4. Ask students to diagram the Point Hope water treatment system from the lake to the treatment plant, then design or engineer a better setup. For example, using quick-change filters or a series of valves that diverts the intake to another filter while one is being changed.
5. Look up a lesson idea on how to set up a water filtration competition using two-liter bottles. Such lessons use a heat source to evaporate the water and use items like soil, clay, sand, gravel, marbles, cotton balls, metal scrap, woodchips, sawdust, packing peanuts, charcoal bricks, coffee filters and vegetation to evaluate the best way to filter water.

Answers:

STUDENT WORKSHEET: Climate Change and Water

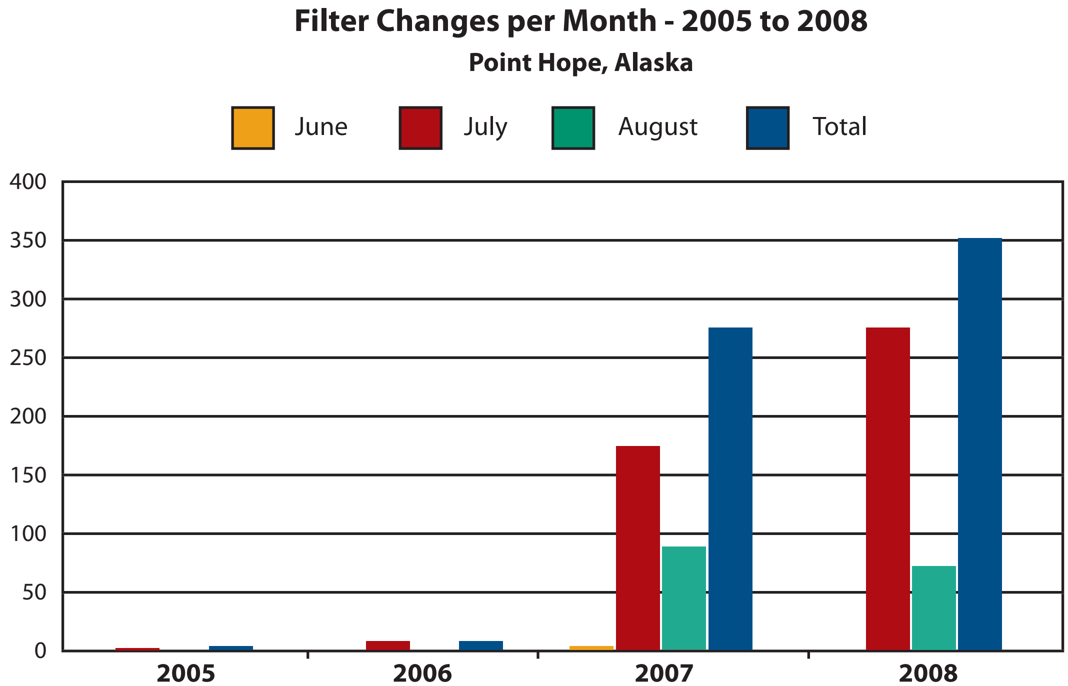
1. surface water such as lakes and ponds
2. People collected snow and ice to melt. It was stored in cellars until needed.
3. Evaporation: warmer temperatures cause more water to evaporate, decreasing availability. The remaining water contains more sediment and biological debris.

