ Stay focused on the question

4 Phases of the Design Process



Generate!

- Try to brainstorm as many ideas as you can. Think big or small.
- Write your ideas on sticky notes, one idea per note!

Pick your favorite ideas

- Each group member will now vote on top 2-3 favorite ideas using a colored marker.
- Identify which idea has the most votes. You will work to create a detailed design plan for this idea.

Flesh out your favorite idea….

The Design Process: Brainstorming Solutions

Design Plan: Use this worksheet to explain your favorite idea and think about the details of how it could work!

Our plan is…
What will it be?

That…
What will it do? Explain how your idea will work.

Because…
How will this design help solve the issue we have identified?

Contact a Community Partner

Directions: Use the template below to plan what your letter will include. Then, type or handwrite a final copy of the letter!

_____

(Date goes here)

Dear _____

(name of Community partner you're writing to goes here)

Paragraph 1: Introduce yourself and name your school and class.

_____

_____

_____

We are studying watersheds and want to provide a meaningful service project that will improve our Great Lakes ecosystem. The issue our class is focusing on is:

_____

_____

We have brainstormed some ideas for how our class can work to address this issue. Some solutions we have thought of are:

_____

_____

_____

Would you please visit our class to tell us more about your work and explain ways you might be able to help us with our project?

Thank you for your time,

_____

(Sign your name here)

Lesson 9: Developing an Action Plan

Overview

This lesson provides a framework for choosing and developing a stewardship project in conjunction with a committed community partner. The process again utilizes a criteria-based decision making model that allows community partners to share their expertise in an organized, constructive way while still incorporating and honoring student ideas and input.

Curriculum Connections

Michigan K-12 Science Standards

- Ecosystems: Interactions, Energy, and Dynamics
    - MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
    - HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- Earth and Human Activity
    - 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
    - MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
    - HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- Engineering Design
    - 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
    - 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.

Michigan K-12 Social Studies Standards

- 5 – P4 .2 .1 Develop and implement an action plan and know how, when, and where to address or inform others about a public issue.
- 5 – P4 .2 .2; 6– P4 .2 .3; 7 – P4 .2 .3; 8 – P4 .2 .3 Participate in projects to help or inform others (e.g. service learning projects).

Great Lakes Literacy Principle(s)

N/A

Focus Areas of GLRI Action Plan

Could address any of the following areas depending on the issue you've selected and the partner you include:

- Cleaning up Great Lakes Areas of Concern
- Preventing and controlling invasive species
- Reducing nutrient runoff that contributes to harmful/nuisance algal blooms
- Restoring habitat to protect native species

Key Questions

- What are the specific needs and constraints we must consider in selecting a project?
- What resources does this project require?
- Are we ready to start our project work?

Student Objectives

- Student groups will use the prototypes they developed to present their project ideas to a community partner.
- Students will collaborate with a community partner to select the best project based on a set of needs and constraints.
- Instructors and students will develop an action plan and assess their readiness to complete their stewardship project.
- Students will enact a stewardship project to positively impact their community and watershed.

Vocabulary

Criteria

Materials List and Setup

- Project selection grid (1 per student)
- Checklist worksheet (1 per student)
- Arrange for your community partner to come in for the first half of this lesson plan

Program Activities

1. Engage:
    a. Materials
        i. Student-created prototypes from previous lesson
        ii. Completed design plan worksheets from previous lesson
    b. Procedure:
        i. Invite community partner in and have student groups use their prototypes and design plan documents to pitch their ideas from the brainstorming activity.
2. Explore:
    a. Materials:
        i. Project Selection grid
        ii. Community partner
    b. Procedure:
        i. The Project Selection grid will be used to decide which stewardship project your class will create. Explain that this method is called Criteria-Based Decision Making and remind the class that this is the same process you used when you were identifying which issue you wanted to focus on with your Groundswell unit.
        ii. Write the project ideas in the top row of the grid.
        iii. Read over the criteria that will be used to select a project and explain that in choosing a good project we need to think about the time and materials available to us as well as what we are most passionate and knowledgeable about.
        iv. The community partner (or you as the teacher if you are unable to bring in a partner for this step) will score each box in the grid with a ranking of 1-5, with a 5 indicating that the criterion is fully met, and a 1 meaning the criterion is not met at all. Ask the community partner to provide commentary on their thought process and keep a good balance between staying positive about student project ideas and providing their expert knowledge on what the

realistic considerations are. Students will follow along, recording the scores in their own copy of the grid.

v. The very last row will be specific to each student's personal interest. When every score has been assigned, students can add up the scores and record them in the "Totals" row.

vi. The instructor may collect these grids, calculate class totals, and present the highest-scoring issue at the next class meeting.

