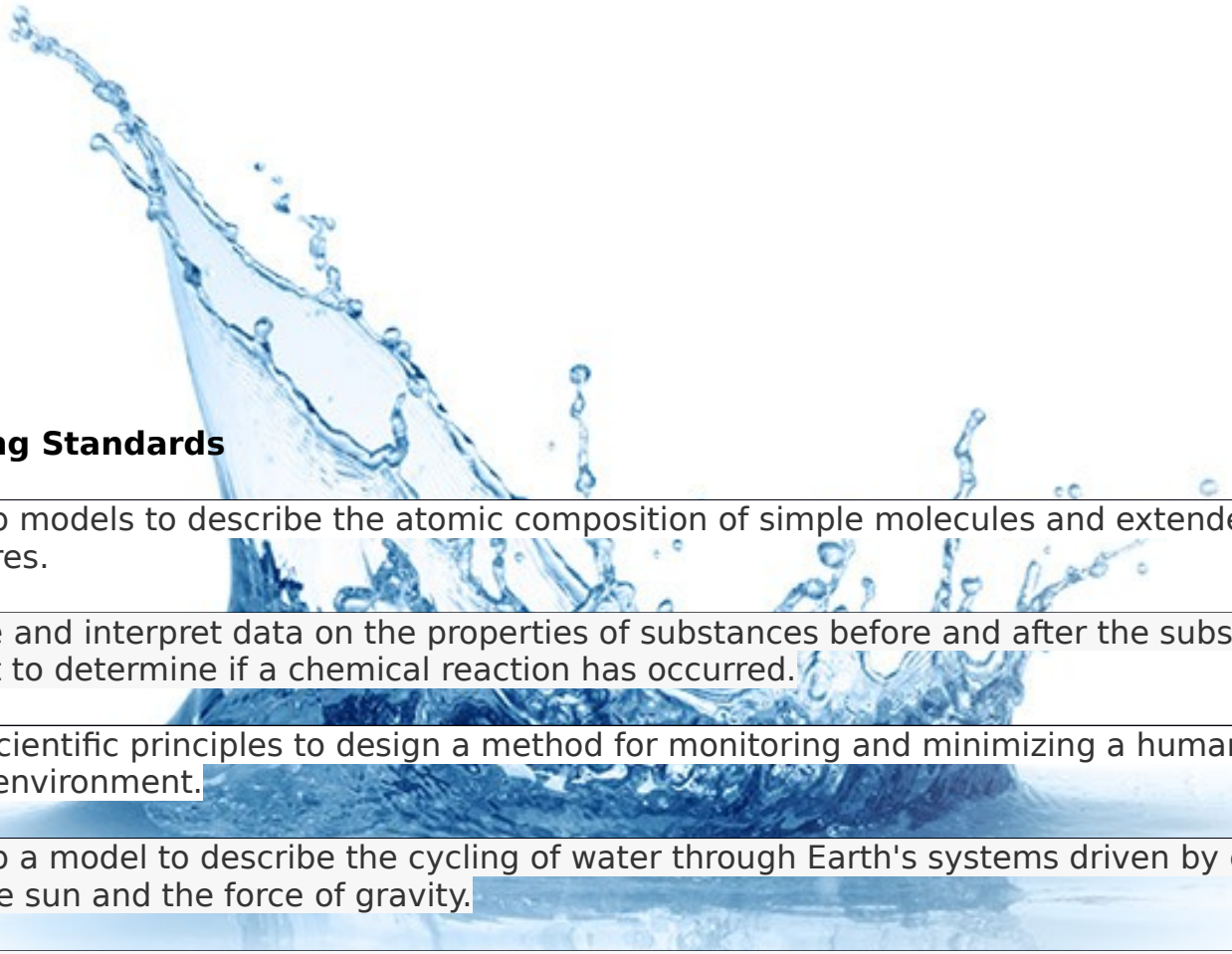
INTEGRATED STEM LESSON PLAN by Tameka Farrell
Topic: Water Pollution Unit
Time: six-seven 40-minute periods, one 70-minute period
Grade Level/Subject: Grade 7-8 Science

Justification

Water pollution is an issue that affects everyone. It stretches far beyond thinking that there are countries that do not have access to clean drinking water. There are many factors that compromise the quality of drinking water in our own country. It is important that global learners understand the effects of industries and government have on the quality of the water that we use each day. Water pollution is a topic in science where it is natural to introduce the connections it has to technology and engineering, as both of those components are crucial to finding solutions to the water quality crisis.
This water pollution lesson plan incorporates each component of STEM.

Goals

- Students will participate in an engineering design challenge where they must construct an effective water filter
- Students will analyze water samples for contaminants by using Vernier probes and software
- Students will recognize products that contains microplastics and be able to choose more environmental-friendly alternatives
- Students will make connections between the contaminants and local sources.
- Students will learn how to use Google Sheets or Microsoft Excel to create class data sets and determine the best way to present their data



NGSS Learning Standards

MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
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.
MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved

MS-ESS 3.C	Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise
MS-ESS 3-4	Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-ETS 1-1	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

CCSS Mathematical Practices

	Make sense of problems and persevere in solving them
	Construct viable arguments and critique the reasoning of others
	Model with mathematics
	Attend to precision
	Draw evidence from informational texts to support analysis, reflection, and research

NYS P-12 SLSs

ENGINEERING DESIGN

MS-ETS Develop a model to generate data for iterative testing and modification

1-4.	**of a proposed object, tool, or process such that an optimal design can be achieved.**
MS-ETS 1-3.	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success**
MS-ETS 1-2.	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
MS-ETS 1-3.	**Analyze data from tests to determine**
MS-ETS 1-1.	**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.**

HUMAN IMPACT

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.

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

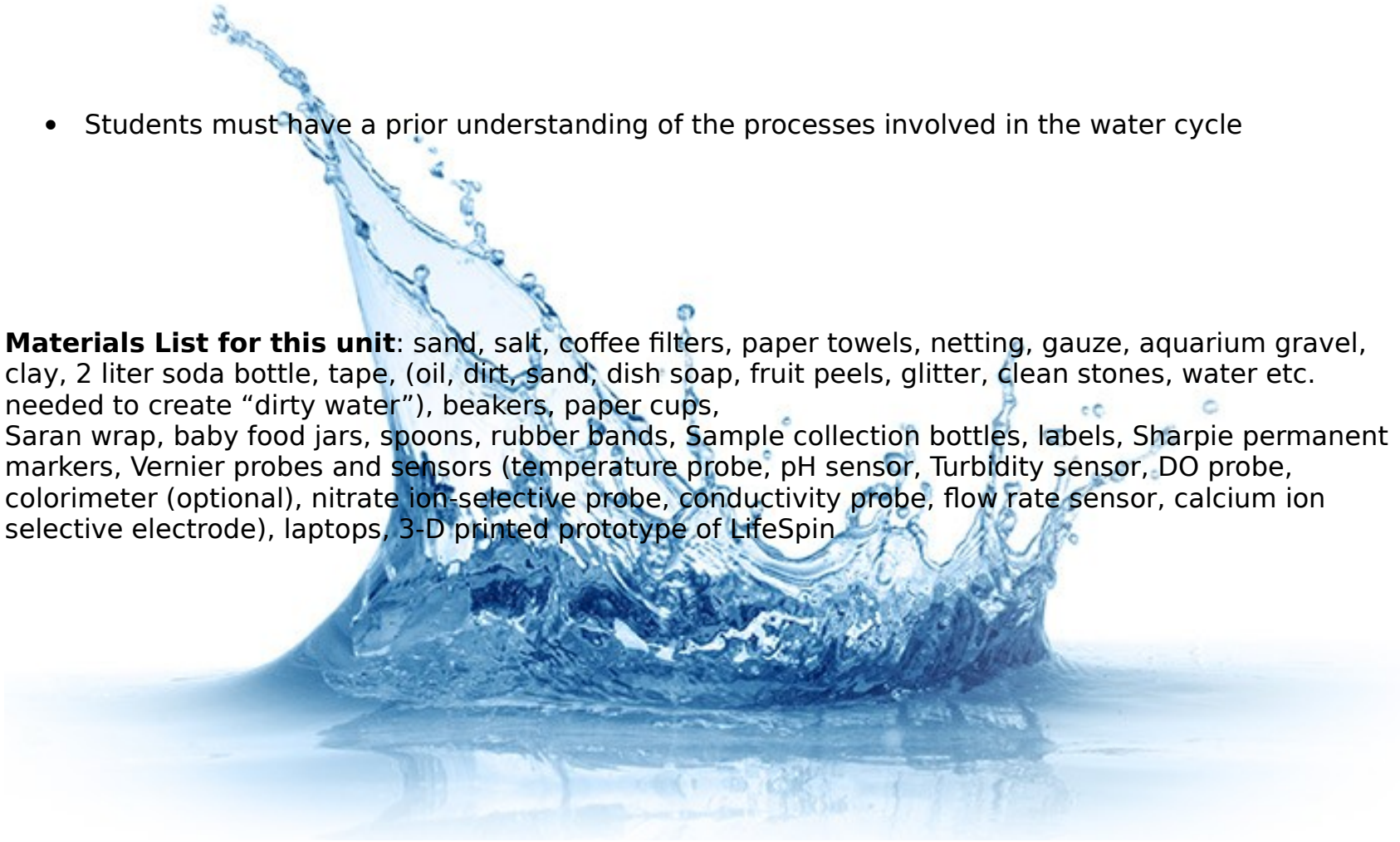
NYS Science and Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
● Analyzing and Interpreting Data ● Constructing Explanations and Designing Solutions ● Developing and Using Models ● Engaging in Argument from Evidence ● Planning and Carrying Out Investigations ● Using Mathematical and Computational Thinking	Types of Interactions Research Effect of human activities	Patterns Cause and Effect

