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Introduction

Thank you for using this Raising Educational Achievement through Cultural Heritage Up (REACH Up) unit in your classroom! The lessons are designed to address the Alaska Science Standards and Grade Level Expectations, Alaska Cultural Standards and the Bering Strait School District Scope and Sequence goals. All of the activities focus on infrastructure and related changes from Alaska Native cultural, physical and earth science perspectives. This supplemental unit addresses the place-based question: How is climate change affecting infrastructure in our area and why are these changes important to our community?

The REACH Up Infrastructure unit consists of a total of four activities: Ask an Expert, Infrastructure Vocabulary, and a two-part Water Quality lab activity. Each activity will require its own class period (approximately 45 minutes) and discussion could easily be extended into multiple class periods. You may also want to repeat sections of an activity during subsequent class meetings, such as reviewing the Impact on Infrastructure video or having your students practice the vocabulary card games multiple times. If you are utilizing the entire Infrastructure unit, you should introduce the activities in the order they are presented. However, if time is short, any of the activities could be presented independently.

The accompanying student guide is intended for use with multiple groups of students and you should not allow students to write in them. You can either have students record their work in a science notebook or create copies of the corresponding worksheets that are included in this teacher's guide.

Whole Picture

Climate change is affecting Alaska. Snow is melting earlier in the spring and fall is getting extended. Sea ice starts to form later in the season or does not form at all, causing stronger onshore storms and increased flooding. Rapid erosion due to permafrost thaw is more frequently observed.

These environmental changes are affecting infrastructure, including water pipes, sewers and water treatment plants, making it difficult to secure safe drinking water and to keep a healthy environment. Lack of access to safe drinking water and sewage disposal is a cause of high disease rates, such as severe skin infections and respiratory illnesses. Decreased water availability for hand washing also leads to increased transmission of disease.

Different communities have different water and sewer systems. According to the Alaska Department of Environmental Conservation, water and sewer systems currently in use in rural Alaska include washeterias and central watering points (don't provide drinking water), individual

wells and septic systems (possible water contamination due to inadequately treated sewage), water and sewer truck or trailer haul systems (high operating costs), and piped water and sewer systems (high construction and maintenance costs). Many homes lack running water and a flush toilet. Currently, over 3,300 rural Alaska homes lack running water and a flush toilet. Over 700 homes are served by operation-intensive haul systems. Approximately 4,500 rural homes are connected to community-wide piped systems that have surpassed the end of their design life.

Concerns are high about the safety of water and the possibility of running out of clean water before the end of each winter, especially in communities where water and sewer lines are not in place. Due to a changing climate, increasing temperatures are accelerating permafrost thaw, which can result in reduced access to sustainable water sources, as thawing permafrost leads to shrinking lakes and shifting ground can cause water pipes to break. These are big concerns as water is one of few resources for which there is no substitute.

References

Alaska Department of Environmental Conservation, Division of Water
http://dec.alaska.gov/water/watersewerchallenge

U.S. Environmental Protection Agency:
https://www.epa.gov/environmental-topics/water-topics

U.S. Geological Survey: https://water.usgs.gov/edu/nitrogen.html

Fundamentals of Environmental Measurements: http://www.fondriest.com/environmental-measurements/parameters/water-quality/

McCasland, M., N.M. Trautmann, K.S. Porter, and R.J. Wagenet. Nitrate: Health Effect in Drinking Water. Pesticide Safety Education Program, Natural Resources Cornell Cooperative Extension, Cornell University Cooperative Extension: http://psep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.aspx

Environment and Climate Change Canada: https://www.ec.gc.ca/eau-water/

Unit Vocabulary

Science Terms to Define	
flood	an overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land
infrastructure	the basic physical and organizational structures and facilities needed for the operation of a society, such as buildings, roads, water, and power supplies
lake	a large body of water surrounded by land
pond	a small body of still water formed naturally or by hollowing or embanking
rain	moisture condensed from the atmosphere that falls visibly in separate drops
river	a large natural stream of water flowing in a channel to the sea, a lake, or another stream
snow	atmospheric water vapor frozen into ice crystals and falling in light white flakes or lying on the ground as a white layer
sustainable	able to be maintained at a certain rate or level
water	the substance (most commonly encountered as a liquid) which is the principal constituent of seas, lakes, and rivers, and which falls as rain and other forms of precipitation -- as a chemical substance, regardless of its physical state, a compound of hydrogen and oxygen having the formula H_2O.
water quality	the chemical, biological, and physical status of a body of water

Terms for Incorporating Local Indigenous Language				
English	**Iñupiaq**	**Yup'ik**	**Siberian Yupik**	**Local Translation**
clear (water)	imilluataq	ecuilnguq	meghraakeglak	
cloudy (water)	imiqsruaniqtuaq	currluk	sughllak	
flood	ulitqaktuq	ulerpak	uleva	
lake	narvaq	nanvak	naayvaq	
pond	narvauraq	nanvacuar	mayvaghaq	
rain	ivġaniq	ivsuk	eslalluk	
river	kuuk	kuik	kiik	
snow	aniu	qanikcaq	anigu	
water	imiq	meq	meq	

Activity HS.7.1: Ask an Expert

Overview

In this activity, students will interview an elder or cultural knowledge bearer.

Objectives

On successful completion of the lesson, students will be able to:

- demonstrate effective interviewing techniques
- interpret qualitative data from interviews
- describe how different infrastructure was in the past in the local community compared to today
- explain how climate change is affecting infrastructure in the local community

Alaska Standards

Alaska Science Standards / Grade Level Expectations

SA1: The student demonstrates an understanding of the processes of science by:

[9] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating

[10] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

[11] SA1.1 asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating

SC3: The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by:

[11] SC3.2 analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem

Alaska Cultural Standards

[B] Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life. Students who meet this cultural standard are able to:

[B.2] make effective use of the knowledge, skills, and ways of knowing from their own cultural traditions to learn about the larger world in which they live.

[D] Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning. Students who meet this cultural standard are able to:

[D.4] gather oral and written history information from the local community and provide an appropriate interpretation of its cultural meaning and significance.

[E] Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them. Students who meet this cultural standard are able to:

[E.4] determine how ideas and concepts from one knowledge system relate to those derived from other knowledge systems.

Bering Strait School District Scope & Sequence

9.9A Understand the interaction of living and nonliving parts of an ecosystem. (SC3.2, SC3.3, SF)

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem. (SC3.2)

9.10E Understand, describe and diagram the biogeochemical cycle in an ecosystem including:

- Water
- Nitrogen

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate (SD 3.1)

- Global warming/climate change

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives. (SF)

Materials

- REACH Up High School Student Guide: *Impact on Infrastructure*
- Student Worksheet: *Ask an Expert about Impact on Infrastructure*
- Internet access and projector

Activity Preparations

1. Identify adults within your school who have lived year-round in the community for many years. This might include teachers, administrators, secretaries, teacher aides, lunchroom/kitchen staff, recess duties, maintenance and custodial staff, etc. Ask these local knowledge bearers if they would be willing to speak with a group of your students about how infrastructure in the area has changed, and how those changes have affected the community. Make sure that the volunteers you have identified will be available during the time that your class will be completing this activity.
2. Ask the volunteers if they speak an Alaska Native Language, and if so, which language(s) and dialect(s) they are familiar with. If applicable, have them translate the written words on the student worksheet, so you have an answer key. Also, ask them to teach you the pronunciation of the terms.

Activity Procedure

1. Distribute the REACH Up High School Student Guide: Impact on Infrastructure and ask students to work with a partner to read pages 1-3.
2. Show the video, Impact on Infrastructure, available at www.k12reach.org/videos.php. Videos are located under the Multimedia tab. Allow time for students to share comments and ask questions.
3. Explain that students will interview a few community members about local infrastructure changes. Separate students into small groups according to how many knowledge bearers are available to share information with your class. Explain if the appointed interviewees speak an Alaska Native Language, so students know whether or not they should pursue that portion of the interview.
4. Review expectations for student behavior while conducting the interview, including introductions and thanking the interviewee at the end of the interview. Discuss suggestions for effective interviewing techniques, such as allowing ample time for the interviewee to answer, and asking follow-up questions.
5. Distribute one Student Worksheet: *Ask an Expert about Impact on Infrastructure* to each group and assign each group one local knowledge bearer to interview. Provide 15-20 minutes for students to locate and interview the knowledge bearer.

