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The Nature of Science

Science is a systematic way of observing our world using our senses. This process helps us see processes and patterns in natural systems. As we gather new data, our understanding of the world may change, and we, as humans, make decisions based on the best data we have available to us at a particular point in time.

Society (a group of people living together in an ordered community) also influences these decisions. Cities and regions have to consider the wants and needs of their citizens in addition to available scientific data. At times, all of these factors may align in one direction that leads to an obvious decision. At other times, different factors may be in conflict, and the answer to a problem may not be obvious. Also, different groups within the community may have differing perspectives.

In this project, we're going to take a look at an example of a complex situation to understand how science and society intersect. Then you will choose a local or regional current environmental issue to identify the complex components involved in the situation.



In this project we are going to practice these skills from Ohio’s Learning Standards for Science:

Standard	Explanation
Scientific inquiry, practice and applications	<p>Students will:</p> <ul style="list-style-type: none"> ● Apply knowledge of science to real-world projects ● Identify questions that can be answered through scientific investigations ● Analyze and interpret data ● Think critically and logically to connect evidence and explanations ● Recognize and analyze alternative explanations and predictions ● Design technological/engineering solutions
Science is a way of knowing	<ul style="list-style-type: none"> ● Science is a way of knowing about the world around us based on evidence from experimentation and observations. ● Science is a continual process and the body of scientific knowledge continues to grow and change. ● Science is based on observable data and empirical evidence.
Scientific knowledge is open to revision in light of new evidence	<ul style="list-style-type: none"> ● Science explanations are subject to revision and improvement in light of additional scientific evidence or new understanding of scientific evidence.

Welcome to Olympic National Park!

[This park](#) is famous for being [three parks in one](#). It includes [wild beaches](#), [rugged mountains](#), and an incredibly diverse [temperate rainforest](#). It is [located](#) in Washington State, the northwest corner of the continental United States.



Image source: [google.com/maps](https://www.google.com/maps)



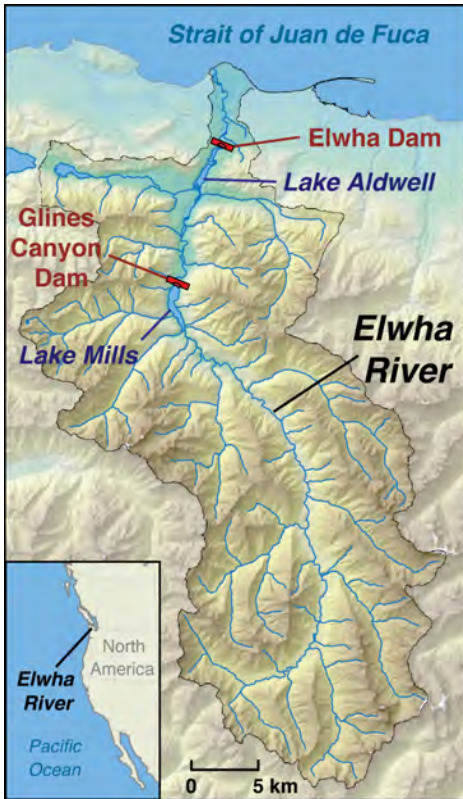
[Rock the Park: Olympic National Park video](#)



Image source: [nps.gov/olym/planyourvisit/gettingaround.htm](https://www.nps.gov/olym/planyourvisit/gettingaround.htm)

The Elwha River

The Elwha River flows through cool shady old-growth forests, rugged canyons, and wide floodplains on its way to the Strait of Juan de Fuca. [Check it out on Google Earth](#). This river serves as an important breeding ground for numerous native fish that sustain wildlife and human life. It is also an example of how human understanding of science and natural systems can change throughout time. Take a look at the [history of the river here](#). Then place the following events in order.



Number the following events - 1 = first, 7 = last.