Driving Questions

1. **What is the impact of water pollution in our environment?**
2. **How is the government involved in helping solve issues involving pollution?**
3. **How can we assess the quality of water in our community?**
4. **What substances can be found in our local water and how did they get there?**

Prior Knowledge

- Students must have prior knowledge about the necessity of water within the human body
- Students must have an understanding of components of a water based solution



- Students must have a prior understanding of the processes involved in the water cycle

Materials List for this unit: sand, salt, coffee filters, paper towels, netting, gauze, aquarium gravel, clay, 2 liter soda bottle, tape, (oil, dirt, sand, dish soap, fruit peels, glitter, clean stones, water etc. needed to create “dirty water”), beakers, paper cups,
Saran wrap, baby food jars, spoons, rubber bands, Sample collection bottles, labels, Sharpie permanent markers, Vernier probes and sensors (temperature probe, pH sensor, Turbidity sensor, DO probe, colorimeter (optional), nitrate ion-selective probe, conductivity probe, flow rate sensor, calcium ion selective electrode), laptops, 3-D printed prototype of LifeSpin

Engagement (Day 1)
40-minute class period

Student's prior knowledge assessed and interest engaged in the phenomenon

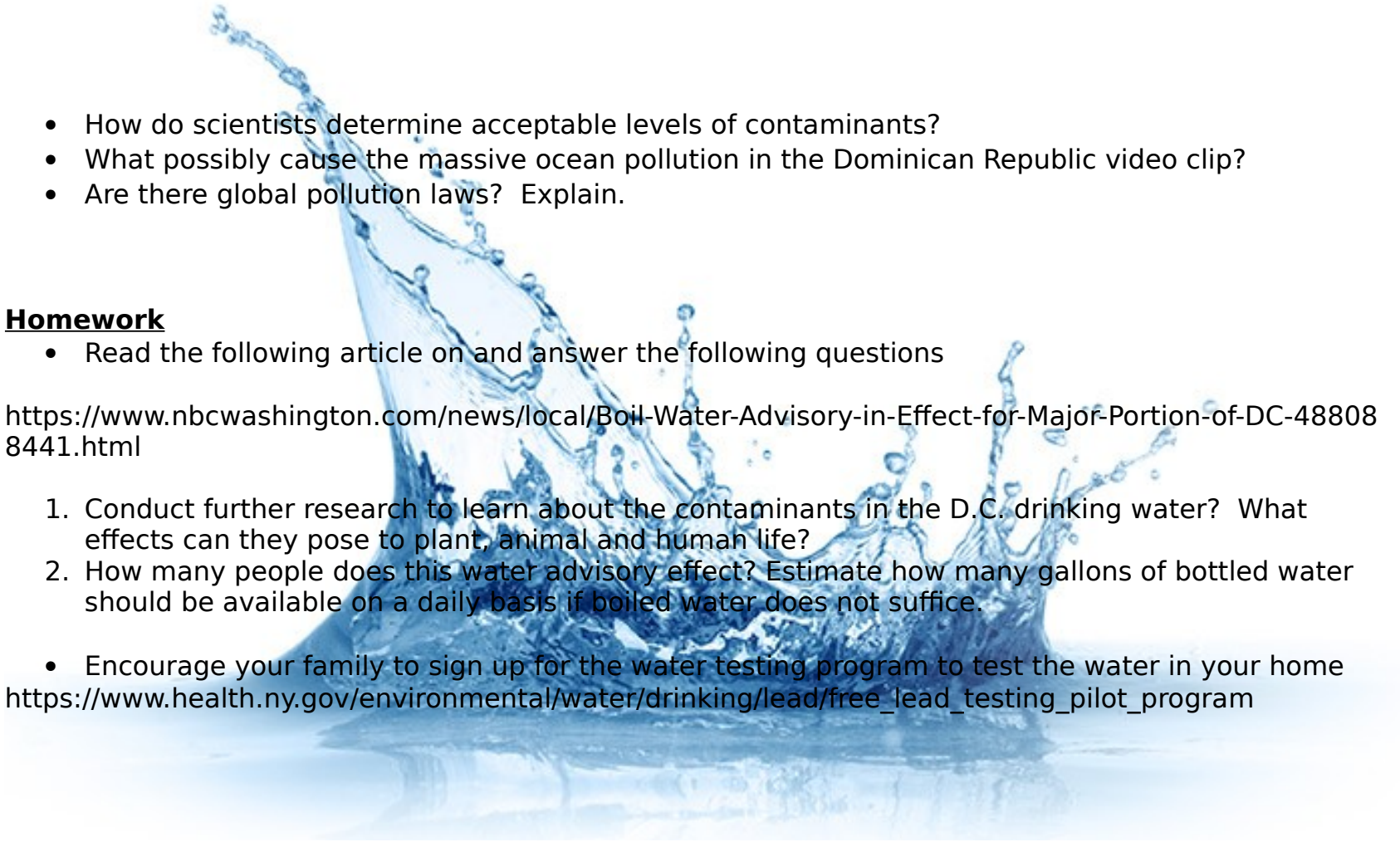
Class Activity

- Students will do a board brainstorm of all daily activities and habits that require water (2 minutes)
- How would your day be impacted if the water supply were suddenly compromised?
- Students will hypothesize what possibly occurred to cause the following picture. (Source: http://www.faim.org/help-for-flint-water-crisis-chelation-therapy)

- Students will watch the following news clip (https://www.youtube.com/watch?v=sFy1Vmm42zQ)

Class Discussion

- Students will learn about the Flint water crisis by watching a clip from “Poisoned Water” (http://www.pbs.org/wgbh/nova/body/poisoned-water.html)
- Have a student lead discussion about what government could have done to prevent this from happening?
- The video clip explained the lead contamination in terms of parts per million and parts per billion. What does that mean? How can we calculate it?



- How do scientists determine acceptable levels of contaminants?
- What possibly cause the massive ocean pollution in the Dominican Republic video clip?
- Are there global pollution laws? Explain.

Homework

- Read the following article on and answer the following questions

https://www.nbcwashington.com/news/local/Boil-Water-Advisory-in-Effect-for-Major-Portion-of-DC-488088441.html

1. Conduct further research to learn about the contaminants in the D.C. drinking water? What effects can they pose to plant, animal and human life?
2. How many people does this water advisory effect? Estimate how many gallons of bottled water should be available on a daily basis if boiled water does not suffice.