6. Reconvene in the classroom and ask groups to share their findings. How has the local infrastructure changed? What impacts might the changes have on local lifestyles? If your students learned local indigenous words for the vocabulary terms, compare their translations with the translations found on page 4.

STUDENT WORKSHEET: ***Ask an Expert about Impact on Infrastructure***

Names of Group Members: _____

Interview a long-term community member to learn more about infrastructure in your area. Take notes about what you learn.

Who did you interview? _____

Ask:

What was infrastructure such as roads and houses like in the past compared to today?

How is climate change affecting infrastructure in your community (roads, houses and buildings, water resources, etc.)?

Have you or someone you know had to make any changes to your living environment (inside/outside of houses/buildings, water supply, roads, etc.)? If so, how?

Other notes:

For Alaska Native Language Speakers:

What language(s) do you speak? _____

What dialect(s)?_____

Could you translate the following words?

Clear (water): _____

Cloudy (water): _____

Flood: _____

Lake: _____

Pond: _____

Rain: _____

River: _____

Snow: _____

Water: _____

Activity HS.7.2: Infrastructure Vocabulary

What terminology do we need to know to discuss infrastructure?

Overview

In this activity, students will learn key infrastructure terminology in English and their local Alaska Native language by playing vocabulary games with peers.

Background Information

Based on the Visual Iñupiaq Vocabulary Acquisition (VIVA) Program of the North Slope Borough School District, the vocabulary cards provided for this activity have Alaska Native Language and English terms and an associated image. The games suggested are meant to promote fluency through repeated practice. Other vocabulary cards can be easily integrated into the games. This will extend potential length of the games and add a greater challenge. By working with the words through different games, students can develop greater fluency with the vocabulary.

Objectives

On successful completion of this lesson, students will be able to:

- read and speak indigenous terms related to climate and infrastructure, and
- illustrate and define terms related to infrastructure and changing climate's impact on infrastructure.

Alaska Standards:

Alaska Cultural Standards

[A] Culturally-knowledgeable students are well grounded in the cultural heritage and traditions of their community. Students who meet this cultural standard are able to:

[A.1] Assume responsibilities for their role in relation to the well-being of the cultural community and their lifelong obligations as a community member.

[B] Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life. Students who meet this cultural standard are able to:

[B.2] Make effective use of the knowledge, skills, and ways of knowing from their own cultural traditions to learn about the larger world in which they live.

[D] Culturally-knowledgeable students are able to engage effectively in learning activities that

are based on traditional ways of knowing and learning. Students who meet this cultural standard are able to:

[D.5] Identify and utilize appropriate sources of cultural knowledge to find solutions to everyday problems.

Bering Strait School District Scope & Sequence:

9.9A Understand the interaction of living and nonliving parts of an ecosystem.

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem.

9.10E Understand, describe and diagram the biogeochemical cycle in an ecosystem including:

- Water
- Nitrogen

10.2C Identify the interrelationships and different stages of the water, carbon and nitrogen cycles.

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate.

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives.

Materials

- REACH Up High School Student Guide: Impact on Infrastructure
- Vocabulary card sets (1 per group of 4-5 students)
- Student Information Sheet: Word Games Instructions (1 per group)
- Student Worksheet: Infrastructure Vocabulary
- Dry Erase Markers (1 per group)
- Timers (optional)

Activity Preparations

1. If your students completed Activity HS.7.1 Ask an Expert, refer to their completed worksheets for the terms you will have them use for the vocabulary word card games.
2. If your students did not conduct interviews with Native language speakers, consult with a local knowledge bearer or language expert to determine which language/dialect translation provided on page 4 of the Student Guide would be most appropriate for your students to practice. The following chart is provided for reference.

Alaska Native Languages in the Bering Strait Region				
Language	**Dialect Group**	**Dialect**	**Subdialect**	**Community**
Iñupiaq	Seward Peninsula Inupiaq	Bering Strait		Brevig Mission
			Diomede	Little Diomede
				Shishmaref
			Wales (Kinikmiu)	Wales
		Qawariaq	Teller	Teller
				Unalakleet
				Shaktoolik
			Fish River	Golovin*
				White Mountain
	Northern Alaskan Iñupiaq	Malimiut		Koyuk
Siberian Yupik		St. Lawrence Island Yupik		Gambell
				Savoonga
Yup'ik		Norton Sound (Unaliq-Pastuliq)	Unaliq	Elim
				Golovin*
				St. Michael
		General Central Yup'ik	Nelson Island and Stebbins	Stebbins

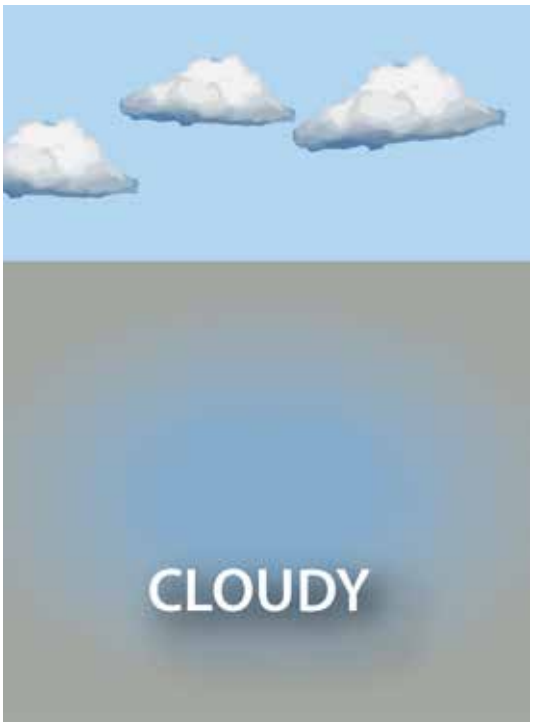
* It is very common for more than one language/dialect, or a combination of dialects, to be spoken in a community. It should also be noted that Inupiaq-Yup'ik bilingualism was common throughout the 1900s in the Norton Sound villages of White Mountain, Golovin, Elim, and Unalakleet. Golovin is listed twice on our chart because specific subdialects were cited in the research found on the Alaska Native Language Center website: http://www.uaf.edu/anlc/languages/.

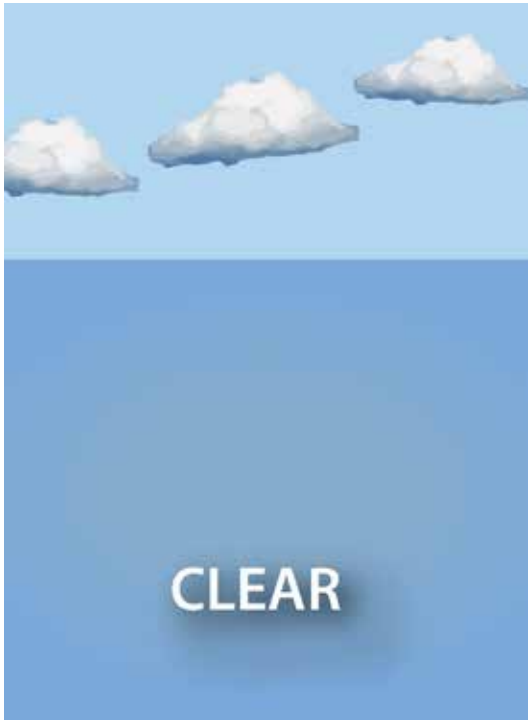
3. Keep in mind that different individuals may translate certain terms differently. It's fine to have different student groups working with various translations, or you can choose a set list of words for your whole class to practice. Highlight the diversity and do not attempt to offer an authoritative translation; the goal is to practice an Alaska Native language while discussing climate change topics.
4. If using the Vocabulary Cards provided by REACH Up, label a sample set of cards with local indigenous words using a dry erase marker. If needed, create your own sets of the vocabulary cards from the template provided.
5. Make copies of the Word Games Instruction Sheet (one per group) and the Impact on Infrastructure Vocabulary worksheet (one per student).