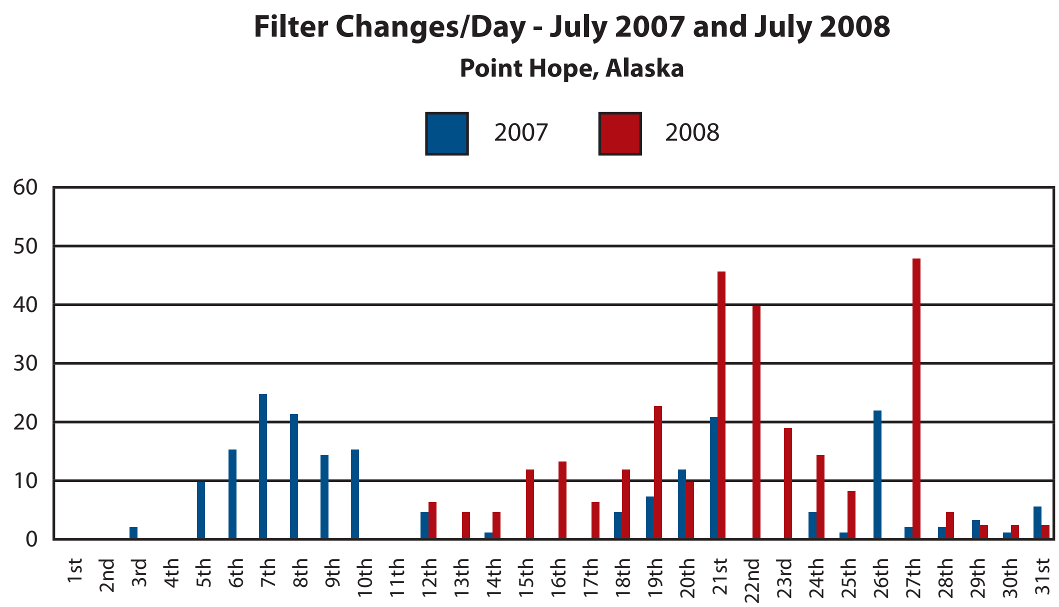
   Permafrost thaw: permafrost thaw removes the barrier that keeps water close to the surface and easily accessible to people, plants and animals. Without the barrier, the water drains away.
4. Warmer temperatures allow bacteria like E. coli to thrive
5. Any three or more of the following: more fires, less water for storage, harder to get water, habitats could change, water travel could be affected, subsistence could be affected
6. Water is put through a treatment system. It is run through filters and chemicals are added to make it safe to drink.
7. The time between spring thaw and fall freeze-up will be longer; summers will be warmer and drier.
8. Parts of Alaska could become prairie-like. There would be fewer lakes and rivers.

STUDENT WORKSHEET: Point Hope Case Study

1. 11
2. 17
3. 55%; (17-11) / 11 x 100 = 54.5%
4. 50
5. 1,567%; (50 - 3) / 3 x 100 = 1,566.7%
6. Answers will vary based on graph interpretation, but should approximate the following:
   - 2006 shows about 12 changes, so 12 x 10 = 120 minutes or 2 hours;
   - 2007 shows about 280 changes, so 280 x 10 = 2,800 minutes or 46.7 hours; and
   - 2008 shows about 355 changes, so 355 x 10 = 3,550 minutes or 59.2 hours.
7. There appears to be a connection between a temperature increase and filter change rate. Five to ten days after a temperature increase, filter change numbers increased.
8. Within a day or two after a high wind-speed day, filter changes increased.
9. Answers will vary. It appears that increased temperatures have warmed water and increased algae growth. Increased temperatures and algae growth support increased volume of larvae. Wind mixes the lake and transports biologic growth (algae and larvae) to the drinking water system intake.
10. Answers will vary, but may include:
    - continued monitoring and careful logbook entries of data to see if trends continue
    - modifying water treatment equipment to handle increased biomass
    - buying water filters in bulk for less cost per unit
    - adding containment floats around intake pipe to keep out floating biological material
    - adding prey species that feed on mosquitoes and mosquito larvae such as fish
    - utilizing other water sources
    - seeking assistance from university and other available state resource