- Encourage your family to sign up for the water testing program to test the water in your home

https://www.health.ny.gov/environmental/water/drinking/lead/free_lead_testing_pilot_program

Exploration (Day 2)

70-minute class period

Students engage in an activity that facilitates conceptual change

Objectives

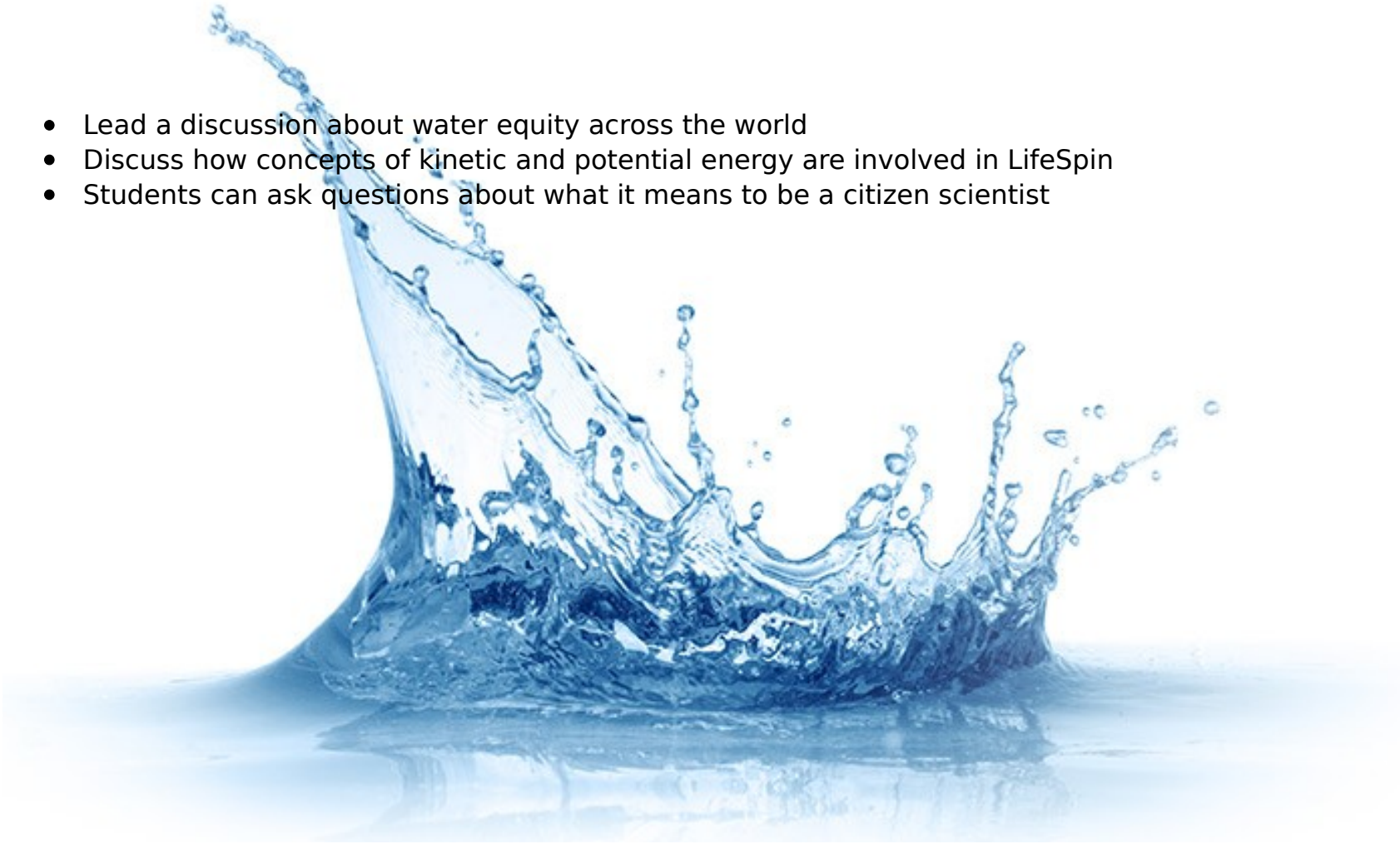
- Students will understand the importance of access to clean water
- **MS-LS2-5**. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **MS-ETS1-1.** 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.

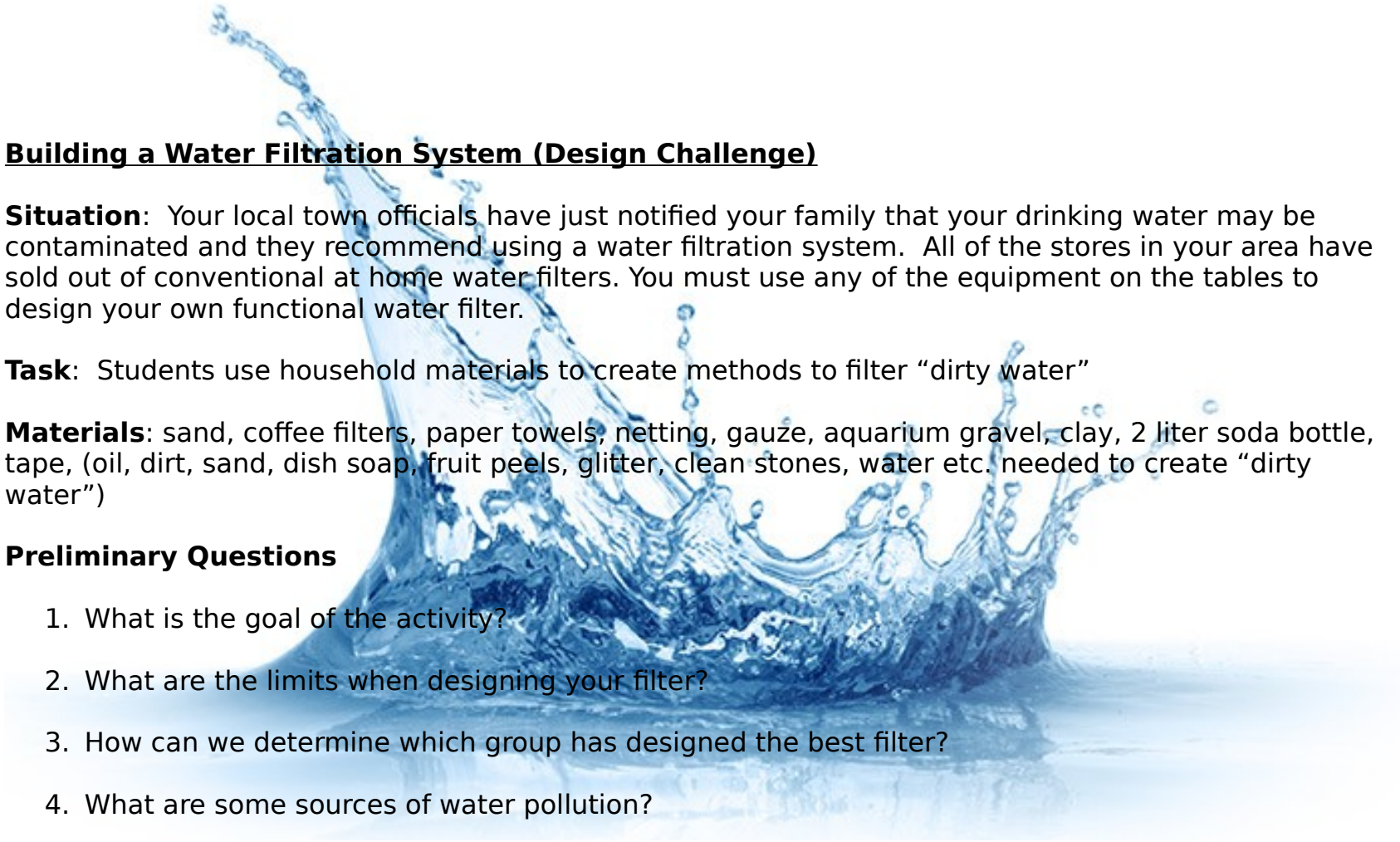
Introduce Shane Tomaino's prototype of LifeSpin

Abstract from her INTEL Submission

Despite industrialization, Sub-Saharan Africa's water infrastructure leaves ~341 million people without access to potable water. In addition to water purification problems, transportation problems include that women and children spend ~140 million hours collecting water daily, with adverse musculoskeletal implications that compound medical ramifications of contaminated water. By harnessing the energy produced by a rolling barrel, a purification system can be powered. A cylindrical polyethylene vessel streamlines water purification and the rolling transport process. Research shows exposure to UV light and Activated Carbon is effective in purification. The challenge is to integrate these technologies in hydro-transport systems. For UV light, the electrical source, rotational energy, was harnessed by magnet and coil. As the barrel rotated, electrical output averaging 79.97W was produced, approximately 50% more energy than required to power the UV light. For effective purification, water must turbulently circulate. Two vessels were rotated at 50RPMs, one with 3D-printed fins, and one with none. Water and modeling beads were added to indicate flow patterns. In the finned vessel, circulation of headspace air and chaotic dispersion of beads showed increased fluid friction. This compared favorably against fin-less rotation. Each of these systems are integrated into a 90L polyethylene barrel to simultaneously apprehend water purification and transportation challenges.