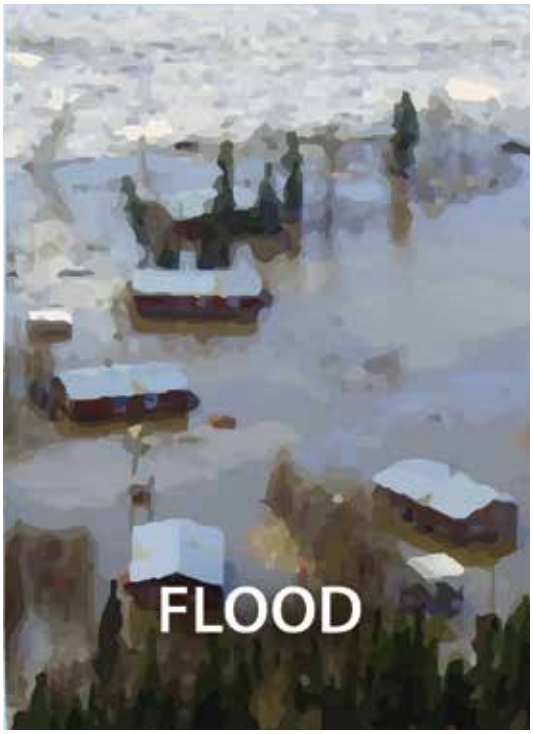
Activity Procedure

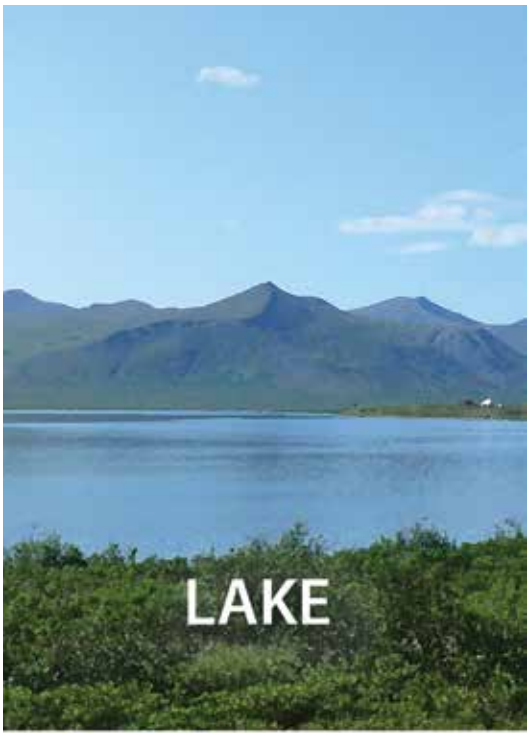
1. Distribute the REACH Up High School Student Guide: Impact on Infrastructure and review pages 1-4.
2. Show students the vocabulary cards. Hold up each card. Discuss what each card depicts. How do these terms relate to infrastructure in their region?
3. Say the English and local Alaska Native Language word for the illustration depicted on the card. Ask students to repeat the words. Repeat this once or twice, then ask students to call out the correct words as you hold up each card.
4. Divide the class into four groups.
5. Provide each group with the Word Games Instruction sheet, a set of Vocabulary Cards, dry erase marker, and a timer (optional).
6. Instruct students to label their cards with the local indigenous words. Groups can select one student from the group for this task, or take turns.
7. Direct students' attention to the Word Games Instruction sheet. Students can commit to one game for a period of time or mix and match.
8. Encourage students to play the vocabulary games and practice the vocabulary words during free time throughout the duration of the Impact on Infrastrcture unit. If possible, schedule 10-15 minutes twice per week to practice the vocabulary terms.
9. Write the following terms on the board: clear (water), cloudy (water), flood, lake, pond, river, rain, snow, water. Ask students to share definitions for these terms. Refer back to the REACH Up High School Student Guide: Impact on Infrastructure as necessary.
10. Distribute the Impact on Infrastructure Vocabulary Worksheet and ask students to complete it.

Vocabulary Cards

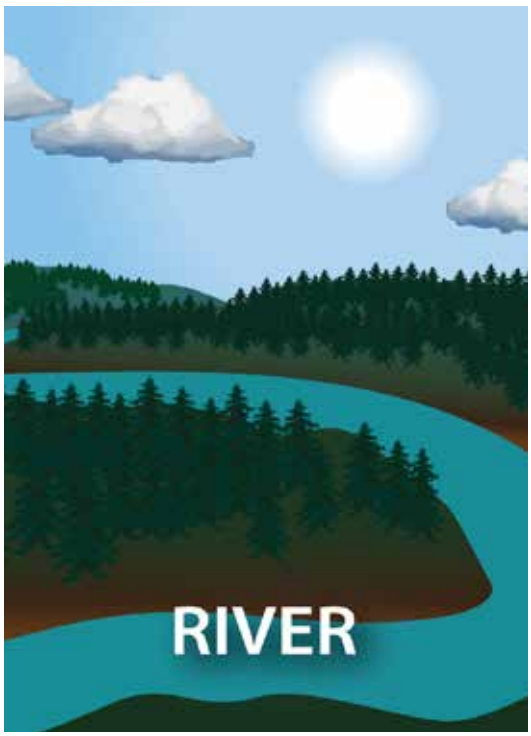




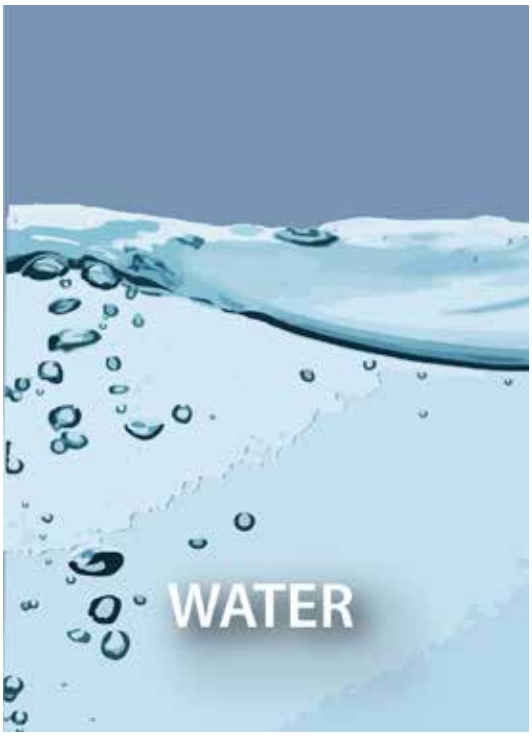




Vocabulary Cards



Vocabulary Cards



Vocabulary Cards

Local Indigenous Word

Local Indigenous Word

Local Indigenous Word

Local Indigenous Word

STUDENT INFORMATION SHEET: *Word Games Instructions*

VOCABULARY SWAP:

1. Distribute one card to each person.
2. Practice the word on your card, then find a classmate. Teach them the word on your card and learn the word on their card. Trade cards.
3. Find another classmate and repeat.

FIND THE CARD:

1. Divide into small groups. Each group will need a set of vocabulary cards. Spread the cards in front of you so that everyone in your group can see the pictures.
2. Listen as your teacher says a word aloud from one of the cards.
3. Work with your group to find and hold up the correct card.

VOCABULARY SLAP:

1. Select one student to serve as the "caller" for this game. That student should make a list of the vocabulary words on a separate sheet of paper. The words can be found on the back of the cards.
2. Place the cards in a circle, picture-side-up, in the middle of the playing area.
3. The caller should call out a word from their list. Everyone else should quickly place their hand on the picture that they believe represents that word.
4. Turn over the card or cards that students selected to see who chose correctly. Each student who placed his or her hand on the correct card earns a point.
5. Put the card(s) back in the circle and play again.
6. Play for a designated period of time. At the end of the time, the person with the most points wins.

TEAMWORK:

1. Divide your group into two teams. Each team will need a pencil and paper.
2. Shuffle the vocabulary cards and stack them picture-side up in the middle of the table.
3. Work with your team to write down the local Alaska Native Language terms for the picture on the card.
4. After both teams have written answers for the top card, turn the card over to check. Teams get 1 point for the correct Alaska Native Language word.
5. Repeat until all cards are gone. The team with the most points wins.

