Water Chemistry

Investigative Questions: Why do you think it is important to measure water quality before changing a landscape (Why is water quality important)? How is water quality measured? How can water quality inform decisions about building placement?

Goal: Students will learn how to test several water quality parameters to gain an understanding of the importance of water quality.

Learning Objectives
Knowledge: Students test abiotic water quality indicators and explore what these factors tell us about water quality.
Skills: Students use hand-held water testing equipment (Vernier) to measure water quality. Students analyze water quality indicators and describe what they mean to the health of an ecosystem.
Value: Students appreciate the importance of water quality to the health of a system.

Virginia SOL: Science (2018) 6.1, 6.6, 6.8

Materials
- Outdoor (Plastic) 5' x 8' rugs (1/student group)
- Foam mats (3/student group)
- Water sample from Lake Georgette
- Distilled water for rinsing probes
- Large beakers (500 or 1000 ml)
- Buckets for water samples
- Kim-Wipes
- Aquatic thermometers
    - **High Tech Tests:** Vernier Labquest2 and EasyLinks probeware with TI-84. (See page 3 for detailed list.)
    - **Low tech Tests:**

pH test strips & reference sheet	Nitrate test strip & Reference sheet
Dissolved oxygen test, DO Testabs, small glass vials, reference sheet	Turbidity test - Turbidity tube & reference sheet
Aquachek Phosphate test & reference sheet	

Setup:
- Place one rug on the ground per student group to create a work station. Place 3 foam mats across the center of each rug to place the testing equipment on.
- At each work station, place one Vernier Labquest2, two graphing calculators and one of each probe/sensor/test. See list on page 3 for detailed set up.
- Calibrate nitrate and turbidity sensors.

Special Safety
- Keep Vernier Labquest 2 units away from the water.

Procedure/Instructional Practice

1) Introduction: Instruct students to look around and conduct a quick site analysis of Lake Georgette. First ask, Why do you think testing water quality is important (or why do you think it is important for Blandy to have good water quality)? How can you determine the quality of water in a particular stream or pond? Hydrologists, water

scientists, study water quality by testing the living and non-living aspects (refer to macro station if they have already been to this station). Inquire with students to determine what prior knowledge they have about water quality (based on where they are in the Blandy rotation cycle).

2) Inquiry discussion of water quality factors. Factors to discuss:

a) **Temperature**: higher temps increase metabolism (the rate at which organisms process food into energy) and the rate of growth of aquatic organisms. High temperatures also increase the rate of decomposition; this decreases available oxygen because decomposing organisms use up oxygen in the water.

b) **Dissolved oxygen**: Aquatic animals use oxygen that is dissolved in the water; dissolved oxygen is introduced into water from aquatic plants (a by-product of photosynthesis) and also by air being introduced to water as water riffles, or moves, over rocks.

c) **Turbidity:** clarity/clearness of water; a measure of small particles, such as soil particles, in the water. High turbidity can clog gills, bury eggs, and block sunlight. The small particles also absorb sunlight which increases the temperature of the water.

d) **Nitrates and phosphates** are both important for plant growth but are considered water pollutants when their levels are high. Aquatic plants, such as algae, use these additional nitrates and phosphates to grow faster. This abundance of algae growth is called an algal bloom. Masses of algae can block sunlight and reduce DO that other organisms need. Nitrates and phosphates can come from animal waste and fertilizer runoff.

e) **pH**: a measure of the acidity or alkalinity of the water. The pH can range from 0-14 with 7.0 as neutral. Most aquatic organisms survive in water with pH in a range of 5 to 9 (moderately acidic to moderately alkaline or basic).

f) **Macroinvertebrates:** the type and abundance of aquatic invertebrate animals (large enough to be seen with the naked eye, no backbone) is an indicator of water quality. Some macroinvertebrates can tolerate pollution; others cannot. For example, some immature insects such as stonefly nymphs and mayfly nymphs are very sensitive to pollutants and poor water quality.

