Testing Water Quality in the York River

Grade Level: 7

Subject Area: Life Science

Virginia Standards of Learning: LS. 1, LS. 4, LS. 7

Objectives:
Students will:

- Gain a basic understanding of water quality, why it is important, and how abiotic factors can influence aquatic life
- Test water samples for different factors
- Collect data, organize it into a data table, and make inferences
- Learn about the nature of science by investigating the quality of water in the Chesapeake Bay

Summary:
Students will test water samples collected from the Chesapeake Bay for a variety of factors. They will record their data and use it to figure out where each sample was taken from along the estuarine salinity gradient.

Vocabulary: water quality, estuary, salinity, pH, dissolved oxygen, turbidity, nitrogen, phosphorus

Materials:

For each group you will need (designed for 5 groups of 2-5 students per group):

- Data table (included, hard and electronic form)
- Map of the York River (included, hard and electronic form)
- Vis-à-vis Marker
- One pH tablet, test tube, pipet, and pH instruction sheet in a labeled ("pH") plastic bag (copy of instructions included at the end of this guide)
- One Nitrate tablet, test tube, pipet, and nitrate instruction sheet in a labeled ("Nitrate") plastic bag (copy of instructions included at the end of this guide)
- One Phosphate tablet, test tube, pipet, and phosphate instruction sheet in a labeled ("Phosphate") plastic bag (copy of instructions included at the end of this guide)
- One Refractometer, pipet, and instruction sheet in a labeled ("Salinity") plastic bag (copy of instructions included at the end of this guide)
- One water sample with salinity of about 5 ppt labeled "C"*
- One water sample with salinity of about 10 ppt labeled "A"*
- One water sample with salinity of about 15 ppt labeled "D" *

- One water sample with salinity of about 20 ppt labeled “B” *
- One water sample with salinity different than the other four samples labeled “Unknown” (example: salinity of 0 ppt or 35 ppt)

<u>You will also need:</u>

- Five test vials, five pipets, and one instruction sheet for Fecal Coliform test (each class will test one sample for fecal coliform – not each group) (copy of instructions included at the end of this guide)
- Extra water for each sample in case there are spills
- Two waste jars for tested water from vials (labeled “waste”)
- Extra markers, tablets, pipets, etc.

*The water from the A-D samples needs to follow a salinity gradient. Sample C needs to have the lowest salinity (ideally around 5 ppt), sample A should have the next lowest salinity (ideally around 10 ppt), sample D should be next lowest (ideally around 15 ppt), and sample B should have the highest salinity (ideally ≥20 ppt). Do whatever you need to do to make the samples turn out this way – you can collect a sample with high salinity and then dilute it to “make” the lower salinity samples or you can use aquarium salt to make water samples of different salinities. Just add salt to the water, mix well, and test with a refractometer until you get the desired salinity. The kids will never know what you’ve done! The salinities of the samples also need to be different enough that the students will be able to tell the salinities apart – remember they are not experienced at reading a refractometer. The salinity of the unknown sample needs to be distinct enough from the salinities of the other samples so that the students can tell it came from a different location in the river.

You can manipulate factors other than salinity in the samples as well. If you create your own water using aquarium salt or dilute one water sample, the pH, nitrate, and phosphate levels will all be the same. You can alter the nitrate and phosphate levels in certain samples by adding fertilizer (liquid or powder fertilizer you might use on indoor or outdoor plants), and you can alter the pH of certain samples by adding aquarium chemicals (you can get them at pet stores) or household items like bleach and vinegar.

<u>**Procedure:**</u>

<u>Introduction</u>
** You can use the PowerPoint presentation provided on the included CD during your introduction to this activity.*

1. Give the students some basic background information about estuaries. The Chesapeake Bay and the York River (which they are studying in this lesson) are both estuaries.

   ** An estuary is a partially enclosed body of water where salt water and freshwater mix. Salt water enters an estuary from the ocean and freshwater enters an estuary from rivers and streams. The water inside of an estuary is thus a mixture of salt and freshwater and is called brackish water (it is not as salty as ocean water, but not as fresh as river water).*

Estuaries are characterized by constantly changing conditions. The temperature, salinity (amount of salt), turbidity (amount of sediment or particles in the water), etc. of the water change with the tidal cycle, storms, waves, the amount of rainfall, etc. Plants and animals that live within an estuary are well adapted to deal with these changing conditions. They can often tolerate wide ranges of factors such as temperature and salinity.

2. Discuss water quality with the students.
    a. What is water quality? Ask the students what "good" water looks like, tastes like, smells like. How about "bad" water? Usually the students will say that "bad" water is brown and dirty. But ask them if they can tell just by looking at water if it has chemicals in it. (*No.*)
    b. Discuss the different parameters you might measure if you were testing water quality, what each parameter is, why it is important, and how you measure it (see background information). Let the students try to think of the parameters as you list them on the board.
    c. Ask the students why water quality is important (see background information). Ask the students where their drinking water at home comes from. If they have well water, it comes from ground water, which is water on its way to the Bay. If their water comes from the city it comes from a reservoir, but is still susceptible to contaminants. Healthy river/bay water means clean, healthy water for cooking, cleaning, and drinking.
    d. Ask the students why we should measure water quality (see background information).