STUDENT WORKSHEET: ***Impact on Infrastructure Vocabulary***

Name: _____

1. Find the definition of each word on the left from the right and write its letter next to the word.

flood _____

infrastructure _____

lake _____

pond _____

rain _____

river _____

snow _____

sustainable _____

water _____

water quality _____

A. a large natural stream of water flowing in a channel to the sea, a lake, or another stream
B. the substance (most commonly encountered as a liquid) which is the principal constituent of seas, lakes, and rivers, and which falls as rain and other forms of precipitation -- as a chemical substance, regardless of its physical state, a compound of hydrogen and oxygen having the formula H_2O
C. the chemical, biological, and physical status of a body of water
D. atmospheric water vapor frozen into ice crystals and falling in light white flakes or lying on the ground as a white layer
E. a large body of water surrounded by land
F. a small body of still water formed naturally or by hollowing or embanking
G. the basic physical and organizational structures and facilities needed for the operation of a society, such as buildings, roads, water, and power supplies
H. an overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land
I. able to be maintained at a certain rate or level
J. moisture condensed from the atmosphere that falls visibly in separate drops

2. Complete the chart by writing the local Alaska Native Language terminology and illustrating the missing terms.

My Community: _____

English Word	Local Alaska Native Language Word	Illustration
clear (water)		
cloudy (water)		
flood		
lake		
pond		
rain		
river		
snow		
water		

Answer Key: *Impact on Infrastructure Vocabulary*

1. Find the definition of each word on the left from the right and write its letter next to the word.

flood __H__

infrastructure __G__

lake __E__

pond __F__

rain __J__

river __A__

snow __D__

sustainable __I__

water __B__

water quality __C__

A. a large natural stream of water flowing in a channel to the sea, a lake, or another stream
B. the substance (most commonly encountered as a liquid) which is the principal constituent of seas, lakes, and rivers, and which falls as rain and other forms of precipitation -- as a chemical substance, regardless of its physical state, a compound of hydrogen and oxygen having the formula H_2O
C. the chemical, biological, and physical status of a body of water
D. atmospheric water vapor frozen into ice crystals and falling in light white flakes or lying on the ground as a white layer
E. a large body of water surrounded by land
F. a small body of still water formed naturally or by hollowing or embanking
G. the basic physical and organizational structures and facilities needed for the operation of a society, such as buildings, roads, water, and power supplies
H. an overflowing of a large amount of water beyond its normal confines, especially over what is normally dry land
I. able to be maintained at a certain rate or level
J. moisture condensed from the atmosphere that falls visibly in separate drops

Answer Key: *Impact on Infrastructure Vocabulary*

2. Complete the chart by writing the local Alaska Native Language terminology and illustrating the missing terms.

My Community: _____

English Word	Local Alaska Native Language Word	Illustration
clear (water)	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
cloudy (water)	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
flood	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
lake	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
pond	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
rain	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
river	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
snow	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.
water	Answers will vary depending on language and dialect spoken in this community.	Sketch should illustrate word at left.

Activity HS.7.3: Water Quality

Overview

In this lesson students will learn about factors that affect water quality as well as assess water quality by analyzing pH, turbidity and nitrate levels of different water samples.

Objectives

On successful completion of this lesson, students will be able to:

- identify different water and sewer systems in use in rural Alaska
- describe potential impacts of climate change on water resources
- describe factors that affect water quality
- collect data and assess water quality of different water samples
- consider the implications of changes in water sources and water quality in their region from scientific, cultural and personal perspectives

Next Generation Science Standards

Standards by Disciplinary Core Ideas: Earth and Human Activity

Standards by Topic: Human Sustainability

Performance Expectations

The activity is just one step toward reaching the performance expectations listed below:

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.

Dimention:

Science & Engineering Practices

Constructing Explanations and Designing Solutions

Disciplinary Core Ideas

ESS3.A: Natural Resources

- Resource availability has guided the development of human society. (HS-ESS3-1)

Crosscutting Concepts

Cause and Effect

Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World

Alaska Standards

Alaska Science Standards and Grade Level Expectations

SA1: The student demonstrates an understanding of the processes of science by

- **[9] SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating
- **[10] SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating
- **[11] SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring and communicating
- **[9] SA1.2** hypothesizing, designing a controlled experiment, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions
- **[10] SA1.2** reviewing pertinent literature, hypothesizing, making qualitative and quantitative observations, controlling experimental variables, analyzing data statistically (i.e., mean, median, mode), and using this information to draw conclusions, compare results to others, suggest further experimentation, and apply student's conclusions to other problems
- **[11] SA1.2** recognizing and analyzing multiple explanations and models, using this information to revise students' own explanation or model if necessary

SC3: The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by

- **[11] SC3.2** analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem

Bering Strait School District Scope and Sequence

9.9A Understand the interaction of living and nonliving parts of an ecosystem. (SC3.2, SC3.3, SF)

9.9H Analyze the potential impacts of changes (climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem. (SC3.2)

9.10E Understand, describe and diagram the biogeochemical cycle in an ecosystem including: Water

- Water
- Nitrogen

10.5D Describe causes, effects, preventions, and mitigations of human impact on climate (SD 3.1)

- Global warming/climate change

11.7E Students develop an understanding of the dynamic relationships among scientific, cultural, social and personal perspectives. (SF)

Materials for Activity Part 1

- REACH Up High School Student Guide: *Impact on Infrastructure*
- Student Worksheet: *Water Quality, Part 1—Factors that Affect Water Quality*
- Student Information Sheet: *Water Quality Factors*
- 500ml Water sample bottles
- Labeling tape and Marker

Materials for Activity Part 2

- REACH Up High School Student Guide: *Impact on Infrastructure*
- Student Worksheet: *Water Quality, Part 2—Analyzing Water Quality*
- Student Information Sheet: *Water Quality Analysis Procedure Guide*
- Student Information Sheet: *Water Quality Factors*
- Distilled water (Make distilled water, using a distiller, ahead of time)
- 250ml beakers (to keep distilled water)
- 100ml beakers (Each student group will need one 100ml beaker for each of the pH, Nitrate and Turbidity analyses. If you choose to have them analyze only one or two of the factors, you will need only one or two beaker(s) accordingly for each group.)
- Basin
- Paper towel/napkins
- LabQuest 2 (fully charged)
- Correctly calibrated pH sensor – for pH analysis
- Electrode storage bottle, containing pH 4/KC 1 solution (buffer) – for pH analysis
- Correctly calibrated nitrate sensor ("Nitrate Ion-Selective Elctrode")
- Correctly calibrated turbidity sensor – for Turbidity analysis
- Pipettes (to transfer water samples to cuvettes) – for Turbidity analysis
- Cuvettes – for Turbidity analysis
- Lint-free cloth – for Turbidity analysis

Activity Preparations

Part 1—Factors that Affect Water Quality

1. Make copies of the Student Worksheet: Water Quality, Part 1—Factors that Affect Water Quality.
2. Make copies of the Student Information Sheet: Water Quality Factors.

Part 2—Analyzing Water Quality

1. Check the LabQuest 2 to see if they are fully charged. If not, recharge them.
2. Decide whether you would like your students to analyze all of the factors, i.e., pH, nitrate, and turbidity. You may choose one or two, depending on available time or other constraints.
3. Calibrate the nitrate and turbidity sensors ahead of time to save classroom time, unless you want to have students calibrate them themselves. Refer to the Student Information Sheet: Water Quality Analysis Procedure Guide for calibration procedures. You may also wish to consult instructions provided by the suppliers, including safety precautions.
4. Make copies of the Student Worksheet: Water Quality, Part 2—Analyzing Water Quality.
5. Have the copies of the Student Information Sheet: Water Quality Factors ready.
6. Make copies of the Student Information Sheet: Water Quality Analysis Procedure Guide.