3. Explain:
    a. Materials:
        i. Action plan template (for instructor reference)
        ii. Checklist worksheet (1 per student)
    b. Procedure:
        i. Instructors will work with partners and others to plan the logistics of the project session for the class. Instructors will come back and generate an action plan with students so they gain an understanding of the materials and time needed to create their project. A template of questions to address in your action plan is included in the lesson materials.
        ii. Have students take ownership and assess their personal readiness for the stewardship project with the "Are you Ready to do this Project?" checklist worksheet.
4. Elaborate/Extend:
    a. Procedure:
        i. Students will go into the field and carry out their plan with support from partners!

Supplementary Materials

Great resource for planting rain garden:

Earth Partnership for Schools. (2011). *Rain Garden Curricular Sampler*. *Retrieved from* https://arboretum.wisc.edu/content/uploads/2015/04/RGS-Full-Rain-Garden-Sampler-2011.pdf

Reference the Groundswell Community Partners page if you are looking for organizations that have expertise in the area of the issue you've selected:

Groundswell. (2019). *Our Partners*. Retrieved from https://www.gvsu.edu/groundswell/

Directions: Use the table below to decide which project idea the class will develop.

- Record the project ideas of each student group in the top row.
- Score every box with a ranking of 1-5, with a 5 indicating that the criterion is fully met.
- Add your scores in the bottom row, circle the winner, and report your results.

Issues, Challenges, or Opportunities

Definition of criteria: *Standards that can be used to judge or decide something*	1	2	3	4	5	6	7
The project addresses the issue we have identified							
The amount of resources the project would cost is manageable							
The amount of time the project would take is manageable							
Our community partner has the knowledge and experience to help us with this issue							
I personally care about and am interested in this project							
Totals:							

Action Plan

1. What action will you take?

2. What is the result you want?

3. What community partner(s) will you be working with?

4. How will they assist with your project?

5. What kinds of materials or resources do you think you would need to complete this project?

6. How much time do you think this will take?

Are you ready to do this project?

Put a check next to the statements that are true for you to see if your project is meaningful and manageable.

- ❑ Are you committed to putting your time and energy into this project?
- ❑ Do you believe that this project will improve the quality of your watershed?
- ❑ Do you understand how this project will impact the larger Great Lakes Watershed?
- ❑ Could you explain your project to friends and family?
- ❑ Do you think there's enough time to complete this project?
- ❑ Do you have a community partner who is willing to help you on this project?

If you have a check next to every box, you should be set to create your project!

1. If you do not have boxes checked, what can you do to make sure you are ready for action?

2. What are you most excited about for this phase of the project?

Lesson 10: Reflect, share, and celebrate!

Overview

In this phase, students will reflect on the experience of participating in the Groundswell project. They will consider the best ways to inform others about their watershed and about the importance of practicing stewardship. Additionally, they will reflect on the range of influence of their project, examining how local actions can have wide-ranging ripple effects.

Curriculum Connections

Michigan K-12 Science Standards

- Earth and Human Activity:
    - 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
    - HS-ESS3-4.Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- Ecosystems: Interactions, Energy, and Dynamics
    - HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Michigan K-12 Social Studies Standards

- 5 – P4 .2 .1 Develop and implement an action plan and know how, when, and where to address or inform others about a public issue.
- 5 – P4 .2 .2; 6 – P4 .2 .3; 7 – P4 .2 .3; 8 – P4 .2 .3 Participate in projects to help or inform others (e.g. service learning projects).