POINT HOPE CASE STUDY



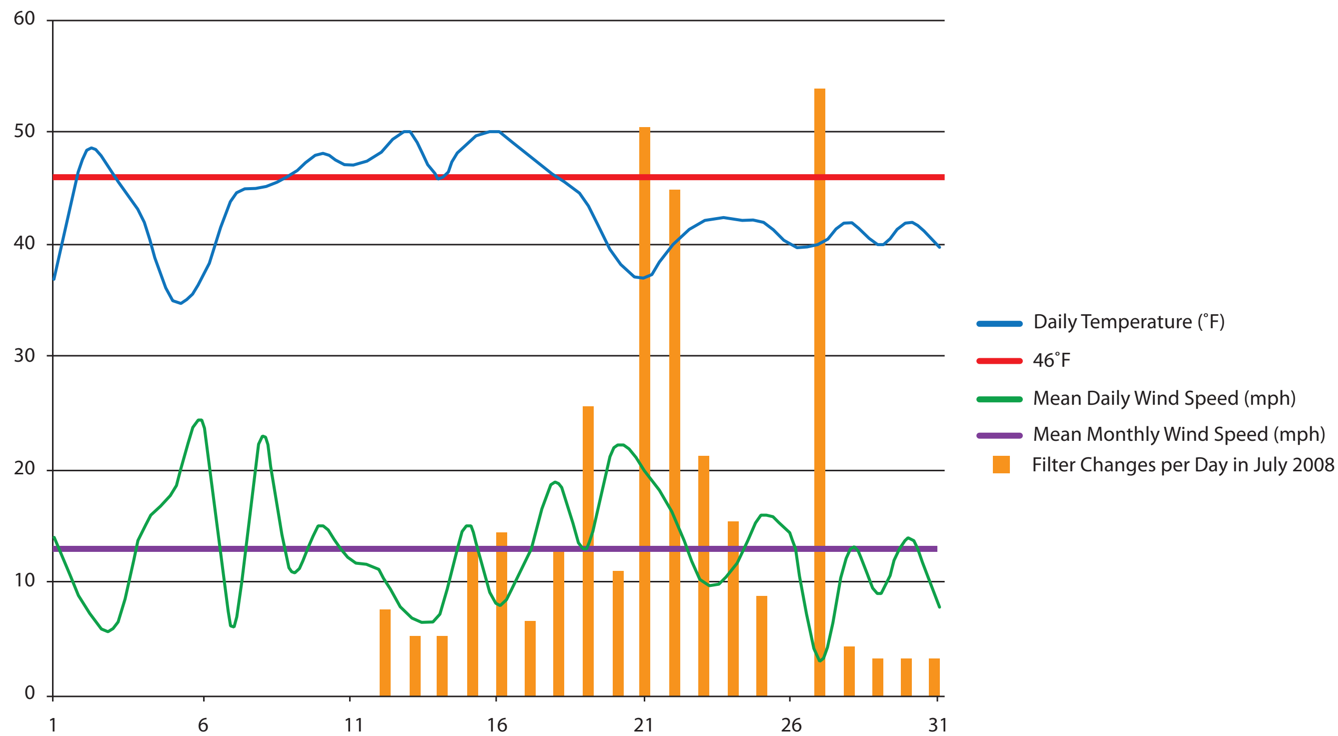


POINT HOPE CASE STUDY

This graph combines air temperature, wind data and bag filter change data for July 2008. The blue line shows air temperature, the green line shows wind speed. Orange bars show bag filter change data. The data is from the Point Hope Water Treatment Plant logbook and from Weather Underground.

Daily Mean Air Temperature and Wind Velocity for July 2008 with Water Treatment Plant Daily Bag Filter Changes

Point Hope, Alaska



Everyone in the world needs fresh water for drinking, cooking and cleaning. In rural Alaska fresh water is a precious commodity because it can be hard to get. Much of Alaska can be classified as an arid landscape. The little precipitation that does fall is often in the form of snow and ice and remains frozen for much of the year. Fortunately, when it melts, much of the freshwater in the Arctic sits on top of permafrost, which acts as a barrier similar to a layer of bedrock, and keeps it from draining away. This keeps it accessible to plants, animals and people.

Then and Now

In early times Indigenous people melted snow and ice to have water for drinking and cooking when open water was frozen. Elder Evelyn Alexander tells about the traditional way of collecting water in the winter.