Activity Procedure

Part 1—Factors that Affect Water Quality

1. Review pages 1-4 in the REACH Up High School Student Guide: Impact on Infrastructure.
2. Next, read and discuss pages 5-7 together as a class.
3. Read and discuss the top half (through "Introduction") of page 8 together as a class.
   a. Distribute the Student Worksheets (Water Quality, Part 1—Factors that Affect Water Quality), have students answer questions on the worksheet, and lead discussions.
4. Many factors affect water quality. Help students learn about pH, Nitrate and Turbidity, using the Student Information Sheet: Water Quality Factors. (Instruct students to bring the Water Quality Factors sheet back for the Part 2 activity.)
5. Go over the rest of page 8 of the Student Guide as a class.
6. Divide your class into groups, ideally with each group having three to four students. Each group will collect water samples, as a preparation for the next activity, Part 2—Analyzing Water Quality.
   a. Have each group collect a sample of school tap water in a 500ml water sample bottle. They must label the bottle "Tap water," using tape and a marker.

b. Have each group collect samples of water from three other different local sources (as they discussed in 3a) in 500ml water sample bottles. Students can collect samples together as a group or individually. Have them label each bottle with the location where they collected the water, using tape and a marker.

Part 2—Analyzing Water Quality

1. Read and discuss page 9 together as a class.
   a. Distribute copies of the Student Worksheet (Water Quality, Part 2—Analyzing Water Quality) and go over the experiment directions.
2. Instruct students to have the Student Information Sheet: Water Quality Factors, ready, which they used in the Part 1 activity. They will need the last page, "Reference chart," to evaluate water samples later.
3. Review instructions for using the sensors. Refer to the Student Information Sheet: Water Quality Analysis Procedure Guide. (You may also wish to consult instructions provided by the suppliers, including safety precautions.)
4. Follow the water quality analyses procedure in the Student Information Sheet: Water Quality Analysis Procedure Guide and have each group of students assess water samples and record their findings in the Student Worksheet: Water Quality, Part 2—Analyzing Water Quality (page 2).
5. Have each group of students record their group findings on the board for others and copy other groups' data in the Student Worksheet: Water Quality, Part 2—Analyzing Water Quality (page 3).
6. Look at the board and compare the analyses of different water samples each group has collected. Discuss how similar or different the results were. (Student Worksheet: Water Quality, Part 2—Analyzing Water Quality, page 4)
7. Consulting the "Reference chart" on the last page of the Student Information Sheet: Water Quality Factors, discuss what each sample of water could be used for (e.g., drinking water, shower, irrigation). Point out that ppm may be used instead of mg/L for Nitrate.

Extension Activities

- Have students write a paragraph on the questions: Based on your evaluation of each water sample,
  - Which sample(s) of water is good enough for drinking?
  - What should be done, if anything, to improve the quality of water for drinking?

- Have students analyze additional water samples. Have them report the test result.

- Take students on a field trip to the local water treatment facility. Have students write what they have learned.

- Repeat the water analysis activity from the same water sources in a month or 3 months' time to see if the results are the same.

Assessment

Evaluate the responses to the questions and quality of writing.

STUDENT WORKSHEET: Water Quality

Part 1—Factors that Affect Water Quality

Name: _____

1. There are many sources of water around you. List below all the water sources you can think of and share with the class.

2. Can you drink water from all the sources you listed? Discuss with the class why you think you can or you cannot.

Water Resources	Can you drink the water? (yes/no)

Answer Key: *Water Quality*

Part 1—Factors that Affect Water Quality

1. There are many sources of water around you. List below all the water sources you can think of and share with the class.

2. Can you drink water from all the sources you listed? Discuss with the class why you think you can or you cannot.

Water Resources	Can you drink the water? (yes/no)
Answers will vary but may include:	
Washeteria	
Rain/Snow	
River	
Pond/Lake	
Puddle	
Ocean/Slough	
Bottled water	

STUDENT WORKSHEET: *Water Quality*

Part 2—Analyzing Water Quality

Name: _____

Experiment

1. Have water samples collected in Part 1 ready. Each group should have school tap water and water samples from three other sources.

2. With your teacher and class, review the STUDENT INFORMATION SHEET: Water Quality Analysis Procedure Guide for calibration procedures. You may also wish to consult instructions for using the sensors provided by the supplier, including any safety precautions.

3. Assess water samples and record your findings on your worksheet below.

	Sample 1: School tap water	Sample 2: _____	Sample 3: _____	Sample 4: _____
pH				
Nitrate (mg/L)				
Turbidity (NTU*)				

* NTU = Nephelometric Turbidity Units

4. When you complete the water analysis, record your group's findings on the board for others.

Discuss

5. Look at the board and compare the analyses of different water samples your and other groups have collected. How similar or different were the results?

6. What could each sample of water be used for (e.g. drinking water, shower, irrigation)?

ANSWER KEY: *Water Quality*

Part 2—Analyzing Water Quality

Name: _____

Experiment

1. Have water samples collected in Part 1 ready. Each group should have school tap water and water samples from three other sources.
2. With your teacher and class, review the STUDENT INFORMATION SHEET: Water Quality Analysis Procedure Guide for calibration procedures. You may also wish to consult instructions for using the sensors provided by the supplier, including any safety precautions.
3. Assess water samples and record your findings on your worksheet below.

Answers will vary.
(You may wish to point out that ppm is also often used instead of mg/L for Nitrate analysis.)

	Sample 1: School tap water	Sample 2: _____	Sample 3: _____	Sample 4: _____
pH				
Nitrate (mg/L)				
Turbidity (NTU*)				

* NTU = Nephelometric Turbidity Units

4. When you complete the water analysis, record your group's findings on the board for others.

Answers will vary.

Discuss

5. Look at the board and compare the analyses of different water samples your and other groups have collected. How similar or different were the results?

   Answers will vary.

6. What could each sample of water be used for (e.g., drinking water, shower, irrigation)?

   Answers will vary.

STUDENT INFORMATION SHEET: *Water Quality Factors*

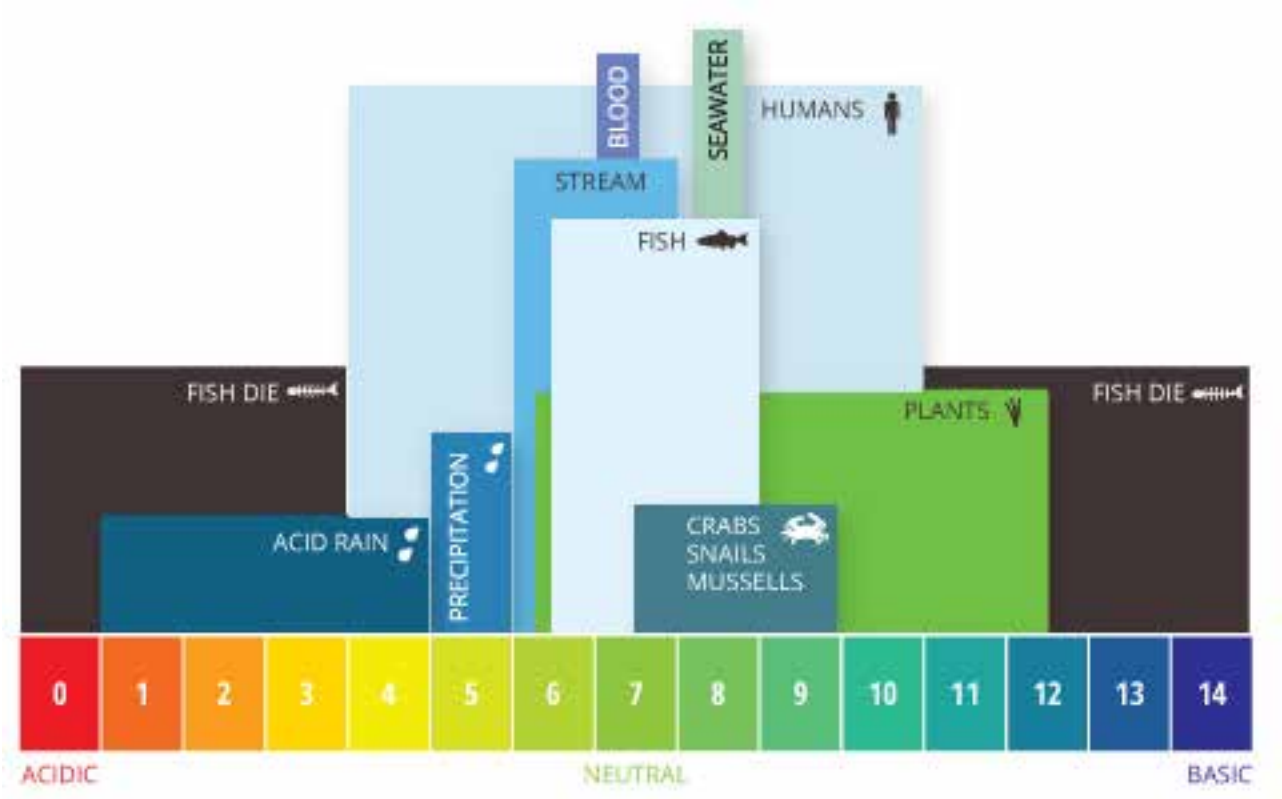
Many factors affect water quality, such as alkalinity, carbon dioxide, chlorine, dissolved oxygen, nitrate, pH, phosphate, salinity, temperature and turbidity. Most of the characteristics, however, cannot be determined by observation alone. In the following, you will learn about pH, nitrate and turbidity, and test several water samples for these factors.

pH

What is pH?