Great Lakes Literacy Principle(s)

#1 - The Great Lakes, bodies of fresh water with many features, are connected to each other and to the world ocean.
#6 - The Great Lakes and humans in their watersheds are inextricably interconnected.

Focus Areas of GLRI Action Plan

N/A

Key Questions

- How do I share my work with the community?
- What do I want others to learn/know about the project?
- Why is sharing our effort important?
- How did the project impact my place?
- How have we changed our watershed?

Student Objectives

- Students will be able to describe the importance of sharing their involvement in stewardship efforts with the community.
- Students will be able to provide specific examples of actions people can take to become good stewards of the Great Lakes.
- Students will reflect on how their project impacted their place, from the site of their project to the Grand River, to the Great Lakes system, and even the world.

Materials List and Setup

- Projector/Computer or whiteboard and markers
- Student notebooks or paper for writing reflections
- Materials for student groups to demonstrate their work (poster paper and markers, technology for creating a slideshow, etc.)

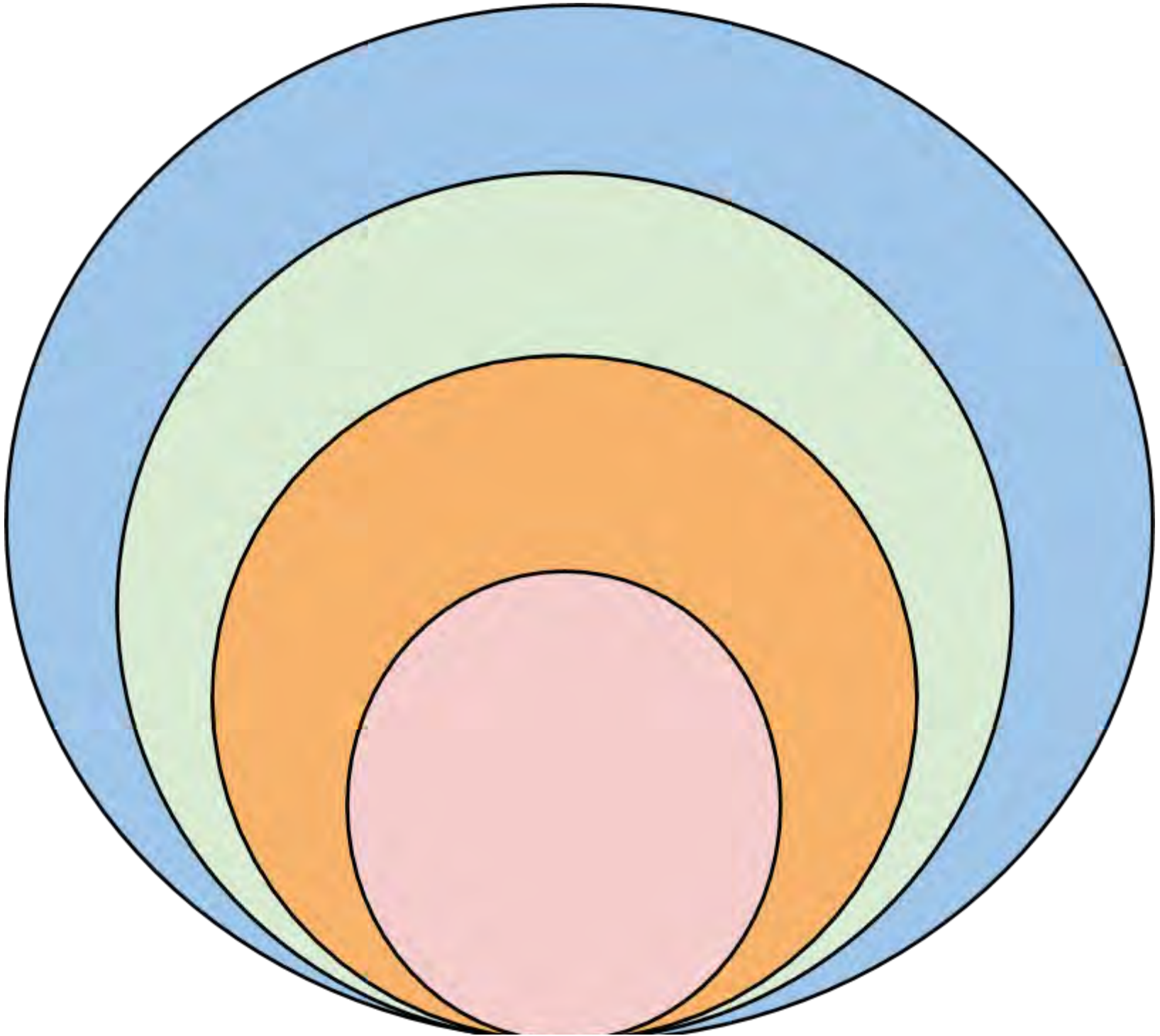
- Worksheets “Concentric Spheres of Influence” (1 per group or 1 per student; printed in color)