> *Tsitle tu'* means snow water. We taught the kids to dig to the bottom to get the snow there. *Yeth uga'* – bottom snow. Kind of little bigger than the top snow. You fill up a bucket like this; the water will be this much for the top snow. But if you get the bottom snow the water will be almost full. More water comes out of the bottom snow. Anyway they used to say clear water, cleaner than top snow. All winter we used snow water. Springtime come we use water, but sometimes we go around in canoe we look for snowdrift. We get snow. We save it for drinking water until no more snow, until in June – sometimes late June. Out in camp. We stay out in camp. They make cellar and they keep snow in the cellar. Tanana River, when ice move, we put ice to shore. We cut them up and haul back to our house. Most of the people used to have cellar. We keep ice there. *Òut tso k' a drighila* means ice cellar.
>
> Sometime when the water come, it is a little bit muddy, you know? Lots of little grass – gotta settle them. Lots of little bugs sometimes. We have to boil them and settle it. I haven't seen that for a long time. We don't do that no more. If I move I'll take that snow, maybe I'll save ice. We get ice too. Clear water. Snow water, *tsitl tu'.* We use that for tea and drinking. It tastes better than well water.

In modern times, rural Alaskans have adapted by building huge storage facilities and filling them with water during the short window when water supplies, such as lakes, are snow and ice-free. Most community water supplies are treated with chemicals to make them safe for drinking and cooking. But water tanks run dry when their capacity is too small to meet community needs, if the pumping season is too short, or if there just isn't enough water to collect.

How Could a Warmer Climate Impact Water?

Climate change impacts the water supply in rural Alaska in many ways. On the positive side, shorter winters and more precipitation could make it easier to get water for more of the year, decreasing reliance on stored water. But warmer temperatures and thawing permafrost could reduce the availability of surface water and leave the remaining water harder to get and harder to treat.

- Warm temperatures cause water to evaporate leading to less surface water and decreased river flow.
- Thawing permafrost removes the barrier that holds water close to the surface, where it is accessible, allowing it to drain away.

Two related articles from the Geophysical Institute's Alaska Science Forum follow.

Village Water Supplies in a Warmer World, by Ned Rozell
Alaska Science Forum Article #1735
January 27, 2005

This column is provided as a public service by the Geophysical Institute, University of Alaska Fairbanks, in cooperation with the UAF research community. Ned Rozell is a science writer at the institute.

More than 200 villages are spread throughout Alaska, many of them on river systems and low-lying tundra with permafrost beneath it. These conditions have contributed to the problems many villages have with waste disposal; village dumps are often sprawling mounds of garbage spilling into ponds or sloughs. A University of Alaska Fairbanks graduate student is sampling the water and soil around village dumps to see how, or if, pollutants are migrating into the surrounding environment.

Edda Mutter visited seven villages in rural Alaska last summer. She talked to people there and then pulled on her rubber boots and heavy raingear, even though it wasn't raining. She then walked through village dumps and collected water and soil samples. She found elevated levels of aluminum in the water samples from all seven communities (the civic leaders of which don't want the village names published), along with high levels of E. coli and other bacteria.

It's a dirty job ("I make sure I don't set down my backpack just anywhere," Mutter said), but she's hoping to track the fate of toxic substances disposed of in village dumps.

"I want to figure out what's there, and how these pollutants behave," she said. "Do they stay in the soil, or bind with water? How will things change with a warmer climate and more permafrost degradation?"

In a study performed by Zender Environmental in 2003, Lynn Zender wrote that 72 percent of village dumps are within about one mile of homes, and at least 30 percent are within one-quarter mile of homes. More than 56 percent of village dumps are seasonally flooded, and 34 percent of dumps are one-quarter mile from a village drinking-water source. About half of isolated Native villages use honey bucket systems, where people carry toilet waste from their homes in five-gallon buckets lined with plastic bags. They often dump the honey bucket contents at the same dumpsite as everything else.

"At some sites, everything goes into the hole," Mutter said.

Mutter is from a village in Germany about the size of some she is visiting in Alaska. She and her project collaborators at the University of Alaska Anchorage and the Rural Alaska Community Action Program have gotten funding from the U.S. Department of Agriculture, the Environmental Protection Agency and the U.S. Geological Survey. Her Ph.D. advisor, Bill Schnabel, the director of the Water and Environmental Research Center at UAF, said Mutter's project is the first step of a long-term plan to see what problems exist in solid waste pollution in village Alaska and what solutions might be workable there.