The pH (percentage of Hydrogen) of water is a measurement of how acidic or basic (opposite of acidic) the water is. The pH scale ranges from a value of 0 (very acidic) to 14 (very basic). Pure water has a pH of 7—it is neutral, meaning it is neither an acid nor a base.

In a lake or pond, the water's pH is affected by its age and the chemicals discharged by communities and industries. Most lakes are basic when they are first formed and become more acidic with time, due to the build-up of organic materials. They can also be affected by acid rain from air pollution as well as agricultural and industrial runoff.



Aquatic pH levels. The optimum pH levels for fish are from 6.5 to 9.0. Outside of optimum ranges, organisms can become stressed or die. Source: Fundamentals of Environmental Measurements: www.fondirest.com.

Why is pH important?

The pH of natural water is usually between 6.5 and 8.2. Aquatic organisms have adapted to a specific level of pH. They may die if the pH of the water changes even slightly.

What causes changes in pH?

- Carbon dioxide concentration in water
- Acid rain
- Temperature
- Wastewater

Nitrate

What is Nitrate?

Nitrate (NO_3-) is one form of the element Nitrogen (N), which makes up about 80 percent of the air we breathe as Nitrogen gas (N_2). Plants can take up Nitrate through their roots and use it for growth. All aquatic plants and animals need Nitrate to build proteins.

Why is Nitrate important?

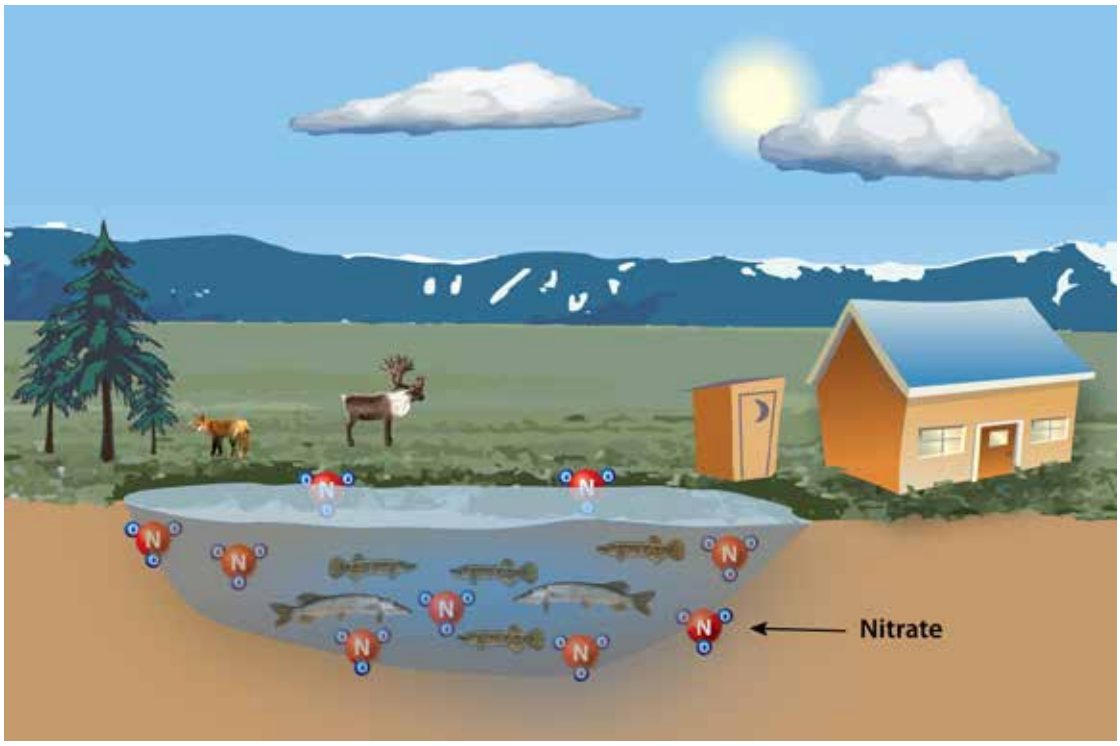
Nitrate is usually present in low concentration in most waters. If too much Nitrate is present, algae and water weeds grow wildly and stimulate bacterial decomposition. Bacteria need oxygen to decompose organic waste and use up a large amount of oxygen. This process of nutrient enrichment, called eutrophication, may cause fish and other aquatic organisms to die, because of a lack of oxygen.

When Nitrogen fertilizers are used to enrich soils on farmland, the nutrients may be carried by rain, irrigation and other surface waters through the soil into ground water. Human and animal wastes can also contribute to nutrient contamination of ground water. In Alaska, nutrient contamination is mostly caused by human and animal waste.

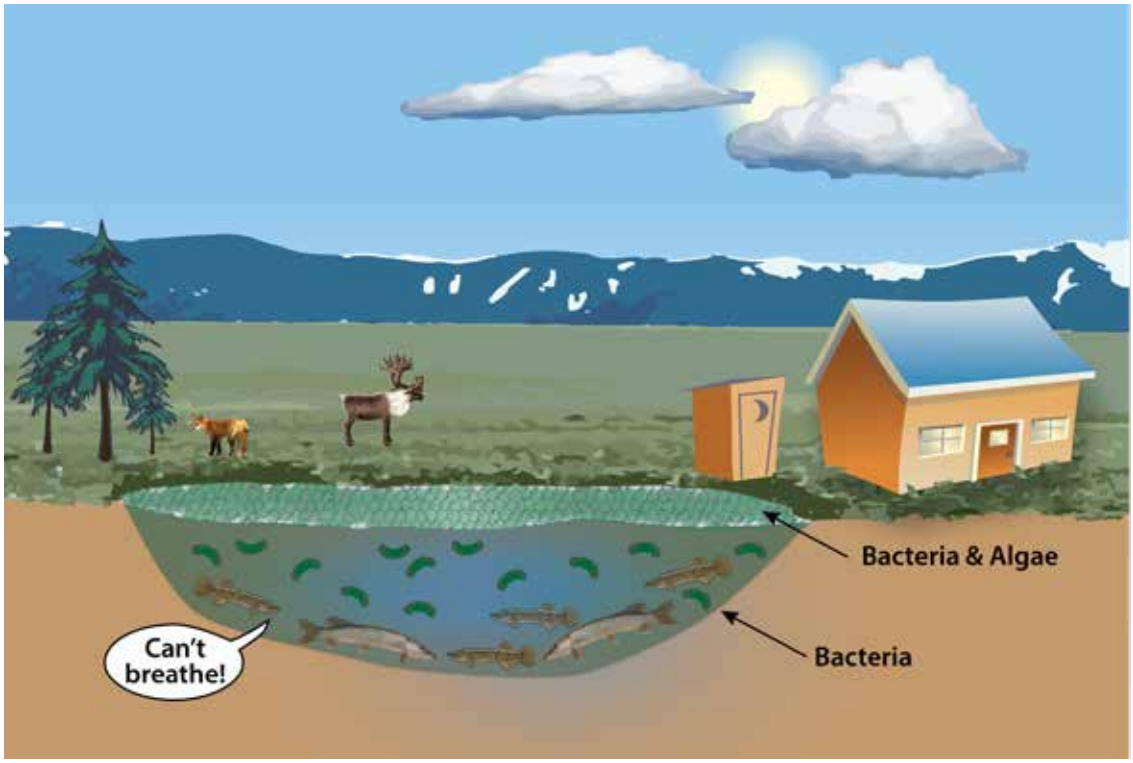
Excess levels of Nitrate in drinking water can cause methemoglobinemia, or "blue baby" disease, causing infants to die due to lack of oxygen. Although they do not pose a direct threat to older children and adults, they do indicate the possible presence of more serious contaminants such as bacteria or pesticides.