	Construction of the Elwha Dam begins
	Glines Canyon Dam removal begins
	President Theodore Roosevelt designates the Mount Olympus National Monument (this area eventually becomes Olympic National Park)
	Congress passes the Elwha River Ecosystem and Fisheries Restoration Act which includes funds to remove both dams
	The Glines Canyon Dam is constructed
	Elwha Dam removal begins
	Fish used the freely-flowing river for habitat and spawning



Lower Elwha Klallam Tribe

The story of this river includes the people who first inhabited its banks - members of the Lower Elwha Klallam Tribe. For generations, they have fished in these waters, lived in these valleys, and enjoyed the shorelines. Rivers can have many different uses including scenic enjoyment. Let's take a look at [what a river is for](#).

1. What is the significance of the Elwha River to the Lower Elwha Klallam Tribe?

2. How did the construction of the Elwha Dam and the Glines Canyon Dam affect the Elwha River ecosystem?

3. How did the construction of the dams impact the Lower Elwha Klallam Tribe?

Dam Construction

Imagine you are one of the first European settlers in this area. There are plentiful natural resources, and your family is excited to settle in. Take a look at this picture from Downtown Port Angeles. What do you notice?



Image source: media-cdn.tripadvisor.com/media/photo-s/0e/85/b9/0b/historic-image-of-downtown.jpg

Based on the scientific knowledge at the time and the needs of the community, officials decided to build two dams on the Elwha River. [Take a look at this story here](#). Then answer the questions below.

4. Why were the Elwha and Glines Canyon dams originally built?

5. When were the dams constructed?

6. What were some of the benefits that were expected to come from the construction of the dams?

7. How did the construction of the dams affect recreational activities in the area?



Image source: nps.gov/teachers/classrooms/freeing-the-elwha-good-intentions.htm

Let's try to build a dam ourselves!

- What are some dams that you have seen?
- What are the purposes of a dam?
- How do people build a dam?

[Watch this video about dam construction](#). And check out [how a dam changes a river](#). [This video](#) explains how moving water turns into electricity.

Build a Dam

You are now going to try to build your own dam. You will have 15 minutes to build using the materials provided. Your group must come to a consensus for your final design.

Directions:

1. Build up a river in your stream table.
2. Construct your dam that your entire group agreed upon towards the top of your stream's elevation. This can be at the top of your paint tray, or towards the top of your stream table.
3. Make sure your river has sediment behind the dam, as well as in front of the dam, without blocking all the water that will be poured.
4. Get your design checked by a teacher.
5. Once you have been checked, slowly pour half of the water behind the dam.
6. Write your initial observations on a piece of paper and then copy them into the spaces below. Then finish pouring the last of the water. Complete more observations on the movement of the water or sediments that you see.

8. Observations:

9. What part(s) failed first? What part(s) failed later? Why?

10. How would you improve your design?

Dam Removal

While there were several great benefits from the dams such as a stable water supply, electricity, and recreational opportunities, however, there were unintended consequences as well. Some of these did not become apparent until decades after the dams' construction. Think and brainstorm about the following questions:

What might be some of the ecological impacts of the dams?	
How did they affect the geology of the area?	
How were biological systems disrupted ?	
Who benefitted from these dams?	














<p>What people were harmed by these structures? How so?</p>	
<p>How did the dams themselves change over time? What was their condition right before they were removed?</p>	