- Lead a discussion about water equity across the world
- Discuss how concepts of kinetic and potential energy are involved in LifeSpin
- Students can ask questions about what it means to be a citizen scientist





Building a Water Filtration System (Design Challenge)

Situation: Your local town officials have just notified your family that your drinking water may be contaminated and they recommend using a water filtration system. All of the stores in your area have sold out of conventional at home water filters. You must use any of the equipment on the tables to design your own functional water filter.

Task: Students use household materials to create methods to filter "dirty water"

Materials: sand, coffee filters, paper towels, netting, gauze, aquarium gravel, clay, 2 liter soda bottle, tape, (oil, dirt, sand, dish soap, fruit peels, glitter, clean stones, water etc. needed to create "dirty water")

Preliminary Questions

1. What is the goal of the activity?
2. What are the limits when designing your filter?
3. How can we determine which group has designed the best filter?
4. What are some sources of water pollution?

Filter Details

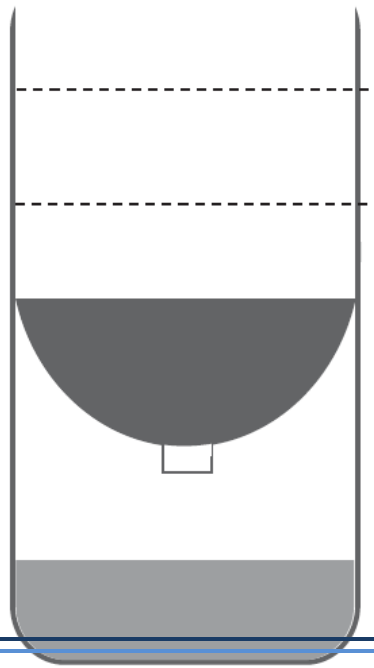
Materials to Use:

Predictions

How do you think the quality of your water will be affected by your filter? Which material will make the most difference? Why?

Water Filter Sketch

Label which materials you will use for your filter and in what order:



Water Filtration Rubric

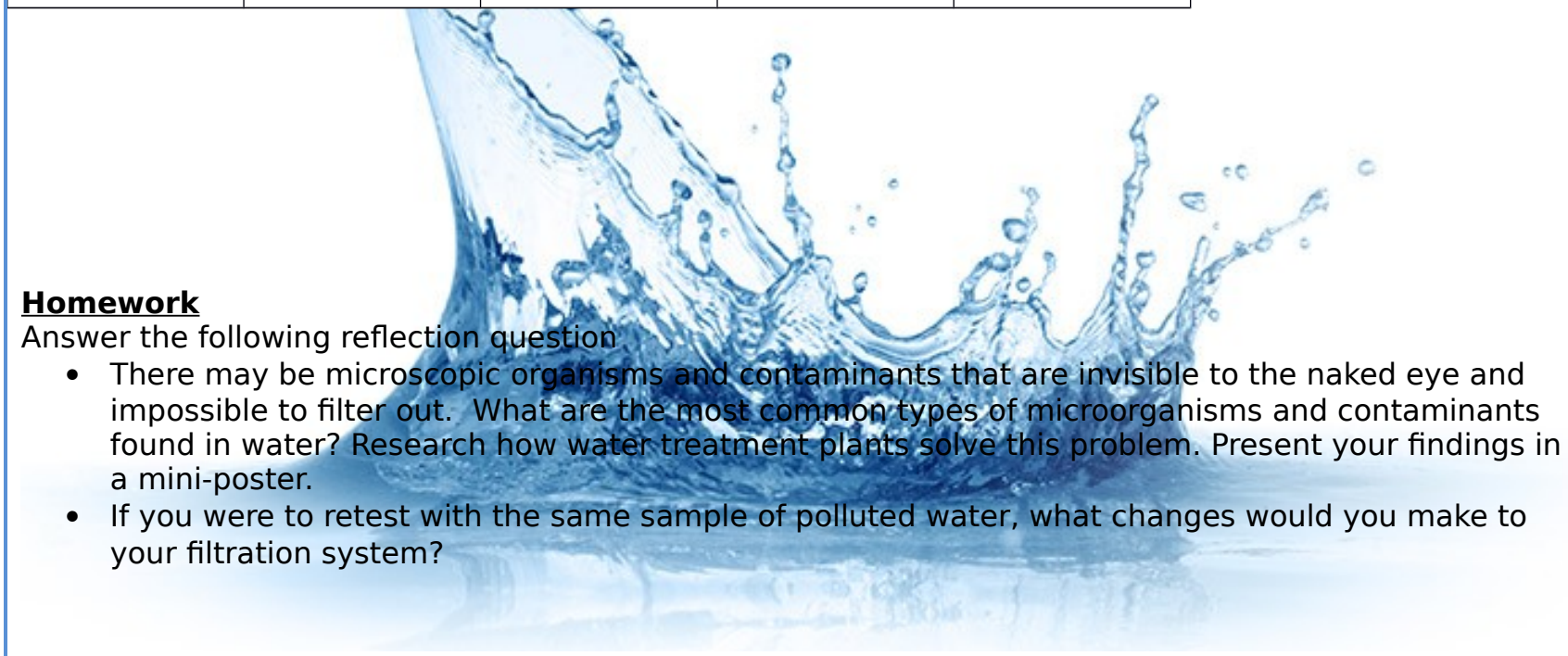
CATEGORY	4	3	2	1
Water Quality	Very clear, no particles	Clear, some small particles remaining	Murky, large particles remaining	No noticeable change from start
Time	0-60 seconds	61-120 seconds	121-180 seconds	>181 seconds

Participation Rubric:

CATEGORY	4	3	2	1
Attitude	Never publicly critical of the project or the work of others. Always positive about the task(s).	Rarely publicly critical of the project or the work of others. Often positive about the task(s).	Occasionally publicly critical of the project or the work of others. Usually positive about the task(s).	Often publicly critical of the project or the work of others. Often negative about the task(s).
Team Cooperation	Almost always listens to, shares with, and supports the efforts of others. Tries	Usually listens to, shares, with, and supports the efforts of others. Does not cause	Often listens to, shares with, and supports the efforts of others, but sometimes is	Rarely listens to, shares with, and supports the efforts of others. Often is not a good

	to keep people working well together.	"waves" in the group.	not a good team member.	team player.
Time-management	Routinely uses time well throughout the lesson to ensure things get done on time. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Usually uses time well throughout the lessons, but may have procrastinated on one thing. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Tends to procrastinate, but always gets tasks done by the deadlines. Group does not have to adjust deadlines or work responsibilities because of this person's procrastination.	Rarely gets tasks done by the deadlines AND group has to adjust deadlines or work responsibilities because of this person's inadequate time management.
Contributions	Routinely provides useful ideas to the team. A definite	Usually provides useful ideas to the team. A strong	Sometimes provides useful ideas to the team. A satisfactory	Rarely provides useful ideas to the team. May refuse to

	leader who contributes a lot of effort.	group member who tries hard!	group member who does what is required.	participate or give up at times.



Homework

Answer the following reflection question

- There may be microscopic organisms and contaminants that are invisible to the naked eye and impossible to filter out. What are the most common types of microorganisms and contaminants found in water? Research how water treatment plants solve this problem. Present your findings in a mini-poster.
- If you were to retest with the same sample of polluted water, what changes would you make to your filtration system?