"How much of a problem do we really have?" he said. "Do we have noxious material getting into the water and soil? As researchers, we're attempting to get in there and get some of these answers. Is this a human or environmental health problem, or is it simply an aesthetic issue?"

Mutter will return to the villages this summer for another round of sampling. She said people she has met there want answers.

"I was fascinated with how much help I got in the communities," Mutter said. "Some people would go out and help me collect (samples) at the dump site. They're concerned about where to hunt and pick berries. Sometimes, the most beautiful berries are around the dumpsites."

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A recent "water bottle airlift" from Bethel to the western Alaska village of Nunam Iqua showed how precious clean water can be in the Alaska Bush. A team of scientists is now studying how changes in climate might impact the water supplies of some Alaska villages.

Nunam Iqua is like many Alaska villages that use a variety of fresh water sources. The 35 families who live in Nunam Iqua rely on a nearby river for water that they store during the winter in a 200,000-gallon tank. When a December 2004 storm fouled the river with salt water and a tank fitting failed, draining their stored water, residents asked for help. The state Division of Homeland Security and Emergency Services began flying 500 gallons of water each day to Nunam Iqua. When the river cleared later in the month, residents were able to begin storing water again and officials called off the water airlift.

Farther north, villagers on the Seward Peninsula gather their water in many ways, from pumping wells to digging depressions in the tundra and lining them with plastic to catch snowmelt runoff, according to Dan White of UAF's Water and Environmental Research Center. White is leading a four-year study on the water supplies of Seward Peninsula villages and how a changing climate might affect those water sources.

White and his colleagues, Lillian Alessa of UAA and UAF's Larry Hinzman and Peter Schweitzer, chose the Seward Peninsula for research because much of the permafrost there is close to thawing. Permafrost acts as a barrier that traps water near the surface in many areas; when it melts, the water above it may drain away. In the warmest-case scenario of Alaska's future, permafrost wetlands could turn into an arid landscape, said White, who pointed out that areas of Alaska's North Slope receive less precipitation than Tucson, Arizona.

"The whole reason water's abundant in the Arctic is permafrost," White said. "If the permafrost melts, it likely won't be a wetlands."

White, a civil engineer, has visited the Seward Peninsula communities of Nome, Elim, Golovin, Shishmaref, White Mountain, Brevig Mission and Wales. He has seen the stream where Wales residents collect their water, the well in Elim, and the "municipal water reserve" in Shishmaref, a reservoir lined with plastic to gather snowmelt. Communities that rely on surface water need to store large amounts of it during the eight or more months their usual water source is frozen.

"Any place that relies on surface water is at risk of running out of water," White said, adding that many villages drain their storage tanks before they can replenish them in summer.

"In many communities, the water tank is just too small," White said. "When water runs out sometimes in April or May, they've got to harvest their own water, and it's a tricky time for them."

Residents of some Bush villages harvest water by collecting ice or rainwater, or sometimes traveling to open streams and rivers. Gathering water often becomes impossible during breakup, when snow machine trails get soft and ice begins to rot.

"How's climate going to affect this?" White said. "If breakup is earlier or is prolonged, harvesting water could be more of a problem."

In addition to the possible change in water sources and more difficult water-gathering that might accompany the continuation of observed warming, waterfowl, caribou, and other local food sources might be more scarce on a dryer Seward Peninsula, White said.

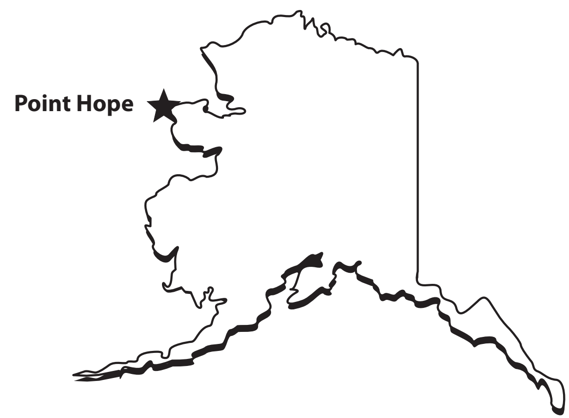
During the four-year study, White and his colleagues will try to find potential problems with water supplies and also solutions that might work if a warming climate threatens fresh water supplies on the Seward Peninsula.