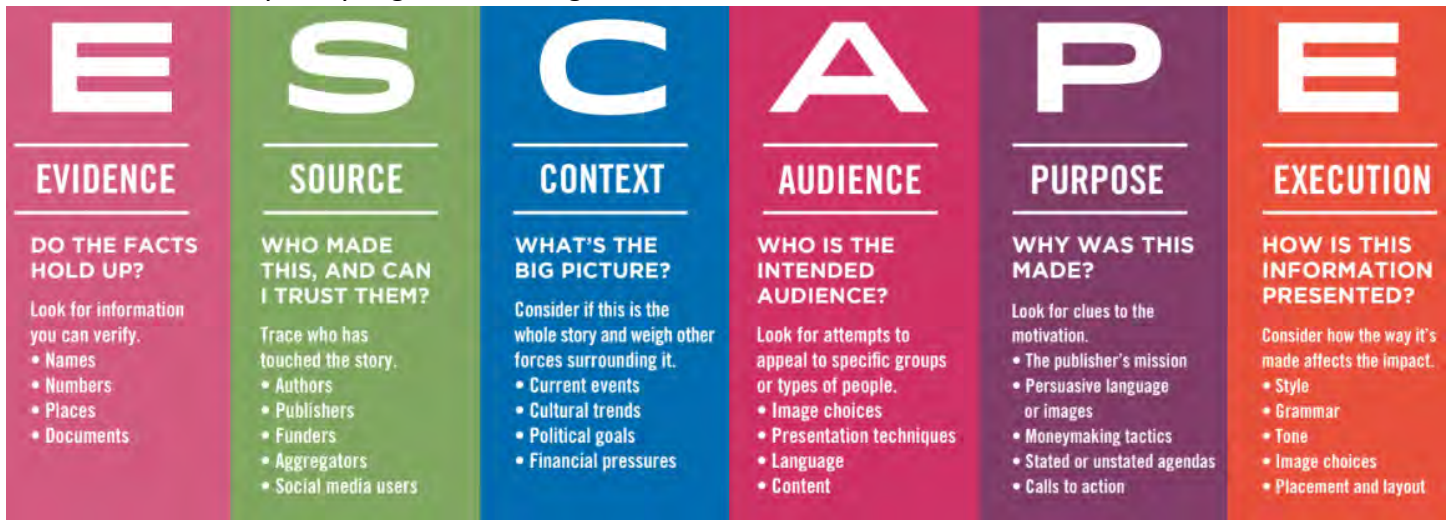
Town Hall Meeting

Let’s take a look at this situation from a variety of angles. If we remove these dams, how would that affect different groups of people? Some might benefit while others might lose out. You and a partner will be assigned one of the roles below to research and understand that group’s perspective. Also, the group might have differing views within the organization (e.g. some people might be for dam removal while others in the same group oppose it).

The following resources are a starting point. Highlight the group you will be representing in the town hall meeting.

 <p>National Park Service</p>	 <p>Washington State Department of Ecology</p>	 <p>Coastal Watershed Institute</p>	 <p>Lower Elwha Klallam Tribe (Native Americans)</p>	 <p>Paper/power company - article 1, article 2</p>	 <p>Loggers</p>
 <p>Washington Department of Fish and Wildlife</p>	 <p>Port Angeles City Council</p>	 <p>Clallam County</p>	 <p>Jefferson County</p>	 <p>Washington Environmentalists</p>	 <p>Washington Trails Association (hikers)</p>
 <p>NOAA</p>	 <p>USGS</p>	<p>Do you have other groups we might consider?</p>			

You are welcome to continue wherever your research leads you. However, always be careful to evaluate internet resources by analyzing the following:



Source: newseumed.org

Additional resources:

- [The Elwha River](#)
- [Socioecological and Societal Impacts of the Elwha Dam Removal](#)
- [Dam Removal - Olympic National Park \(U.S. National Park Service\)](#)
- [Elwha: Roaring back to life](#)
- [Elwha Educational Videos - Olympic National Park \(U.S. National Park Service\)](#)
- [Freeing the Elwha](#)
- [Undamming the Elwha](#)

Once we have completed our research, we will hold a town hall meeting to discuss whether the dams should be left in place, modified in some way, or completely removed. In order to have an informed perspective, you should investigate and consider the viewpoints from the other participants.

Each group will prepare:

- an opening statement
- arguments to support the position
- comments or questions for other attendees
- a closing statement

There will be two town hall meeting simulations. You will participate as a character during one of them. During the other, you will observe and fill out a checklist.