Program Activities

1. Engage:
    a. Materials:
        i. Student notebooks or paper for writing prompt
    b. Procedure:
        i. Prompt students to close their eyes and think back about what they thought this Groundswell project was going to be like at the beginning. How did the experience compare?
        ii. Have a group discussion about the successes and challenges of the project over the course of the year:
            1. What successes did we have with this project?
            2. What didn’t work out quite as we hoped/Areas for improvement?
            3. What would you do differently if you could go back and do this again?
            4. What is the most important thing you learned by participating in this project?
2. Explore:
    a. Materials:
        i. Computer and projector
        ii. Student notebooks or paper for journal prompt
    b. Procedure:
        i. Start with the following quote written on the board or on a projector “In the end we will conserve only what we love; we will love only what we understand, and we will understand only what we are taught.” –Babe Dioum
        ii. Have students journal about their response to this quote and then discuss responses in small groups.
            1. Do they agree with it? Why or why not?
            2. How do they think it relates to our Groundswell project?
            3. What do you think are the best ways to help others understand and love the environment where they live?
3. Explain:
    a. Materials:
        i. Materials for student groups to demonstrate their work (poster paper and markers, technology for creating a slideshow, etc.)
    b. Procedure:
        i. During this project, we have worked with community partners to make a difference in our watershed. In order to really make a change, many members in a community need to be committed to being stewards and caring for our environment. How can you teach someone else to become a steward?
        ii. Create a list of what you think are the 3 most important things people can do to become good stewards of our Great Lakes.
        iii. Present this to the class in one of the following ways:
            1. Skit/speech/demonstration
            2. Poster
            3. Slideshow
        iv. For each of your three guidelines, provide supporting information about how that action/behavior would benefit the Great Lakes.
4. Elaborate/Extend: Use the concentric spheres of influence graphic to reflect on how the project impacted your place.
    a. Materials:
        i. Worksheets “Concentric Spheres of Influence” (1 per group or 1 per student; printed in color)

b. Procedure:
    i. Have students work in small groups to sketch or write their thoughts for how their project impacted each of the following areas:
        1. Red circle: How did our work impact our project site?
        2. Orange circle: How did our work impact the Grand River Watershed?
        3. Green circle: How did our work impact the Great Lakes system?
        4. Blue circle: How did our work impact the world?
    ii. Have groups share out as you record responses on a large pad of paper or on a whiteboard.
5. Wrapping up: In preparation for the Groundswell Student Showcase (or any end-of-the-year project displays), recruit parents to help you gather photos, testimonials, marketing, social media posts about the event. When you return to the classroom, dedicate some time for a celebration of your project and consider showing these on a projector to celebrate your class's accomplishments.

Spheres of Influence: How has this Project Impacted our Place?