What causes changes in Nitrate?

- Solid and liquid waste from living animals
- Wastewater from sewage
- Poorly functioning septic system and wastewater treatment facilities
- Farm and lawn fertilizer run-off
- Decomposition of dead plants and animals



Too much nitrate in the water.



Too much nitrate leads to too much bacteria in the water.

Turbidity

What is Turbidity?

Turbidity is the cloudiness of water, or the ability of light to pass through water. A large number of particles that are generally invisible to the naked eye may cause turbidity. The most frequent causes of turbidity in lakes and rivers are plankton and soil erosion.

Why is Turbidity important?

If the water is too cloudy, it blocks out the sunlight. Water plants need light for photosynthesis to produce oxygen for fish and other aquatic life. If light levels get too low, photosynthesis may stop altogether and algae will die.

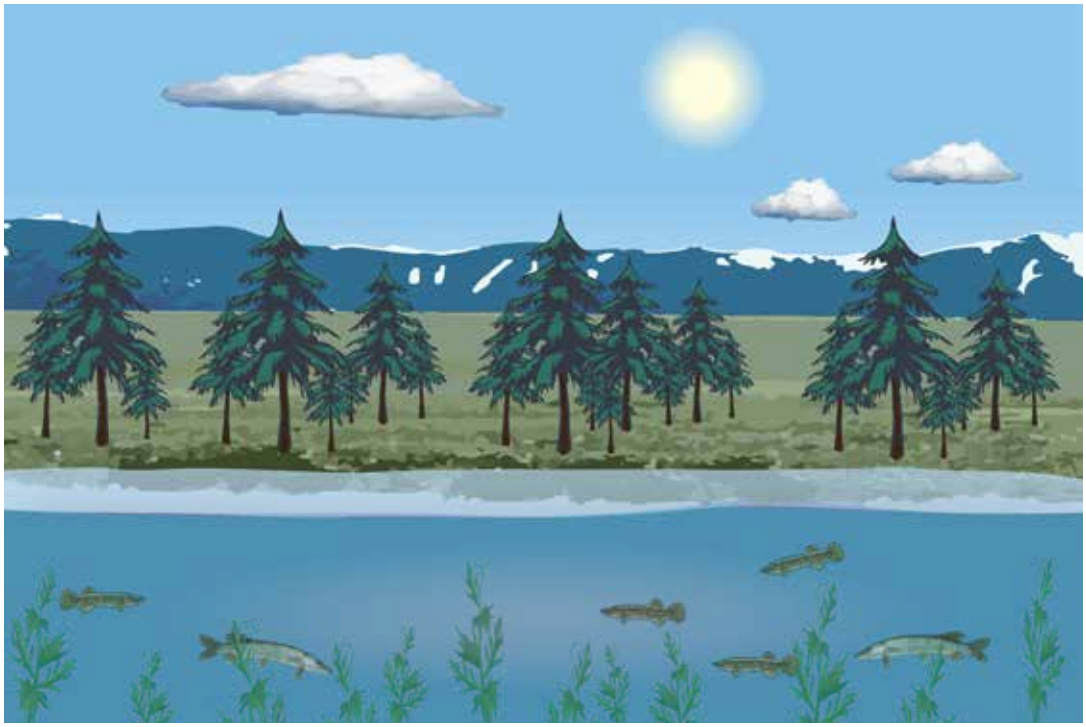
Fish cannot see well in turbid water and may have difficulty finding food. On the other hand, turbid water may protect them from predators.

Water contains particles such as silt, clay and microscopic organisms. They may clog the gills of fish, shellfish and some macroinvertebrates, causing them to die.

Turbidity can provide food and shelter for pathogens (bacteria, viruses or other microorganisms that can cause disease), leading to waterborne diseases, if not properly removed in drinking water.

What causes changes in Turbidity?

- Storms cause sediments to be flushed into the watershed
- Soil erosion (caused by storms, forest fires, building and road construction, loggings and mining)
- Wastewater and septic system effluent
- Decaying plants and animals
- Boat traffic that stirs the bottom sediment



The water is free of fine particulates. Plants and fish thrive in this balanced, oxygen-rich environment.

The water is too cloudy. Water plants can't get enough sunlight for photosynthesis, and fish can't breathe in this oxygen depleted environment.

Reference chart

Using the chart below, evaluate the overall quality of the water samples.

Factor	Result	Meaning	Ranking for drinking water
pH	4	More acidic	Poor
	5		Poor
	6	Neutral	Good
	7		Excellent
	8		Good
	9	More basic	Poor
	10		Poor
Nitrate (mg/L)	<10 mg/L	Less nitrate	Safe to drink
	>10 mg/L	More nitrate	Unsafe to drink
Turbidity (NTU*)	<1 NTU	Less cloudy	Excellent
	1-5 NTU		Safe to drink
	>5 NTU	More cloudy	Unsafe to drink

* NTU = Nephelomentric Turbidity Units

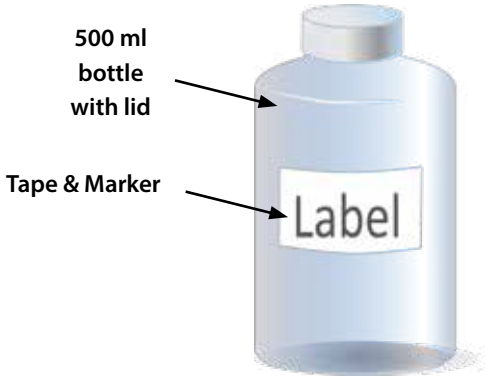
STUDENT INFORMATION SHEET: *Water Quality Analysis Procedure Guide*

Materials:

For each upcoming water quality analysis, you will need:

- Water samples collected in 500ml bottles (Label the water sources with tape and a marker)
- Labeling tape and Marker
- Distilled water
- 250ml Beaker (to keep distilled water)
- 100ml Beakers
- Basin
- LabQuest 2 (fully charged)

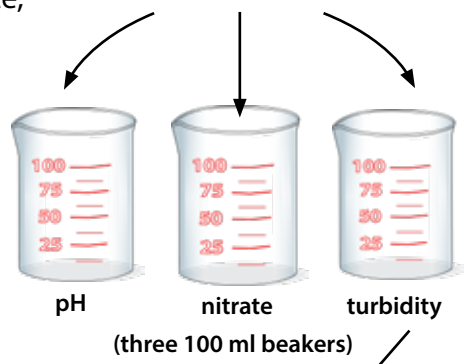
Collect Water Samples

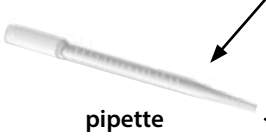


Do the following to prepare for the upcoming analyses:

1. Pour 50ml of Water Sample 1 in each of the three 100ml beakers. Water in each beaker will be used for pH, Nitrate, and Turbidity analyses respectively.
2. When the analyses on Water Sample 1 is finished, discard the water in the 100ml beakers into the basin.
3. Rinse the beakers with Water Sample 2 and pour it out into the basin.
4. Repeat #3.
5. Pour 50ml of Water Sample 2 in each of the three 100ml beakers for the next set of analyses.
6. For Water Samples 3 and 4, follow the same procedures (#2 through #5).

In Class





Other Required Items

plastic basin
(to rinse out water between each anlysis)

250 ml beaker
(to keep distilled water)

pH Analysis

Additional materials

- pH sensor
- Electrode storage bottle, containing pH 4/KC1 solution (buffer)

1. Fill a 250ml beaker half full with distilled water.

2. Remove the storage bottle from the electrode by unscrewing the lid and removing the bottle and lid.

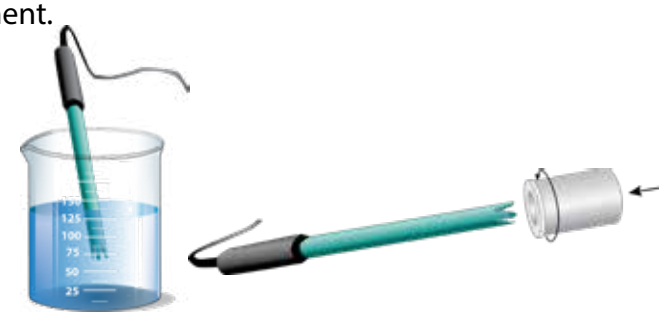
3. Thoroughly rinse the lower section of the pH sensor, especially around the bulb-shaped tip, using distilled water. Be careful with the glass tip, so it won't break.