To **PARTICIPATE** in the town hall meeting:

- Find out from your teacher what role you will play.
- Review the information provided for your position, and do some research on your own. Remember, you are representing a character,



To prepare to **OBSERVE** the town hall meeting:

- Review the observation questions below.
- While you observe the other group's town hall meeting, write a check mark when you hear someone from a team make a good point. Jot a few words to remind yourself of

<p>not your own opinion.</p> <ol style="list-style-type: none"> Get together with your partner to develop good arguments that you can make during the meeting. Decide who on your team will present an opening statement and who on your team will present a closing statement. 	<p>any really good points. Attempt to note at least one good point from each team in the other group.</p> <ol style="list-style-type: none"> Be ready to comment on what you observed after the simulation.
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11. Use the following chart to tally when each group makes a good point, and then jot a summary of that point in the space provided.

	Number of good points	What did they say?
 National Park Service		
 Washington State Department of Ecology		
 Indigenous people		
 Paper/power company - article 1 , article 2		
 Loggers		
 Washington Department of Fish and Wildlife		
 Port Angeles City Council		

 <p>Clallam County</p>		
 <p>Jefferson County</p>		
 <p>Environmentalists</p>		
 <p>Washington Trails Association (hikers)</p>		
 <p>NOAA</p>		
 <p>USGS</p>		
 <p>Coastal Watershed Institute Coastal Watershed Institute</p>		
<p>Other groups Campers Fishers</p>		

Town hall idea modified from: <https://serpmedia.org/scigen/l1.5.html>

The Story Continues

Now, let's see how this story continues today. Refer back to the [river video](#) you watched earlier, and answer the following questions.

12. What motivated the tribe to take action to restore the Elwha River ecosystem?

13. What were some of the challenges involved in removing the dams?

14. How has the removal of the dams impacted the Elwha River ecosystem and the surrounding area?

15. What is the importance of restoring the Elwha River to the health of the region's ecosystem, including the Strait of Juan de Fuca?

Additional resources:

- A. [Moving Mountains: Elwha River Still Changing Five Years After World's Largest Dam-Removal Project](#)

How do science and society intersect in our region?

The following Ohio sites are examples of stories where our understanding of science has changed throughout time. Each of these places was developed in some way to meet the needs of our society at a certain time, but then, as new information was collected, our understanding changed. Also, the needs of our community may have changed. You will select one of the following stories to investigate further, or you may choose a story of your own with your teacher's approval.

As you read these situations, think about the following:

- **Who** is involved in this story? What groups of people or organizations?
- **How are people affected** by this situation?
- **What** happened?
- **When** did this story happen?
- **Where** did this story occur?
- **Why** did this story happen or what makes it newsworthy?
- **How** did this happen?
- **How has the story changed** through time? How has new scientific information changed our understanding?
- **What is happening now?**
- **What is planned** for the future?



Fernald Feed Materials Production Center

The Fernald Feed Materials Production Center (FMPC) was a uranium processing facility located near the rural town of Fernald, Ohio, about 18 miles northwest of Cincinnati. The plant was built in the early 1950s as part of the U.S. government's nuclear weapons program. The FMPC processed uranium ore into uranium metal, which was used to make fuel for nuclear reactors. The plant operated until 1989, when it was closed due to environmental concerns.

The FMPC released large amounts of radioactive contamination into the air, water, and soil. The plant's waste disposal practices were also poor, and large amounts of

radioactive waste were buried on site. The contamination from the FMPC has posed a health risk to people living near the plant and to the environment.

The U.S. government has spent billions of dollars to clean up the Fernald site. The cleanup is still ongoing, but the site is expected to be fully cleaned up by 2026. The Fernald site is now a Superfund site, which is a designation given to the most polluted sites in the United States.

The history of the Fernald plant is a reminder of the dangers of nuclear weapons and the importance of environmental protection. The cleanup of the Fernald site is a major undertaking, but it is important to ensure that the site is safe for future generations.