<u>Explanation</u> (Day 3)
40-minute class period
Students generate an explanation of the phenomenon

Pre-Lab Activity
Objective:

- **Students will recognize and make the connections between the steps in the water cycle**
- **Students will distinguish between a point source and non-point source**

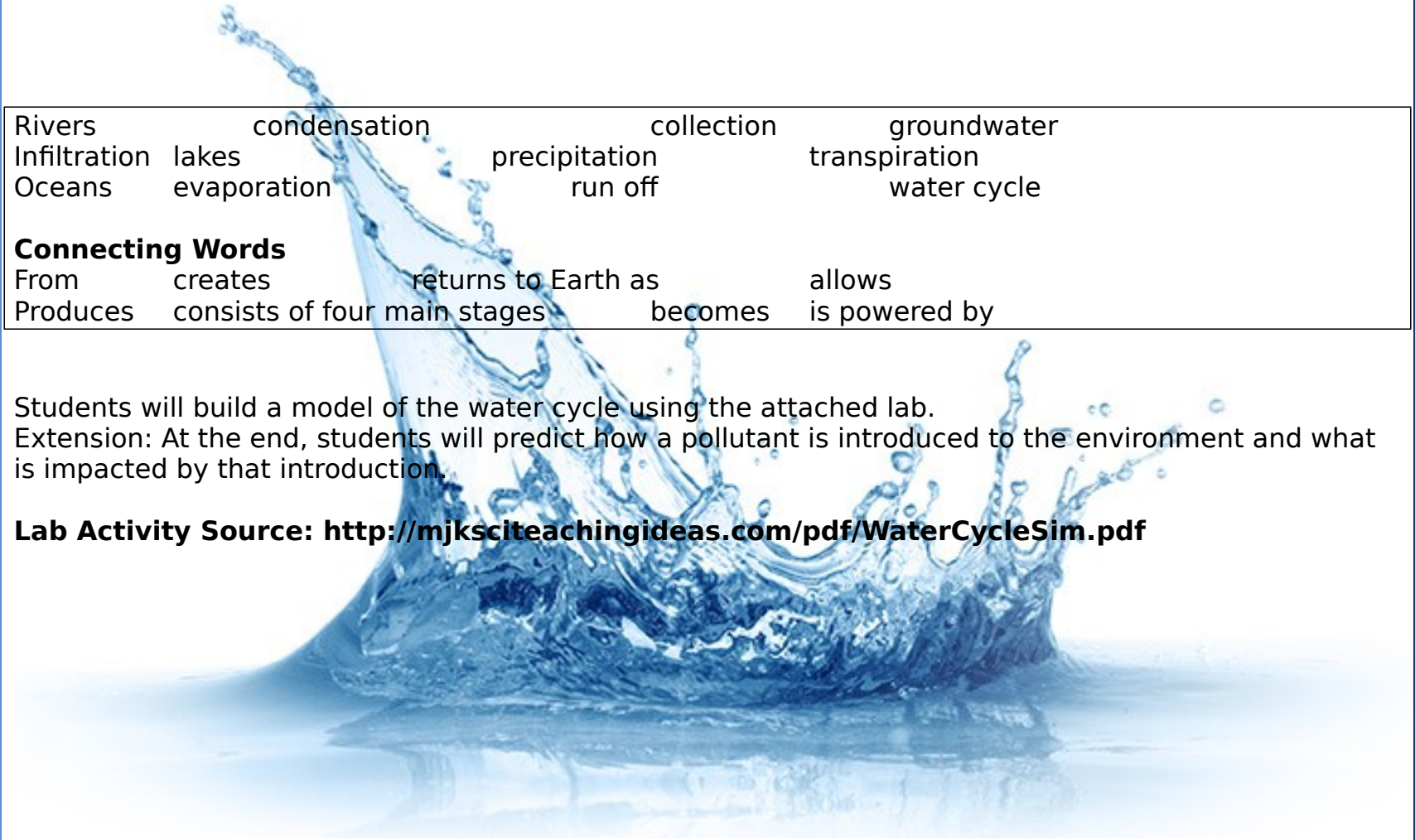
Using the word bank below, create a concept map of the water cycle.

Clouds	water vapor	the sun	collection

Rivers	condensation	collection	groundwater
Infiltration	lakes	precipitation	transpiration
Oceans	evaporation	run off	water cycle

Connecting Words

From	creates	returns to Earth as	allows
Produces	consists of four main stages	becomes	is powered by



Students will build a model of the water cycle using the attached lab.
Extension: At the end, students will predict how a pollutant is introduced to the environment and what is impacted by that introduction.

Lab Activity Source: http://mjksciteachingideas.com/pdf/WaterCycleSim.pdf

SIMULATING THE WATER CYCLE

Name _____ Block_____

Purpose: To simulate and observe the water cycle

Materials: large wide-mouth jar, small beaker, salt, sand, small paper cup, plastic wrap, large rubber band, small rock, spoon

Procedure:

1. Stir salt into the small beaker filled with water until no more salt will dissolve. Pour a one centimeter deep layer of the salt water into the large-mouthed jar.

2. Place a paper cup half filled with sand in the center of the jar.

3. Loosely cover the jar's mouth. Seal the wrap around the jar's side using a rubber band.

4. Place a small rock or weight on the plastic wrap directly over the paper cup.

5. Place the jar in direct sunlight. (Or use a bright light or sun lamp.)

6. After several hours, observe. Record your observations.

Observations:

1. _____

2. _____

SUMMARY QUESTIONS:

1. What is the purpose of sealing the jar?
   What does this represent?

2. What does the jar represent?

3. What does the salt water represent?

4. What does the paper cup of sand represent?

5. What do you notice about the taste of the water on the underside of the plastic wrap? (Carefully open the jar to taste.)

6. Where does this water go in the jar? What does this represent?

7. What processes of the water cycle can you identify occurring in the jar?

8. Draw arrows and label in the jar sketch you made.

9. Define Water cycle:

10. What percentage of the Earth's water cycle is:
    Salt Water _____% Fresh Water _____%

11. Of the Earth's fresh water, what percentage is:
    Ice Caps & Glaciers _____% Surface or Groundwater _____%
    Rivers, Lakes, & Streams _____% Atmosphere _____%

12. The first basic step of the water cycle involves the heat energy of the sun. This energy causes the water on the surface of the Earth to change to vapor (gas.) What is this process called?
    Where does this process take place on Earth?

13. The second basic step of the Water Cycle involves the process by which the vapor (gas) changes back into a liquid.
    What is this process called?
    Where does this process take place on Earth?

Elaboration (Day 4)
40-minute class period
Students understanding of a phenomenon challenged and deepened through new experiences

Objectives

- Students will learn impacts of microplastics on the marine environment
- Students will use scientific data to propose ways to reduce microplastics

Pre Activity Questions

- How is plastic created?
- What are the qualities of plastic that make it helpful for society but harmful for the environment?
- What plastic products do you encounter on a daily basis?

Discussion
Watch the following video “California community works to protect ocean” https://vimeo.com/194356011

- *What are microplastics?*
- *Where are they found?*
- *What are the leading contributors to microplastics?*
- *What are the possible health hazards to humans?*
- *What are the impacts to animal and plant life?*
- *How can individuals reduce microplastic pollution?*

Microbead Activity

NGSS Standards

ESS3.C: Human Impacts on Earth Systems Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)

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 oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem **MS-ESS3.C** Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Common Core

RST.6-8.1 – Cite specific textual evidence to support analysis of science and technical texts

Ocean Literacy

6.D Human activity contributes to changes in the ocean and atmosphere.

6.D.18 Pollutants move from the land into the ocean as water flows through watersheds via runoff and rivers.

Activity (adapted from www.pbs.org)

Pre Activity Questions

- How is plastic created for products?
- What are the qualities of plastic that make it helpful for society but harmful for the environment?
- What plastic products do you encounter on a daily basis?