3) <u>Conducting Tests</u>:

a) In each group, each student will become an expert on one of the five tests. Some students may do two if there are not enough group members. Assign each group to a station. At test stations, direct students to look at their laminated test sheet and READ the directions before using the equipment. Each sheet provides background information on the front and the directions on the back. Point out that the colored circle on the top of their test sheet matches the tape that is on the LabQuest2.

b) Distribute the group data sheets to each group's chaperone. Their task is to record their group's data and return the group data sheet to the lead instructor for the water quality investigation at the end of the activity session.

c) At each station, explain and show the Vernier LabQuests2, probes, easy link device, and calculators. Explain that the probes DO NOT need to be unhooked from the Labquest at any point in time, unless an instructor of the station says to do so. Point out the location of the trash bin (for kim wipes), the waste bucket (for spent phosphate testing water), and sample water containers.

d) Once groups are ready, instruct them to begin testing their water samples. Circulate around to each group to check on progress.

4) <u>Conclusion</u>:

a) Instruct students to carefully place all equipment back on the mats as they found it. Ask students to review test results to determine, based on their data as evidence, whether the water at Blandy is healthy. Make sure they give claims, evidence and reasoning to support their argument.

b) Ask students if we can make an accurate statement as to whether the water at Blandy is healthy based off ONE class on ONE day. (Reiterates that scientists conduct multiple trials over a period of time.)

Extension: For those students who are having trouble understanding pH

- Have students stand in a horizontal line in reference to yourself. Explain to the students they are now the pH scale. Ask students what are the ranges of a pH scale? 1-14. Assign the student on your far right, # 1. Assign the student on your far left, # 14. Ask students what is the median of 1-14. Assign a student in the middle of the line # 7.
- Then ask students what is # 1 and # 14 as represented on the pH scale? (Acidic # 1------- Basic # 14)
- Ask students to name something that may be acidic?
  - Examples can be found on the students' instruction sheet
- Assign students a liquid that corresponds with where the student is standing along the pH scale number line. (ex. Bleach at 10, water at 7, hydrochloric acid at 2, etc.)
- pH is a logarithmic scale, so 6 is ten times more acidic than 7.

NOAA IASC Spring Water Chemistry Investigation Set up Supplies

Supply	# per group	Total #
Vernier LabQuest2	1	**5**
5 Gallon Bucket (water & waste)		**2**
2 gallon Sample water buckets	1	**5**
Small 250 ml beakers	5	**20**
Large 1000 ml beaker (labeled 'Rinse' beaker)	1	**5**
Distilled Water Squirt bottle	1	**5**
Pipettes	1	**5**
Kim Wipes	1 box	**5**

Dissolved Oxygen	Notes
Probe	

Turbidity	Notes
Turbidity Sensor	Calibrate
Glass vial	Green top 1 per group = **5 total**
Pipette	1 per group = **5 total**

Nitrate	Notes
Probe	Calibrate

Phosphate	Notes
Plastic Vial	Black line marking water level & Cap 1 per group = **5 total**
Test Pillow Pack (powder)	1 per group = **20 Total**
Laminated Color reference sheet	1 per group = **5 Total**

Temperature	Notes
Probe	
Easy link (adaptor)	
TI -84 Calculator	1 per group= **5 total**

pH	Notes
Sensor probe	
Easy Link (adaptor)	
TI-84 Calculator	1 per group= **5 total**

Water Chemistry at Lake Georgette

RESEARCH GROUP #: ______________________ DATE: _______ TIME:__________

Your mission today is to determine the overall health of Lake Georgette. Is the water clean and safe for the animals living in the water? Is there unseen danger lurking beneath the surface for the animals? Each member of your team will be assigned as an expert for specific water quality tests. You will learn about what your test measures and how it can help determine the overall health of Lake Georgette. When you are done with your test, you will work in your groups to look at all the data and decide whether you think the water is healthy or not.

My Test: ____

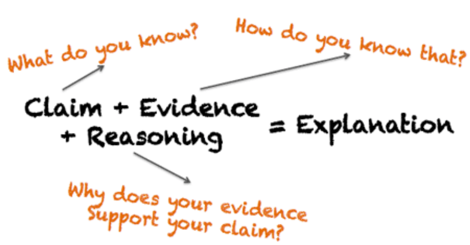
What is the "healthy-range" for your test?