"Our goal is to try to understand how hydrology is likely to be impacted by climate and how those changes will impact people and the culture of the region," he said. "We can expect some changes; we just want to know how to deal with the changes.

POINT HOPE CASE STUDY

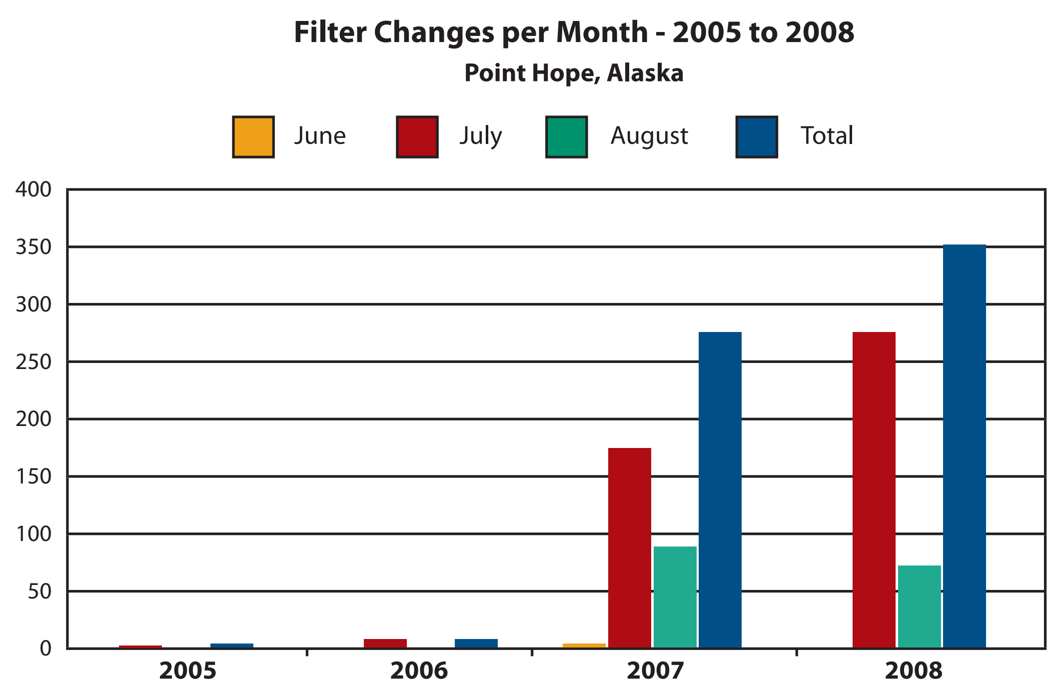
In July of 2009, the Center for Climate and Health, part of the Alaska Native Tribal Health Consortium, worked with the community of Point Hope to help solve a water quality problem. Researchers published Source Drinking Water Challenges Resulting from Changes To an Arctic Tundra Lake, a paper that detailed concerns and outlined some ways to solve them. The following case study is taken from that paper. As you read you will be asked to use data to try to determine what might have caused some of the problems found in Point Hope.

Background: Point Hope is an Inupiaq community of about 700 residents. The climate is Arctic and ranges from -45°C/-49°F to 26°C/78°F. Precipitation is light with ten inches annually. Cumulative snowfall is about 36 inches. Point Hope acquires drinking water from 7-Mile Lake located seven miles east of town. This tundra lake is recharged each year from snowmelt and precipitation. There is a limited time frame when the lake is ice free, and when water can be pumped, treated and transferred to above ground tanks for storage and use throughout the year. From late June until early September water is piped from the lake and treated. During the short pumping window, water plant operators work 12-hour shifts around the clock to produce enough water to last the whole year. Water system customers in Point Hope include approximately 180 homes with piped water and sewer and 11 homes on a haul system with holding tanks.