Glossary of Terms

1. Algal bloom: An environmentally harmful situation that occurs when colonies of algae, simple plants that live in water, grow out of control and negatively impact people, fish, and other wildlife. Algal blooms are often caused by nutrient loading, invasive species introduction, water flow modification, and other factors.
2. Criteria: Standards that can be used to judge or decide something.
3. Design Process: The iterative process of developing a solution or product to meet a desired need. It often includes empathizing with or gathering information about your audience, collaboratively generating ideas, developing a prototype to explain your ideas in a low-cost way, and sharing those ideas to get feedback. These steps can be repeated until a satisfactory end-result is developed.
4. Dissolved Oxygen: This term refers to the amount of free, non-compound oxygen present in water or other liquids. Free oxygen is that which is not bonded to any other element. It is an important parameter in assessing water quality because of its influence on aquatic organisms. Aquatic organisms--including fish, plants, and bacteria--rely on dissolved oxygen for respiration, similar to how we humans use oxygen in the air. A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality.
5. Distribution: A term ecologists use to describe how individuals in a population of plants or animals are dispersed or arranged in space at a given time.
6. Environmental Stewardship: The responsible use and protection of the natural environment through conservation and practices that will keep ecosystems functional for the future. It is a shared responsibility for environmental quality that is shared by everyone whose actions impact the environment.
7. Eutrophication: The process by which bodies of water are enriched by nutrients, generally phosphorus and nitrogen, leading to excessive plant growth. Eutrophication can occur naturally or may be accelerated by human influences such as agriculture, urbanization and shoreline development.
8. Great Lakes Ecosystem: This ecosystem includes all of the biotic and abiotic components of the Great Lakes region. The Great Lakes water system includes five large lakes, one small lake, four connecting channels, and the St. Lawrence Seaway. The large lakes are Superior, Michigan, Huron, Erie, and Ontario. They hold about 90% of the freshwater in the United States and approximately 20% of the world's freshwater supply. Forty million residents of the United States and Canada depend on this system for clean drinking water. Today, the Great Lakes ecoregion contains a variety of habitats, including aquatic, forest, marsh, wetland, and dune ecosystems. Widely varying climate, soils, and topography support more than 3,500 species of plants and animals.
9. Great Lakes Literacy: Great Lakes literacy is an understanding of the Great Lakes' influences on you and your influence on the Great Lakes.

10. Groundwater: Water held below the surface of the land, underground. It is stored in and moves slowly through aquifers. Groundwater is most commonly used in agriculture for crop irrigation, and it supplies drinking water for approximately half of the U.S. population.
11. Invasive species: An invasive species is an organism that causes ecological or economic harm in a new environment where it is not native.
12. Nitrogen: Nitrogen is a nutrient needed for plant growth. About 78% of the air that we breathe is composed of nitrogen gas, and in some areas of the United States certain forms of nitrogen are commonly deposited in acid rain. Although nitrogen is found naturally in the environment, it is also introduced through sewage and crop fertilizers. Nutrients, such as nitrogen and phosphorus, are essential for plant and animal growth and nourishment, but too much of these nutrients in water can cause a number of negative health and ecological effects.
13. Nonpoint-source (NPS) pollution: Non-point source pollution is contamination that occurs when rainwater, snowmelt, or irrigation washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants. Thus, this type of pollution is (NPS)discharged over a wide land area, not from one specific location. NPS pollution may be caused by sediment, nutrients, organic and toxic substances originating from land-use activities; surface runoff carries these pollutants to lakes and streams.
14. pH: A measurement of the amount of hydrogen ions present in a substance, such as water. Knowing the amount of hydrogen in a substance allows us to determine whether it is acidic, neutral or basic. pH is a figure between 0 and 14 along a logarithmic scale; the lower the number, the more acidic the water is. The higher the number, the more basic it is. A neutral pH is 7.
15. Phosphorus: Phosphorus is a common component of agricultural fertilizers, manure, and organic wastes in sewage and industrial production. It is an essential element for plant life, but when there is too much of it in water, it can have negative environmental impacts, such as causing eutrophication and algal blooms. These phenomena lead to a reduction of available dissolved oxygen for aquatic organisms. Soil erosion and agricultural runoff are major contributors of phosphorous to bodies of water.
16. Point-source Pollution: Water pollution coming from a single point, such as a sewage-outflow pipe.
17. Prototype: A prototype is a low-cost model that can be used to demonstrate or explain the design of a future product or idea. A prototype can be anything that demonstrates how your idea works and what it will look like.
18. Retention Time: The average time that water or a dissolved substance spends in a lake. It can be calculated by dividing the lake's volume by the flow rate in to or out of the lake.
19. Runoff: Excess rainfall or snowmelt that flows over land into lakes and rivers because it was not absorbed by soil or plants.
    a. Stormwater runoff: Runoff from storm events that is collected by drainage systems (curbs, storm sewers, and ditches) and carried directly to streams. As it flows over the

land surface, stormwater picks up potential pollutants that may include sediment, nutrients, bacteria (from animal and human waste), pesticides, metals, and petroleum by-products. Polluted stormwater runoff can be harmful to plants, animals, and people.