How can animals at Lake Georgette be affected if the results are outside (greater or less than) the "healthy range"?

My results (don't forget your unit!)

Now that you have finished learning about and conducting your test, get back together with your group and see if you can make a claim!

Based on your groups' evidence, use Claims Evidence Reasoning to explain how healthy you think the water is at Blandy Experimental Farm.

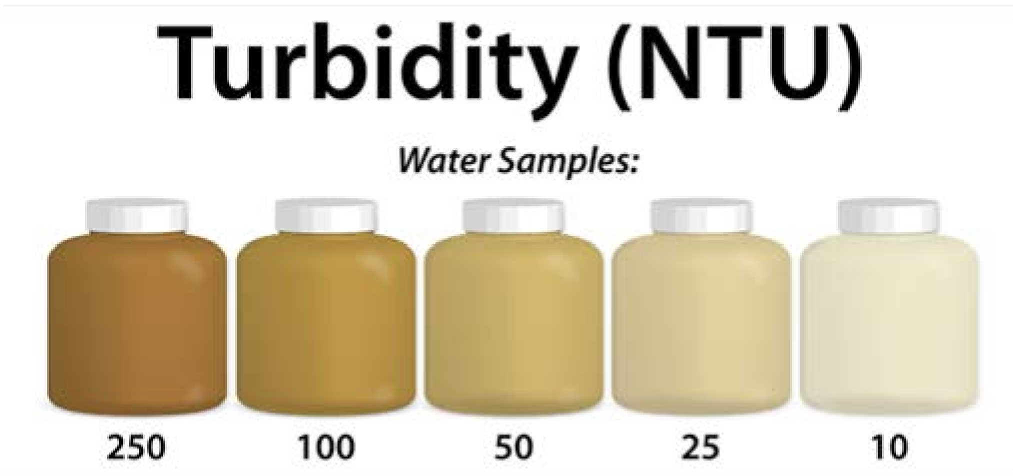


NOAA B-WET Project
2014-2017

TURBIDITY

Congratulations on being chosen as the Turbidity expert! Take a few minutes to read about turbidity below.

Have you ever seen water that you could look right through? How about muddy water where you are not sure where the bottom might be? Turbidity measures how clear or cloudy the water is. The cloudiness of the water is caused by small particles in the water or algal growth and can affect how much light can pass through the water. Since aquatic plants use light to make their food, the amount of light that can pass through the water determines how well they can grow. High turbidity (extremely cloudy water) has resulted in the loss of nearly 90% of the aquatic plants in the Chesapeake Bay.



What is a healthy range for turbidity?

For most aquatic organisms, above 10 NTU* can be unhealthy over time.

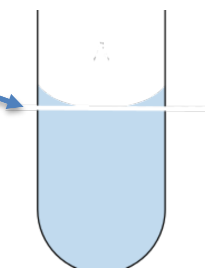
Drinking water for humans <1 NTU*.

*nephelometric turbidity units

To Test Turbidity using the Vernier Probe:

***You will be sharing the LabQuest2 with your DO teammate and Nitrate teammate.*
You will be the one to operate the LabQuest. **

1. Gently stir your bucket of sample water. Use a pipette to fill the vial with the green lid to the top of the line with your sample water. The meniscus should be at the top of the white line.
2. Screw the lid on the vial. Hold the vial by the lid and wipe the outside with a soft, lint-free cloth or tissue.
3. Hold the vial by the lid and place it into the Turbidity Sensor. Make sure the white arrow on the vial and the sensor are lined up. Close the sensor lid.



WAIT… Check that your Dissolved Oxygen and Nitrate teammates are ready to go before the next step.

4. Record the Turbidity reading from the LabQuest2 onto your data sheet.
5. Congratulations! Your test is complete. Remove the vial from the turbidity sensor. <u>Discard the water from the vial in the waste water bucket and put the vial in the used vial box</u>.