Materials

- Microscope, magnifying glasses, baby food jars, large beaker, coffee filters, petri dishes, spoons, toothpaste, facial cleanser, body scrub, body wash, lipstick, Pocketbac antibacterial gel, Neutrogena sunscreen SPF 100

Procedure

1. Squeeze the contents of each of the sample tube into the baby food jar.
2. Add tap water and stir the mixture to dissolve the components
3. Using a large beaker as a receptacle, filter the components through the coffee filter
4. Transfer the beads from the coffee filter to a petri dish
5. Using a microscope or a magnifying glass, count the number of microbeads that have been obtained.
6. Retain the microbeads into a clean jar.

Post Activity Questions

1. **Predict if all microbeads will float in the ocean? What evidence supports your idea?**
2. **Do you think we will be able to clean all of the plastic in the ocean? Why or why not?**
3. **What would you propose to government officials to mitigate the use of microbeads/microplastics?**

Class Kahoot Activity

https://create.kahoot.it/details/plastic-in-the-ocean/fb98e892-58e6-4261-94f4-46bd090581d3

Evaluation/ Final Assessment
Three-four class periods

Objectives for the Assessment

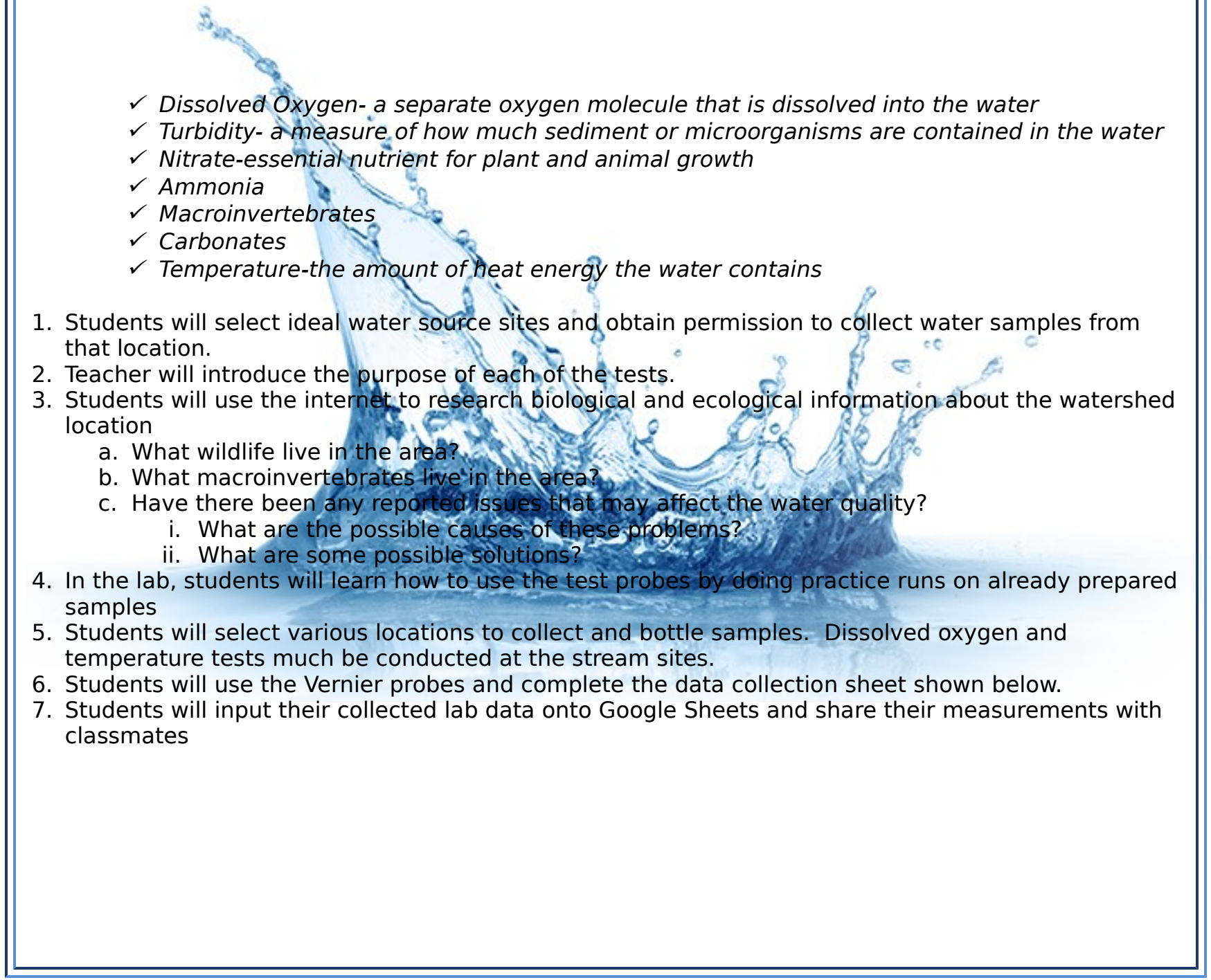
1. Students will analyze how human activities can have a detrimental or beneficial effect on the quality of water
2. Students will explain proper methods to collect water samples
3. Students will incorporate water sampling technology through the use of the Vernier probes
4. Students will develop a logical argument about animals and wildlife and its effect on water quality.

Materials
Sample collection bottles, labels, Sharpie permanent markers, Vernier probes and sensors (temperature probe, pH sensor, Turbidity sensor, DO probe, colorimeter (optional), nitrate ion-selective probe, conductivity probe, flow rate sensor, calcium ion selective electrode)

Procedure

Students will conduct a variety of chemical tests

- ✓ *pH- a measurement of how acidic or basic a solution is*



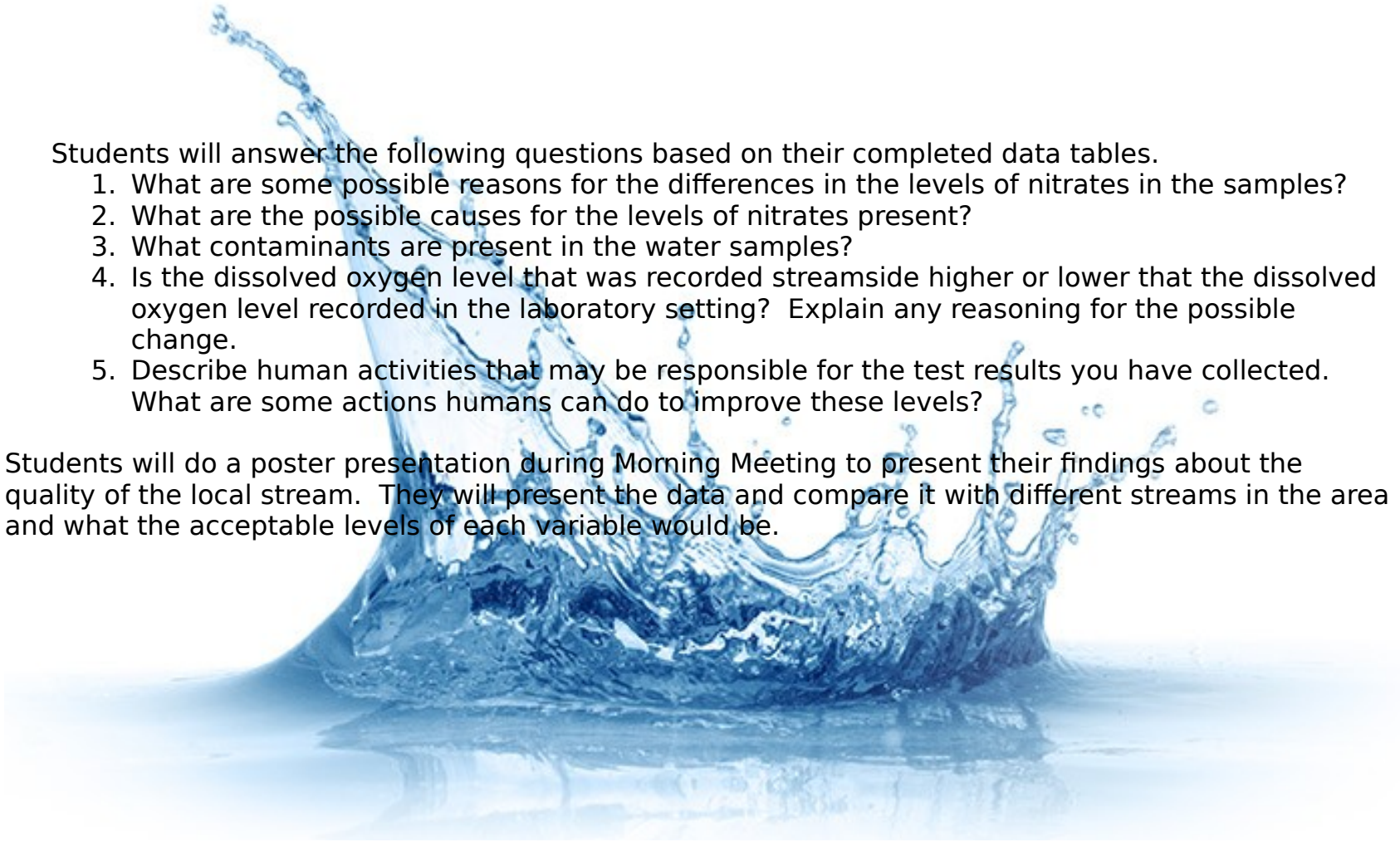
- ✓ *Dissolved Oxygen- a separate oxygen molecule that is dissolved into the water*
- ✓ *Turbidity- a measure of how much sediment or microorganisms are contained in the water*
- ✓ *Nitrate-essential nutrient for plant and animal growth*
- ✓ *Ammonia*
- ✓ *Macroinvertebrates*
- ✓ *Carbonates*
- ✓ *Temperature-the amount of heat energy the water contains*