More information:

- A. [Fernald Site | Ohio Environmental Protection Agency](#)
- B. [Fernald Nature Preserve – The Cincinnati Chapter of National Audubon Society](#)
- C. [Fernald Preserve, Ohio, Site | Department of Energy](#)
- D. [Fernald video](#)

Fracking in Ohio state parks

In 2023, the Ohio state legislature passed a bill that would allow oil and gas companies to frack in state parks. Fracking is a controversial process that involves injecting water, sand, and chemicals into the ground at high pressure to release natural gas from shale rock formations.

Proponents of fracking say that it could bring jobs and economic development to Ohio. They also say that it is a safe and efficient way to extract natural gas. Opponents of fracking say that it could pollute water supplies, contaminate air, and harm public health. They also say that it could damage the environment.



The Ohio Department of Natural Resources (ODNR) is currently reviewing the proposals to frack in state parks. The ODNR is expected to make a decision on the proposals in the coming months. If the ODNR approves the proposals, it would be the first time that fracking has been allowed in state parks in the United States. The decision is likely to be met with protests from environmental groups and local residents.

More information:

- A. [Fracking information from both sides](#)
- B. [Information from the Independent Petroleum Association of America](#)
- C. [Information from the Natural Resources Defense Council](#)



Lake Erie algae blooms

Algae blooms are a natural occurrence, but they have become more frequent and severe in recent years. The main cause of algae blooms in Lake Erie's western basin is nutrient pollution. Nutrients, such as phosphorus and nitrogen, come from a variety of sources, including:

- **Agricultural runoff:** When it rains, fertilizer and manure from farms are washed into streams and rivers that flow into Lake Erie.
- **Urban runoff:** When it rains, oil, grease, and other pollutants from streets and parking lots are washed into storm drains that flow into Lake Erie.
- **Point sources:** Point sources are specific locations where pollutants are released into the environment, such as sewage treatment plants and factories.

When nutrients enter Lake Erie, they can cause algae to grow rapidly. This rapid growth is called an algae bloom. Algae blooms can make the water look green, slimy, and smelly. They can also produce toxins that can harm people, fish, and other animals.

More information:

- A. [Six things to know about Lake Erie's algal blooms | The Ohio State University](#)
- B. [Lake Erie's toxic algae blooms: Why is the water turning green? | NSF](#)
- C. [Lake Erie Algae Blooms](#)
- D. [Lake Erie Harmful Algal Bloom Forecast](#)
- E. [Great Lakes: Harmful Algal Blooms](#)

Village of Cheshire, Ohio

The village of Cheshire was founded in 1837 by settlers from Connecticut. The village was located on the banks of the Ohio River, and its economy was based on agriculture and shipping. In the early 1900s, the village became home to a coal-fired power plant. The power plant provided jobs for many of the village's residents, but it also caused air pollution.

In the 1970s, the Environmental Protection Agency (EPA) began to regulate air pollution more strictly. The power plant was required to install pollution controls, but these controls were expensive. In the early 2000s, the power plant's owner, American Electric Power (AEP), decided to close the plant.



AEP offered to buy the homes of the village's residents, and most of the residents accepted the offer. The village was demolished, and the land was turned into a park. The power plant is still standing, but it is no longer in operation. The story of Cheshire is a reminder of the challenges of balancing economic development with environmental protection.

More information:

- A. [For \\$20 Million, a Coal Utility Bought an Ohio Town and a Clear Conscience - The Atlantic](#)
- B. [The strange deal that created a ghost town - BBC Future](#)
- C. [Documentary Examines Life In Cheshire After AEP Buyout | WOSU News](#)



East Palestine Train Derailment

On February 3, 2023, a Norfolk Southern freight train derailed in East Palestine, Ohio. The train was carrying hazardous materials, including vinyl chloride, ethylene glycol, ethylhexyl acrylate, butyl acrylate, and isobutylene. Twenty of the 38 cars derailed, and several of them caught fire. The fire burned for several days and released harmful fumes into the air.