TEMPERATURE

Congratulations on being the Temperature Expert in your group! First, let's review why the temperature of the water is so important.

Most aquatic organisms live within a **temperature range of 0-32 ˚C (32 - 89.6˚F)**. The temperature of the water determines how much oxygen can stay in the water. The higher the temperature, the less oxygen found in the water. At higher temperatures, there is more plant growth as well.

Different species have differing and specific ideal temperature ranges. Coldwater fish, such as trout, cannot survive in water above 18 ˚C while warm water fish such as largemouth bass do not become very active until the water temperature rises above 13˚C

Temperature	Examples of Life
Greater than 20°C (warm water)	Much plant life, bass, bluegill, carp, catfish, leeches, caddisfly
Middle range (12-20°C)	Some plant life, trout, stonefly, mayfly, caddisfly, water beetles
Low range Less than 12°C	Trout, caddisfly, stonefly, mayflies all thrive

A fairly steady temperature is most important for aquatic life. Large changes in temperature can cause problems since each organism lives in different temperature ranges. For example, if a lake stocked with bass cools down quickly below 12 ˚C, many of the bass may die. When relatively warmer or colder water enters a body of water, it can cause unnatural changes in the temperature of the body of water. This it is called **thermal pollution.**

Major causes of Thermal Pollution:

- Industries & power plants--- discharge of warm water used to cool hot machinery
- Stormwater---running off from hot urban surfaces such as streets
- Cutting of trees along waterways which otherwise shade the water from the sun
- Increased turbidity (cloudiness)---cloudy water absorbs the sun's rays

Heathy Range for Temperature: 0-32 ˚C (32 - 89.6˚F).

To test Temperature using the Vernier Probe:

1. Use the small beaker to measure close to 200mL of your sample water (it does not have to be exact).
2. Make sure the calculator is turned on.
3. Place the temperature probe in your sample.
4. You should see temperature at the top of the screen.
5. Be sure to write down your temperature reading on your group data sheet.
6. Congratulations! Your test is complete. Remove the temperature probe from the water and place the probe back on the table.

pH

Congratulations on being selected as the pH expert for your group! First, let's learn a little bit about pH.

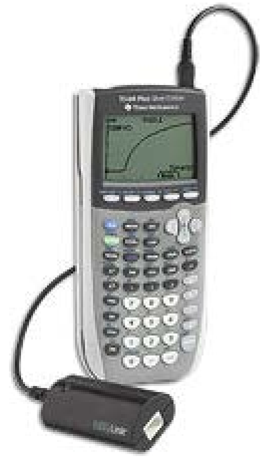
The pH scale is used to determine whether a solution is an acid, a base, or neutral.

- **Acids** have a pH **less than 7**. Common weak household acids are things like vinegar and lemon juice. Strong acids are dangerous; for example, acid from a car battery can burn your skin.
- **Bases** have a pH **greater than 7**. Common weak household bases are things like soap, laundry detergent, and baking soda. Strong bases that you may have in your house are ammonia and bleach. These can burn your skin, also.
- **Pure water** has a **pH of 7** and is considered neutral. The further away the pH is from 7, the stronger the acid or the base.

The pH of water in ponds and streams is very important. Most aquatic animals and plants can only survive in water. If the pH is too high or too low, then these plants and animals cannot survive. The pH of the water changes daily as the amount of oxygen and carbon dioxide in the water changes frequently. Therefore scientists look for a pH range to determine water's health. **The healthy range for most freshwater aquatic organisms is within a pH range of 6.5-9.0**. If the pH falls above or below this or changes rapidly, these organisms will struggle to survive.

To test for pH using the Vernier Probe

1. Use the small beaker to measure out about 200mL of your sample water (it does not have to be exact).
2. Make sure the calculator is turned on. You should see **pH** at the top of the screen of the calculator.
3. Hold the pH probe in your water sample. <u>Do not allow the bottom of the probe to touch the beaker</u>.
4. Record your data in your field journal.
5. Congratulations! Your test is complete. Remove the pH probe from your sample beaker and return to the distilled water beaker.