1. Students will select ideal water source sites and obtain permission to collect water samples from that location.
2. Teacher will introduce the purpose of each of the tests.
3. Students will use the internet to research biological and ecological information about the watershed location
    a. What wildlife live in the area?
    b. What macroinvertebrates live in the area?
    c. Have there been any reported issues that may affect the water quality?
        i. What are the possible causes of these problems?
        ii. What are some possible solutions?
4. In the lab, students will learn how to use the test probes by doing practice runs on already prepared samples
5. Students will select various locations to collect and bottle samples. Dissolved oxygen and temperature tests much be conducted at the stream sites.
6. Students will use the Vernier probes and complete the data collection sheet shown below.
7. Students will input their collected lab data onto Google Sheets and share their measurements with classmates

Data Collection

Lab Group:_____

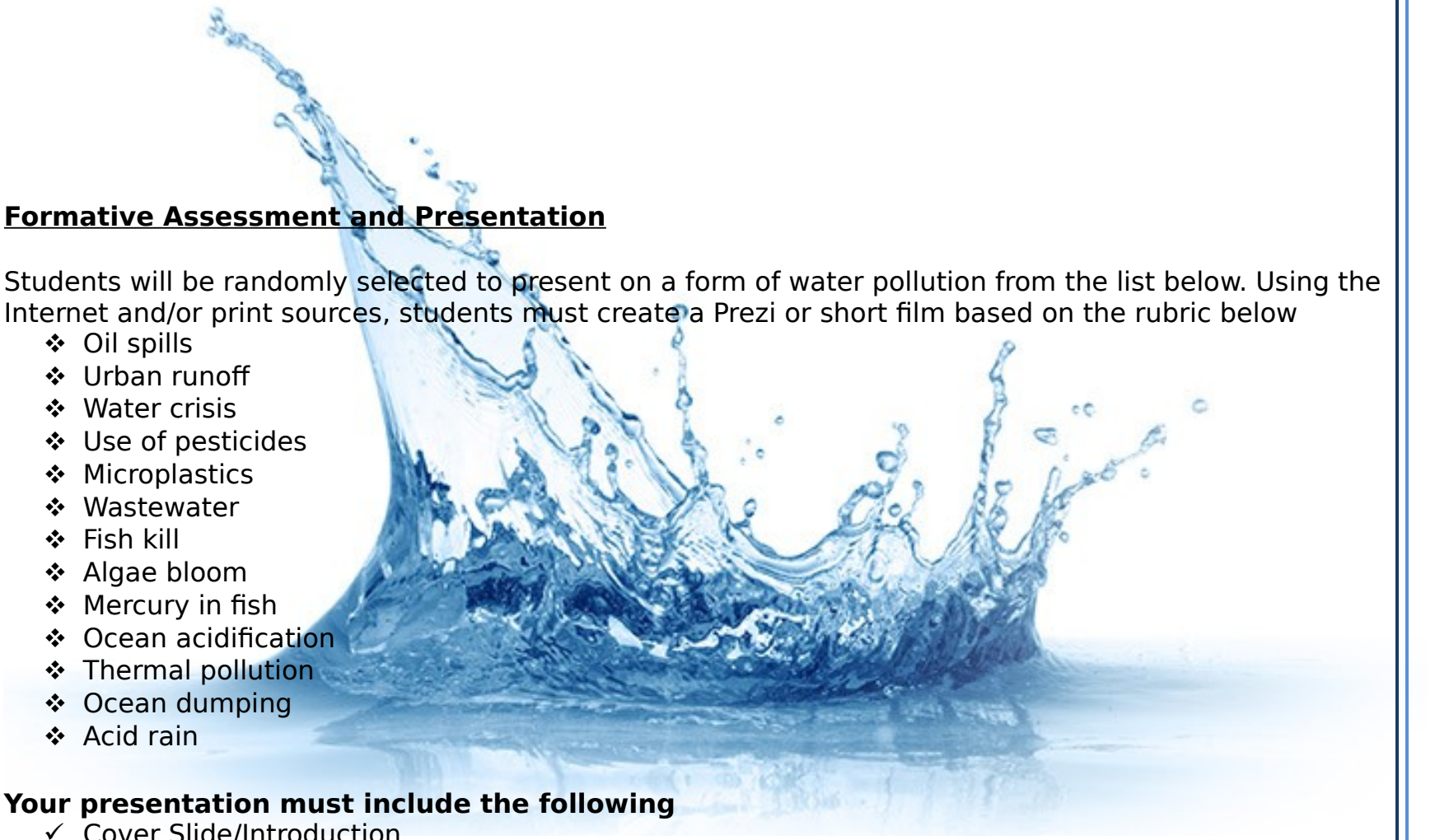
Stream	Carbonates	Stream Temp	Sample Temp	Nitrates pH	Dissolved O2	Turbidity



Students will answer the following questions based on their completed data tables.

1. What are some possible reasons for the differences in the levels of nitrates in the samples?
2. What are the possible causes for the levels of nitrates present?
3. What contaminants are present in the water samples?
4. Is the dissolved oxygen level that was recorded streamside higher or lower that the dissolved oxygen level recorded in the laboratory setting? Explain any reasoning for the possible change.
5. Describe human activities that may be responsible for the test results you have collected. What are some actions humans can do to improve these levels?

Students will do a poster presentation during Morning Meeting to present their findings about the quality of the local stream. They will present the data and compare it with different streams in the area and what the acceptable levels of each variable would be.



Formative Assessment and Presentation

Students will be randomly selected to present on a form of water pollution from the list below. Using the Internet and/or print sources, students must create a Prezi or short film based on the rubric below