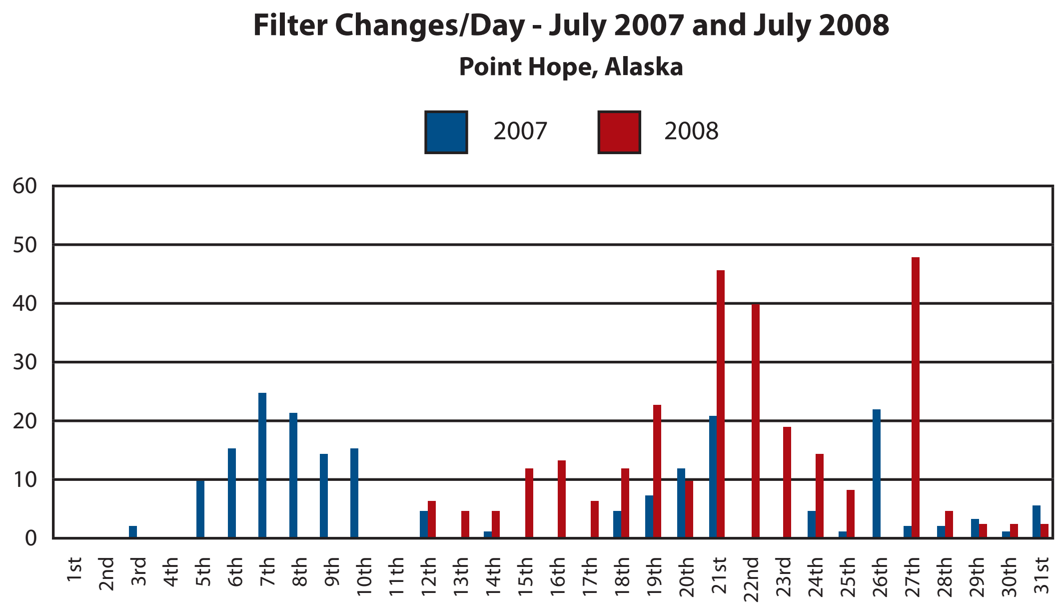
At the deepest part of the lake, where the depth is typically just over ten feet, a screened intake pipe is suspended approximately 1.5 feet below the surface. The water is pumped through a pipeline to the water treatment plant where it is passed through series of filters prior to the addition of chlorine, which is added to cleanse the water of bacteria and microorganisms. Operators measure water pressure and raw water conditions and perform regular analyses to make sure filtered water meets water quality standards.

Problem: Water filters at the Point Hope treatment plant became clogged and had to be cleaned at a much higher rate during the summers of 2007 and 2008 than in previous years. The logbook from the Point Hope Water Plant shows the following data.



Look closely at the month of July for 2007 and 2008:

- At the peak period in 2007 operators were changing filters over 20 times per day.
- In 2008 that number rose to almost 50 times per day.



Cause: Point Hope Water Plant operators pointed to lower-than-average precipitation and high temperatures as likely contributing to water-quality problems. National weather service data supports their observation. The Northwest Arctic climate has been gradually warming.

- Between 1949 and 2005, temperatures showed an annual increase of about 1.6°C/3.3°F.
- Summer temperatures have increased an average of 1.5°C/2.7°F.
- Weather data shows that records were set for low precipitation and high temperatures in 2007 and 2008.
- During the summers of 2007 and 2008 water temperatures at the Point Hope treatment plant were elevated. Typical raw water temperatures are between 4°C/40°F and 10°C/50°F, but during those years were 10°C/50°F to 16°C/60°F. Lake water temperatures were not recorded.

It was during that time that operators began reporting changes in the quality of raw water entering the plant, specifically the amount of mosquito larvae and algae in the filter bags.

- Workers at the treatment plant reported an increase in mosquito larva in the filters.
- Workers at the lake reported an increase in hatched mosquitoes.

Mosquito larvae need a minimum of 46°F to develop. Larvae are usually found near the edge of large water bodies because the water is warmer and there are algae on which to feed. Algae also prefer warmer water to grow.