20. Sediment: Soil and other particles suspended in water or settled on the bottom of a water body.
21. Turbidity: Measurement of sediment, solid particles, stirred up or suspended in water. Turbidity makes water appear cloudy or even opaque in extreme cases. Turbidity measurements are often used as an indicator of water quality based on clarity and estimated total suspended solids in water.
22. Water Quality: A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose--such as crop irrigation, recreation, supporting aquatic life.
23. Watershed: A land area that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge.

References:

Department of Mechanical & Aerospace Engineering at University of Florida. *Introduction to the Design Process* [pdf presentation]. Retrieved from http://www2.mae.ufl.edu/designlab/Lab%20Assignments/EML2322L-Design%20Process.pdf

EPA. (2016). *Environmental Stewardship.* Retrieved from https://archive.epa.gov/stewardship/web/html/

Fondriest Environmental, Inc. (2014). *Algae, Phytoplankton and Chlorophyll. Fundamentals of Environmental Measurements.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/algae-phytoplankton-and-chlorophyll>.

Fondriest Environmental, Inc. (2013). *Dissolved Oxygen. Fundamentals of Environmental Measurements.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/>.

Fondriest Environmental, Inc. (2013). *pH of Water. Fundamentals of Environmental Measurements.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/

Fondriest Environmental, Inc. (2014). *Turbidity, Total Suspended Solids and Water Clarity. Fundamentals of Environmental Measurements.* Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

The Groundwater Foundation. (2019). *What is Groundwater?* Retrieved from https://www.groundwater.org/get-informed/basics/groundwater.html

Khan Academy. (2016). *Population Ecology.* Retrieved from

https://www.khanacademy.org/science/high-school-biology/hs-ecology#hs-population-ecology

Michigan Sea Grant. (2019). *Teacher Tools: Glossary.* Retrieved from https://www.michiganseagrant.org/lessons/teacher-tools/glossary/

NOAA. (2019). *Great Lakes Ecoregion.* Retrieved from https://www.noaa.gov/education/resource-collections/freshwater-education-resources/great-lakes-ecoregion

NOAA. (2016). *What is a Harmful Algal Bloom?* Retrieved from https://www.noaa.gov/what-is-harmful-algal-bloom

NOAA. (2018). *What is an invasive species?* Retrieved from https://oceanservice.noaa.gov/facts/invasive.html

Ohio Sea Grant. (2013). *Great Lakes Literacy: Essential Principles and Fundamental Concepts for Great Lakes Learning* [Vol 2, PDF pamphlet]. Retrieved from https://ohioseagrant.osu.edu/products/50ef9/gl-literacy-essential-principles-amp-fundamental-concepts-for-gl-learning-brochure

Rueda, F., Moreno-Ostos, E., & Armengol, J. (2006). The residence time of river water in reservoirs. *Ecological Modeling, 191, 260-274.* doi:10.1016/j.ecolmodel.2005.04.030

The University of Maine. (2013). *What is Prototype?* Retrieved from https://umaine.edu/amc/2013/08/07/what-is-a-prototype/

USGS. *Dictionary of Water Terms.* Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/dictionary-water-terms?qt-science_center_objects=0#qt-science_center_objects

USGS. *Nitrogen and Water.* Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/nitrogen-and-water?qt-science_center_objects=0#qt-science_center_objects

USGS. *Phosphorus and Water.* Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/phosphorus-and-water?qt-science_center_objects=0#qt-science_center_objects

USGS. *Runoff: Surface and Overland Water Runoff.* Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/runoff-surface-and-overland-water-runoff?qt-science_center_objects=0#qt-science_center_objects