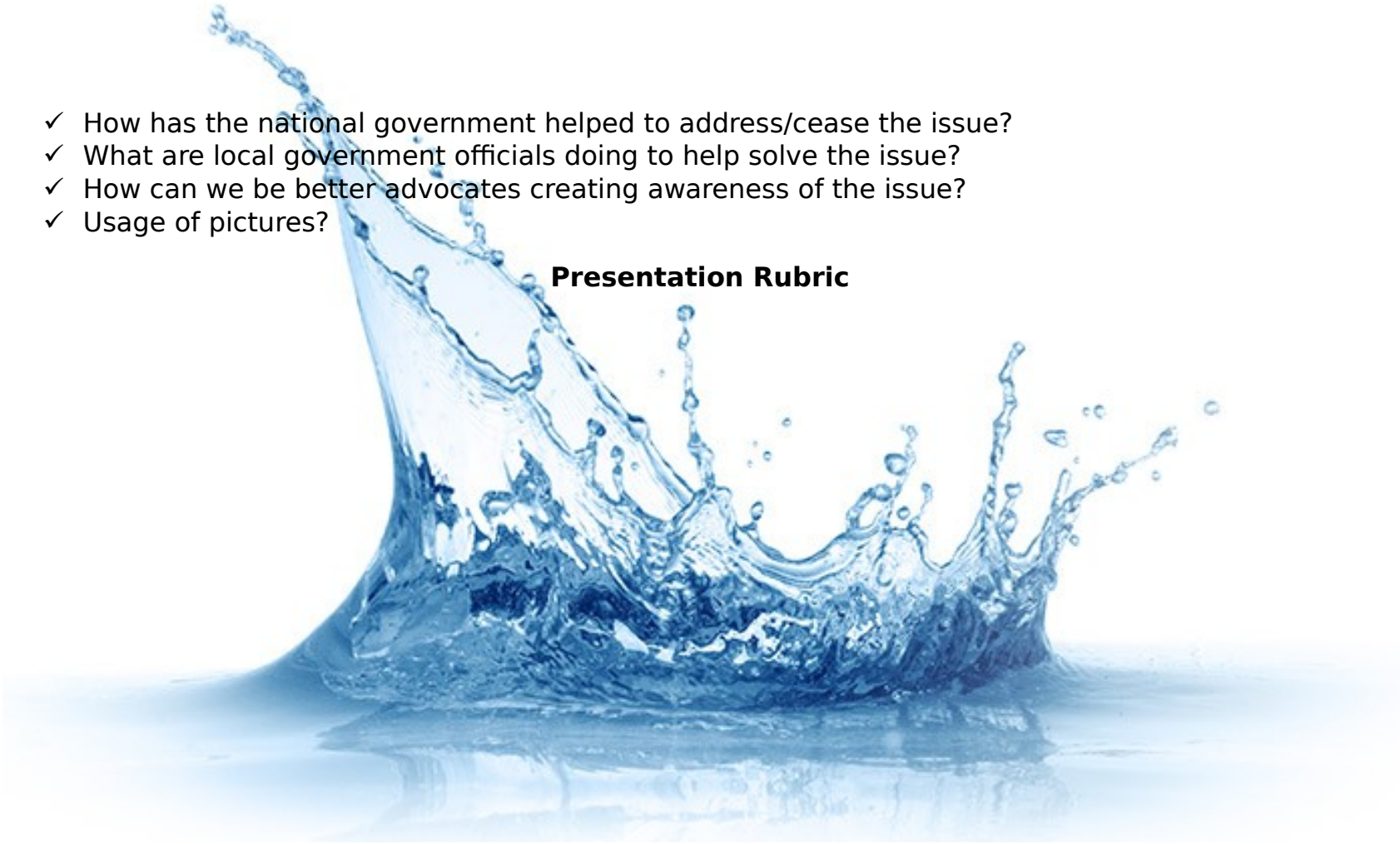
- ❖ Oil spills
- ❖ Urban runoff
- ❖ Water crisis
- ❖ Use of pesticides
- ❖ Microplastics
- ❖ Wastewater
- ❖ Fish kill
- ❖ Algae bloom
- ❖ Mercury in fish
- ❖ Ocean acidification
- ❖ Thermal pollution
- ❖ Ocean dumping
- ❖ Acid rain

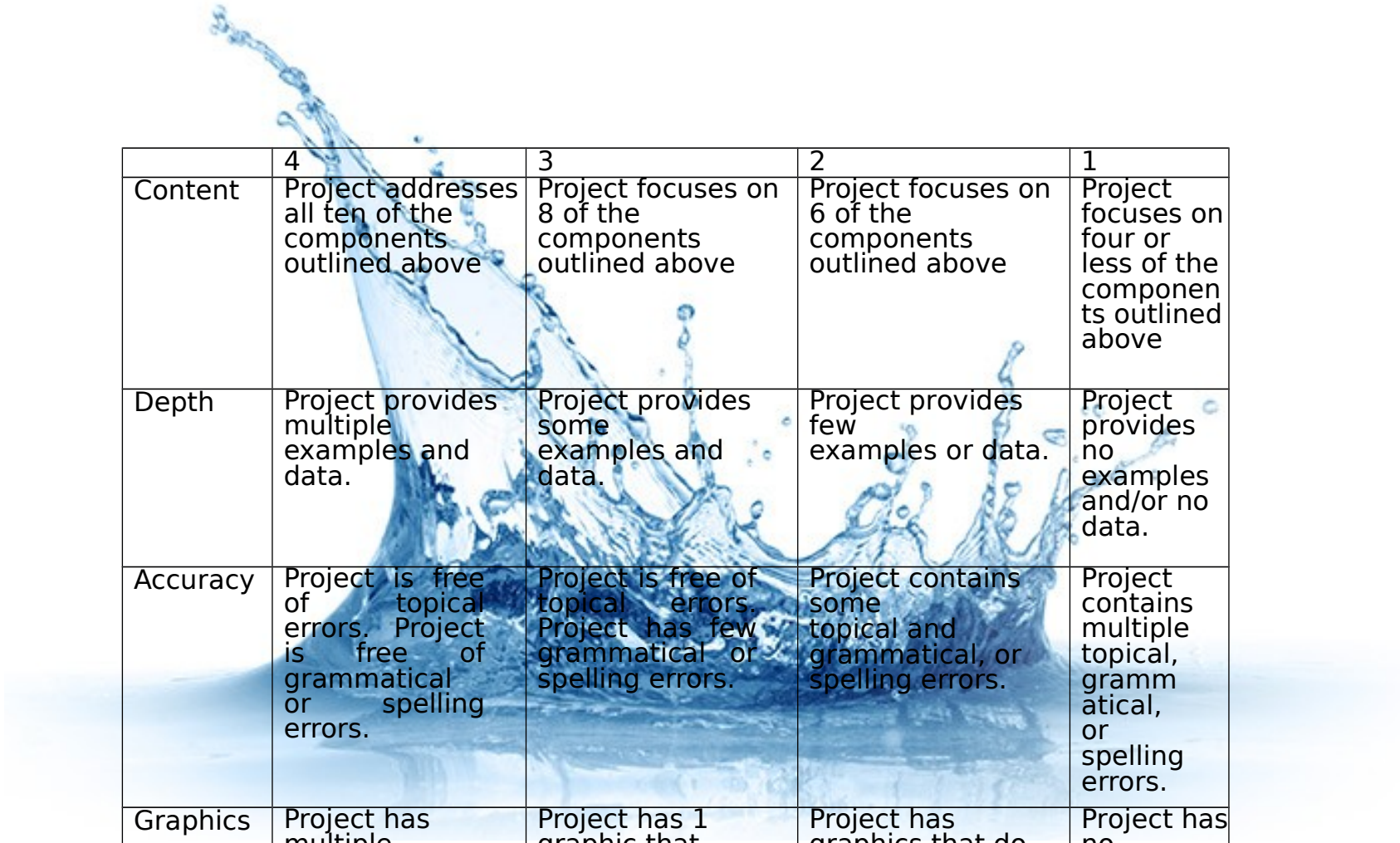
Your presentation must include the following

- ✓ Cover Slide/Introduction
- ✓ Description of the Problem
- ✓ Effects on Human Health
- ✓ Effects on Wildlife
- ✓ Effects on Plant Life
- ✓ What tests can be conducted to detect the issue?

- ✓ How has the national government helped to address/cease the issue?
- ✓ What are local government officials doing to help solve the issue?
- ✓ How can we be better advocates creating awareness of the issue?
- ✓ Usage of pictures?

Presentation Rubric





	4	3	2	1
Content	Project addresses all ten of the components outlined above	Project focuses on 8 of the components outlined above	Project focuses on 6 of the components outlined above	Project focuses on four or less of the components outlined above
Depth	Project provides multiple examples and data.	Project provides some examples and data.	Project provides few examples or data.	Project provides no examples and/or no data.
Accuracy	Project is free of topical errors. Project is free of grammatical or spelling errors.	Project is free of topical errors. Project has few grammatical or spelling errors.	Project contains some topical and grammatical, or spelling errors.	Project contains multiple topical, grammatical, or spelling errors.
Graphics	Project has multiple graphics that enhance the information provided.	Project has 1 graphic that enhances the provided information.	Project has graphics that do not enhance the information.	Project has no graphics.
Neatness	Project is neat.	Project is mostly neat.	Project is somewhat neat.	Project is not neat.