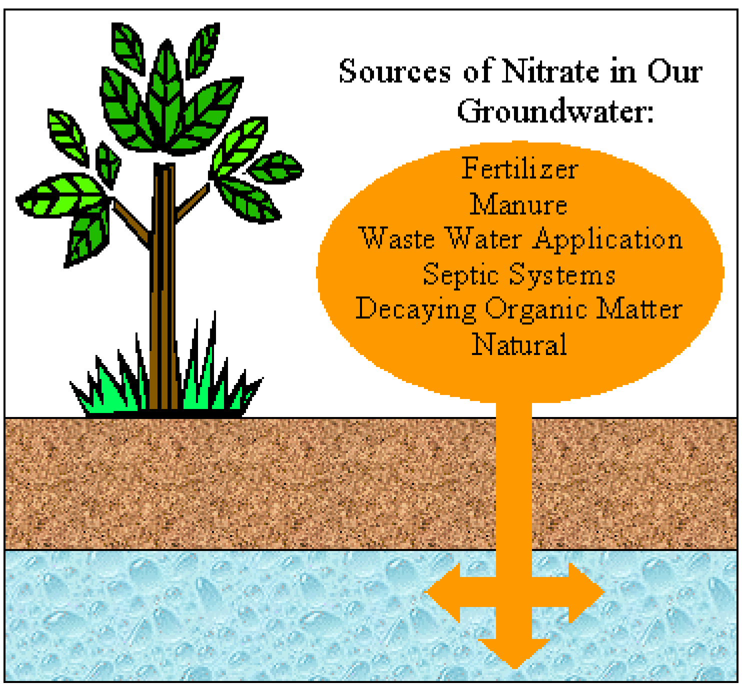
NITRATE & PHOSPHATE

Congratulations on being chosen as the Nitrate and Phosphate expert! Take a few minutes to read about both tests below.

Nitrates and phosphates are essential for plant growth and are found in many fertilizers. While both are very important for plants, excessive amounts cause problems in streams and ponds. The greater the amount of nitrates and phosphates in the water, the faster the algae grow. (Think about a fish tank that hasn't been cleaned in a long time. Do you want our ponds to look like that?) This is called an algal bloom. As the algal bloom grows and algae begin to decompose, dissolved oxygen in the water decreases, leaving little oxygen for the other plants and animals that are dependent on it. High nitrate and phosphate levels are most often caused by fertilizer runoff from farms and yards.

The nitrates in water are measured in parts per million (ppm) or mg/l. For example, if your measurement is 10 ppm, then that means for every **million** water molecules there are **10 nitrate** molecules. **The acceptable/healthy zone for nitrates in pond water is less than 2 ppm.**

The test we are using to detect phosphates are designed to detect amounts greater than what we would expect to occur naturally. Thus, for our test, the **healthy range for phosphate is a reading of NO phosphates**. Your test will determine whether or not there are any excess phosphates in the water.



To Test Nitrates using the Vernier Probe

You will be sharing the LabQuest2 with your Dissolved Oxygen teammate and Turbidity teammate.* ***The teammate in charge of turbidity will be the one to operate the LabQuest2*. ***

1. Use the small beaker to measure out close to 250mL of your sample water. (It does not have to be exact.)
2. Remove the NITRATE probe from the distilled water and blot the tip dry with a Kim Wipe.
3. Place the tip of the probe into your beaker of sample water. <u>Make sure the probe is not resting on the bottom and that the small white dot is underwater</u>. Make sure that no air bubbles are trapped below the probe.

WAIT… Check that your Turbidity and Dissolved Oxygen teammates are ready to go before the next step.