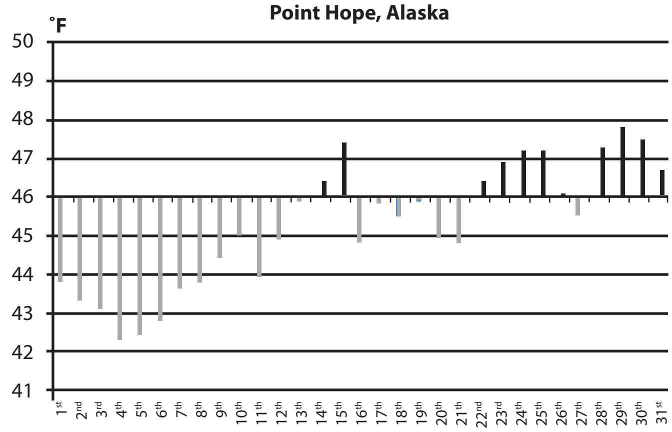
The intake pipe is located in the middle of the lake.

NAME: ______________________________

POINT HOPE CASE STUDY

Directions: Complete the following questions. Refer to STUDENT INFORMATION SHEET: "Point Hope Case Study," when necessary.

Mean Daily July Temperatures for the Period 1991-2008
Point Hope, Alaska



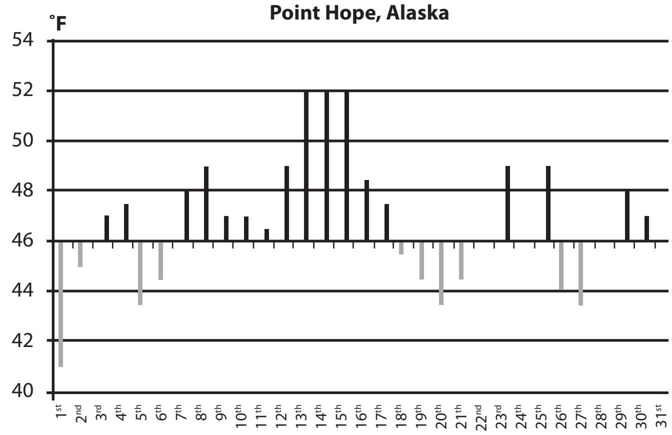
1. Look at the graph at right titled, "Mean Daily July Temperatures for the Period 1991–2008." How many days in a typical July had temperatures warm enough for mosquito larvae development?

   ____

2. Look at the graph at right titled, "Mean Daily July Temperatures for the Period 2007 – 2008." How many days had temperatures warm enough for mosquito larvae development?

   ____

Mean Daily July Temperatures for the Period 2007-2008
Point Hope, Alaska



3. Based on the two graphs shown, what is the percentage increase in potential larvae development days? Round your answer.

   Use the following formula to find the percentage increase:

   (new - original) / original x 100 = percentage of increase

4. Prior to 2007, Point Hope water treatment workers changed the filter an average of three times per day. In July of 2008 that number rose to almost ______________ times per day.

5. What is the percentage uincrease in the number of filter changes? Round your answer. Use the formula in question 3. ______________

6. It takes an average of ten minutes to remove, wash and replace filters. About how much time was dedicated to filter leaning in:

   A. 2006 ___________ B. 2007 ___________ C. 2008 ___________

Ask your teacher to display the VISUAL AID: "Point Hope Case Study," page two, to complete the following questions.

---

7. How does temperature increase seem to impact filter changes?

   ____

   ____

NAME: ______________________________

POINT HOPE CASE STUDY

8. How does wind speed seem to impact filter changes?

____

____

Critical Thinking

9. Using the information and data about Point Hope, explain what you think is happening in the lake to cause the increase in the number of filter changes in recent years. Be sure to discuss temperature, wind speed and the placement of the intake pipe.

____

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____

10. Based on your understanding of the possible weather related concerns as indicated by your interpretation of the data on the graphs, suggest two things the community might do to increase the quantity of safe drinking water pumped during the short window of available time. Explain how you think each suggestion will work to improve the quantity of drinkable water harvested.

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