4. Connect the pH sensor to the LabQuest 2.

5. Dip the sensor in a water sample and take a measurement.

6. Rinse the electrode in distilled water.

7. Repeat 5-6 to make measurements of the rest of the water samples.



8. When all the measurements are done, rinse the electrode in distilled water and store the sensor in the storage bottle. This keeps the sensor from damages.

Important: Do not fully submerge the sensor. The handle is not waterproof.

Nitrate Analysis

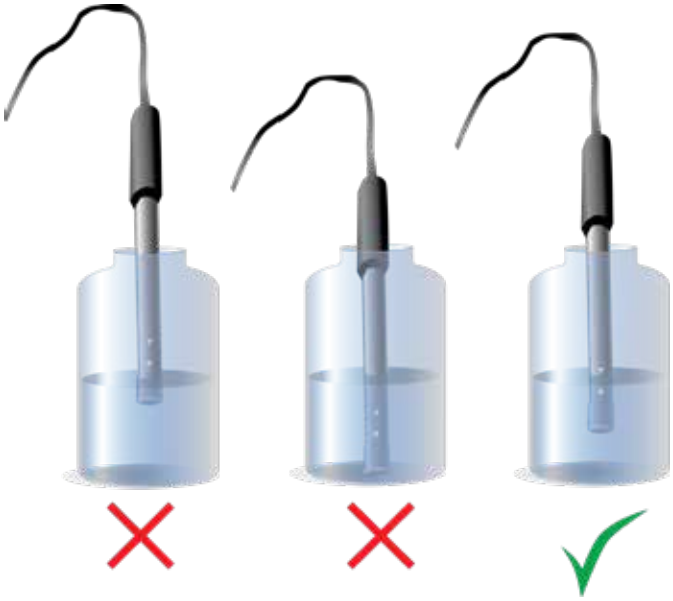
Additional materials

- Nitrate sensor (Nitrate Ion-Selective Electrode, ISE)
- 30ml bottle of High Standard solution with SDS (100mg/L NO_3-) – to calibrate the sensor (included with the Nitrate ISE)
- 30ml bottle of Low Standard solution with SDS (10mg/L NO_3-) – to calibrate the sensor (included with the Nitrate ISE)
- Short-term ISE soaking bottle (included with the Nitrate ISE)

Preparing the Nitrate sensor (Ion-Selective Electrode, or ISE) for use:

1. Soak the ISE in High Standard solution for 30 minutes.

   Important: The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE. Do not leave the ISE soaking for more than 24 hours.



2. Calibrate the ISE:

   2a. Connect the ISE to LabQuest. Choose "Calibrate" from the Sensors menu and select "Calibrate Now."

   2b. The ISE should still be soaking in the High Standard.

Note: Calibration is good for several hours. For accurate testing frequent calibration is recommended.

2c. Enter the concentration of the High Standard (**100** for 100mg/L) for Reading 1.

2d. After the voltage reading stabilizes (~2 minutes), tap Keep. (This sets up the **High Standard Calibration Point**.)

2e. Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel.

2f. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE.

2g. Enter the concentration of the low Standard (**1** for 1mg/L) for Reading 2.

2h. After the voltage reading stabilizes, tap **Keep**. (This establishes the **Low Standard Calibration Point**.)

2i. To save the calibration to the sensor:

- i. Tap Storage.
- ii. Tap Save Calibration to Sensor. Tap OK.
- iii. Tap OK to complete the process.

2j. When you finish using the ISE, rinse it off with distilled water and blot it dry using a paper towel and store it in the storage bottle. NOTE: The tip of the ISE should NOT be touching the sponge. The sponge in the bottom of the storage bottle should be kept moist with distilled water.

Collecting Nitrate Data

1. Make sure the Nitrate sensor (ISE) is properly calibrated.

2. Insert the tip of the ISE into the water sample to be tested.

Important: The ISE should **NOT** rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE.

3. Hold the ISE still until the reading stabilizes and record the displayed reading.

Note: With samples at high concentration, it could take several minutes for the reading of the ISE to stabilize. If you know the approximate concentrations, it is best to analyze them from the lowest concentration to highest.

Turbidity Analysis

Additional materials

- Turbidity sensor
- Pipettes (to transfer water samples to cuvettes)
- Cuvettes
- Lint-free cloth

Preparing the Turbidity sensor for use:

1. Connect the Turbidity sensor to the LabQuest 2 and let it warm up for five minutes.

2. Fill a 250ml beaker half full with distilled water.

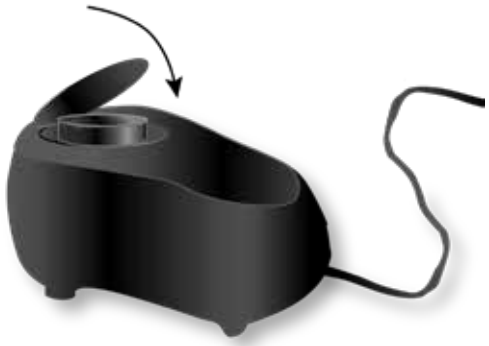
3. Calibrate the Turbidity sensor:

3a. Enter the calibration routine for LabQuest 2.

3b. **First calibration**: Obtain the cuvette containing the turbidity standard (100 NTU) and gently invert it four times to mix in any particles that may have settled to the bottom.

Important: Do NOT shake the standard. This could introduce air bubbles and could affect turbidity readings.

3c. Holding the cuvette by the lid, wipe the outside of the cuvette with a soft, lint-free cloth and place it into the slot of the Turbidity sensor. Align the mark on the cuvette with the mark on the Turbidity sensor for accurate reading.



3d. Close the lid.

3e. When the voltage is stabilized (a few seconds), enter **100** as the value in NTU and press "Keep."

3f. Remove the standard.

3g. **Second calibration**: Rinse the empty cuvette with distilled water. Then fill it to the top of the line with distilled water. **Important**: The bottom of the meniscus should be at the top of the line for every measurement throughout this test. This volume level is critical to obtain correct turbidity values.

3h. Screw the lid on the cuvette. Holding the cuvette by the lid, wipe the outside with a soft, lint-free cloth and place it into the slot of the Turbidity sensor. Align the mark on the cuvette with the mark on the Turbidity sensor for accurate reading.

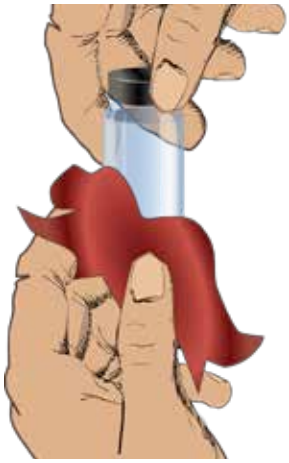
3i. Close the lid and wait for the voltage to stabilized (a few seconds). Enter **0** as the value in NTU.

3j. You are now ready to collect turbidity data.

Collecting Turbidity Data:

1. Rinse a cuvette with sample water. Using a pipette, fill a cuvette to the top of the line with sample water, with the meniscus touching the top of the line. Screw the lid on the cuvette.

2. Hold the cuvette by the lid and gently invert the sample water **four** times to mix in any particles that may have settled to the bottom. Do **NOT** shake the sample.



3. Wipe the outside with a soft, lint-free cloth.

4. Hold the cuvette by the lid and place it into the Turbidity sensor. Make sure the marks are aligned. Close the lid.

5. Monitor the turbidity value and record it on the worksheet.

   Note: Particles in the water will settle over time and show a slow downward drift in turbidity readings. Take your readings, therefore, soon after placing the cuvette in the sensor

6. Repeat 1 through 5 for each water sample.

7. When finished using the Turbidity sensor, rinse the sample cuvette with distilled water before storage.