As a result of the derailment, about half of the town's 5,000 residents were evacuated. The evacuation order was lifted several days later, but many residents have not returned to their homes. The derailment has also caused significant damage to the environment.

The cause of the derailment is still under investigation. However, investigators believe that the derailment may have been caused by a combination of factors, including excessive speed and poor track conditions.

More information:

1. [East Palestine, Ohio Train Derailment | US EPA](#)
2. [East Palestine residents live in limbo months after fiery train derailment | PBS NewsHour](#)
3. [East Palestine Train Derailment | Emergency Management Agency](#)
4. [East Palestine Train Derailment Information | Ohio Environmental Protection Agency](#)

Other environmental situations to consider:

- Air pollution: Ohio ranks 11th in the nation for air pollution. The state's air quality is affected by a number of factors, including coal-fired power plants, industrial emissions, and traffic congestion.
- Water pollution: Ohio's waterways are polluted by a variety of sources, including agricultural runoff, industrial waste, and sewage. The state's water quality is also affected by algae blooms, which are caused by nutrient pollution.
- Soil pollution: Ohio's soil is contaminated by a variety of pollutants, including pesticides, heavy metals, and petroleum products. Soil pollution can harm plants and animals, and it can also pose a health risk to humans.
- Climate change: Ohio is experiencing the effects of climate change, including rising temperatures, more extreme weather events, and changes in precipitation patterns. Climate change is a threat to the state's environment, economy, and public health.

What specific story/topic have you chosen?

16. **Who** is involved in this story? What groups of people or organizations?

17. **How are people affected** by this situation?

18. **What** happened?

19. **When** did this story happen?

20. **Where** did this story occur?

21. **Why** did this story happen or what makes it newsworthy?

22. **How** did this happen?

23. **How has the story changed** through time?

24. **What is happening now?**

25. **What is planned** for the future?

I used to think... Now I think...

Take some time to reflect on all that we have read, watched, discussed, and debated over the last several days. How has your thinking changed, expanded, or deepened? Start your response with the prompt: I used to think _____. Now I think _____.

Here are some additional questions to respond to:

- A. How has science helped us understand these situations?
- B. What kind of observations did scientists use to discover, monitor, and address these situations?
- C. How did our scientific knowledge change in the light of new evidence?

One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

<p>Less Growth Than Expected You have large gaps and/or misunderstandings in your understanding.</p>	<p>Meets Expectations You have demonstrated basic application of the following skills by answering most questions accurately, responding with scientific observations and evidence (not opinions unless an opinion is specifically required), and you have justified your answers using solid scientific facts and reasoning.</p>	<p>Exceeds Expectations You have shown a deep understanding of science by meeting the criteria in the previous category, and you have gone beyond the basics in at least two of the following ways:</p>
<p>C+ (79%)</p>	<p>B+ (89%)</p> <ul style="list-style-type: none"> <input type="checkbox"/> Think critically and logically to connect evidence and explanations <input type="checkbox"/> Science is a way of knowing about the world around us based on evidence from experimentation and observations. <input type="checkbox"/> Science is based on observable data and empirical evidence. <input type="checkbox"/> Science explanations are subject to revision and improvement in light of additional scientific evidence or new understanding of scientific evidence. 	<p>A (100%)</p> <ul style="list-style-type: none"> <input type="checkbox"/> You have made connections to other real-world examples in your life. <input type="checkbox"/> You have connected your understanding back to topics we have studied in science class this year. <input type="checkbox"/> You have raised new questions and/or wondered about the scientific facts/discoveries in these stories. <input type="checkbox"/> You have found additional scientifically-sound resources beyond what the teacher has provided using the resource evaluation criteria included in this document.
<p>Little to No Evidence of Growth Provided (F 59%) - You must complete and/or revise this assignment.</p>		