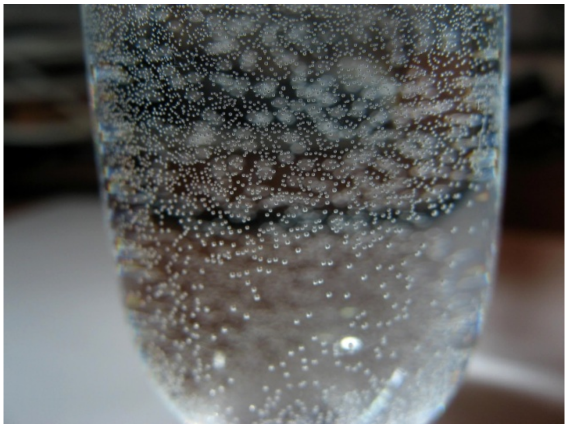
4. You are now ready to collect your data. When the nitrate readings have leveled out (when the numbers are very close and change slowly), record the average for Nitrate.
5. Congratulations! Your test is complete. Remove the Nitrate probe from the water, rinse it with distilled water and place it back in the labeled distilled water container.

To Test for Phosphates

1. Place water in the plastic phosphate vial up to the **'Black'** line.
2. Open the **'phosphate'** powder packet and pour the entire contents into the vial.
3. Cap and gently invert the vial back and forth until the powder dissolves.
4. The water will turn blue if phosphates are present in the water. Hold the vial over the laminated phosphate sheet to compare the color of your sample water with the colored blocks on the sheet.
5. Record your results in your field journal.
6. Once your test is complete, empty the vial contents into the waste water bucket.

DISSOLVED OXYGEN

You are the Dissolved Oxygen Expert for your team! Read on to find out how dissolved oxygen affects water quality and how to test for it using the equipment.



You usually can't tell by looking at water that there is oxygen in it. The oxygen dissolved in lakes, rivers, and oceans is crucial for the organisms living in it. Just like you, aquatic organisms need oxygen to live. Without dissolved oxygen, fish and other aquatic organisms would not be able to 'breathe' and would die! So, to figure out the health of water, you want to find dissolved oxygen in the water. If it is not there, the water is probably severely polluted and is not a healthy habitat for the organisms.

How does oxygen get into water?
Algae and aquatic plants provide O_2 to water through photosynthesis. Water movement over rocks stirs in oxygen from the air to a water body.

What reduces dissolved oxygen levels?

- Warming Temperatures
- Nutrient runoff from fertilizers can cause dissolved oxygen levels to drop
- Organic waste additions

Dissolved oxygen molecules in water are measured in parts per million (ppm) or mg/l. For example, if your measurement is 10 ppm, then that means for every **million** water molecules there are **10 oxygen** molecules. **Healthy lakes and streams have at least 5 mg/L (or PPM*) of dissolved oxygen**. Once the level drops below 5 mg/L, the plants and animals start to suffer. At levels **below 4 mg/L (or PPM),** the water quality is considered poor.

*parts per million

To test for Dissolved Oxygen using the Vernier probe

***You will be sharing the LabQuest2 with your Nitrate teammate and Turbidity teammate. The teammate in charge of Turbidity will be the one to operate the LabQuest2. ***

DO NOT LET THE BOTTOM OF THE PROBE TOUCH ANY PART OF THE BUCKET OR BEAKER. It is very sensitive.

It is Important to Keep stirring the Probe in the water Sample.

1. Use the small beaker to measure out 250mL of your sample water. (It does not have to be exact.)
2. Place the probe into the sample so that the silver dot on the side of the probe is under the water. <u>Make sure the end of the probe does not touch the bottom of the beaker.</u>
3. You are now ready to collect your data. **Keep stirring.**

WAIT… Check that your turbidity and nitrate teammates are ready to go before the next step.

4. When the Dissolved Oxygen readings have leveled out (when the numbers are very close and change slowly), the *LabQuest2* is finished collecting data. Record your D.O. value in your field journal.
5. Congratulations! Your test is complete. Remove the dissolved oxygen probe from the water, rinse it with distilled water, and place back in the distilled water container.

Note: It is important to keep stirring the probe in the water sample. There must always be water flowing past the probe tip when you are taking measurements. If the probe is left still in calm water, reported dissolved oxygen readings will appear to be dropping.

LabQuest 2

If the Labquest screen is dark push the home button to "Wake up"

Dissolved Oxygen

Nitrate

Turbidity