3. Discuss safety issues with students. Do not put tablets or water in your mouth. You don't know what is in the water, and the tablets have chemicals in them that are not healthy for human ingestion. Be careful not to spill jars of water. DO NOT pour water from the test tubes back into the jars. It will contaminate the rest of the sample with chemicals from the test tablets. Once the activity is over, you will bring around a "waste" jar for them to dump their test tubes into. The chemicals should not be poured down any drain – remember all drains lead to the Bay. The waste jar will be taken back to CBNERR where it will be properly disposed of.

<u>Activity</u>

1. Students start out with a *Data Table* and a marker. Describe the data table to them, many students have never seen or filled out a data table before.

2. Demonstrate (in general) how to complete the pH, Nitrate, and Phosphate tests to the students. Remind them that the detailed instructions are in their bags and they should read and follow the instructions. A big part of being a scientist is following instructions and paying attention to details.

3. Pass out the pH, Nitrate, and Phosphate test kits to the students and the sample that they will be testing for these factors (Group 1: sample A, Group 2: sample B, Group 3: sample C, Group 4: sample D, Group 5: sample D).

4. Students will complete the pH, Nitrate, and Phosphate tests on their one sample and will record the results on the *Data Table*.

5. Once all students have completed their three tests, remove the pH, Nitrate, and Phosphate test kits. You can go over these results as a class now if you would like. It might be useful to have a data table drawn on the board and write in each group's measurement for pH, Phosphate, and Nitrate.

6. Demonstrate how to use a refractometer.

7. Pass out the salinity test kit to all the groups and give every group samples A-D.

8. Students will test the salinity of all four samples and record it on their *Data Table*.

9. Once all groups have finished testing the salinity of the four samples, pass out the *Map of the York River*.

10. Describe to students that they need to use the data they collected to figure out where each sample came from in the York River – each sample had to come from one of the sites marked in red. The students should write the letter of the sample next to the site they think it came from. Do not tell students to use the salinity measurements right off. Just tell them to look at the map and at the data they collected. Of all the data they collected, what can they use to figure out the sample locations? You can walk around and help the groups by giving them hints – for which factors do they have measurements for all four samples, what factor will definitely vary over space in an estuary, etc. Try to get them to figure out that salinity is their best indicator of where the samples are from.

11. Once all groups have labeled the four sites, pass out the unknown sample to each group. They will test the salinity of this sample, record it on their *Data Table*, and then try to figure out where in the York River this sample came from. It did not come from one of the red-marked sites, but came from either a location between two of the sites, above the first site, or below the last site.

12. As a class test one sample for fecal coliform. (Fecal coliform tests are the most expensive of all the tests you are completing in this activity. It will save you money and resources if each **class** tests on sample instead of each group.) You can have each class test a different sample so that all five samples get tested. You can do this before or after the wrap up. This test must sit for 48 hours before you can see the results, so the students will have to check on it the next time they are in class. Describe to them what fecal coliform is, where it comes from, and its negative effects. Describe to them what a positive and negative test will look like.

    Note: Fecal coliform is a bacterium that comes from human and animal feces. The presence of fecal coliform in the water may not necessarily be harmful; however, it can cause several health problems including ear infections, dysentery, typhoid fever, viral *and bacterial gastroenteritis, and hepatitis A. Fecal coliform is also used as an indicator that other contaminants may be present in the water – it is generally not found alone. The presence of fecal coliform may indicate a problem with the treatment and discharge of sewage.*

Wrap Up

Use either the big York River map or simply hold up one of the maps that the students used to go over the sample locations with the students. Ask them what they used to determine where each sample came from. They should have used salinity measurements. Ask them why they used that measurement or how they knew to use that one. Go over where samples A-D came from – make sure all the groups got each site labeled correctly. At this time you can make it a point to talk about or remind students how salinity varies in an estuary – higher salinity near the mouth of the estuary, lower salinity near the head – and why it varies. Go over where the students think the unknown sample came from.

If you haven't done so already, go over the measurements for pH, Phosphate, and Nitrate for all of the samples. Draw a data table or make a list of the measurements for each sample on the board. Talk about what "normal/good" pH, Phosphate, and Nitrate levels are. If the pH, Phosphate, and Nitrate levels are outside of the "normal/good" range, discuss some ideas as to why that might be and what implications it might have on the Bay and the organisms that live in the Bay. Nitrate and Phosphate values that are high, and pH values that are out of the "normal" range might negatively affect the organisms that live in the water.

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Background Information on Water Quality

The term water quality refers to the quality and the properties of water. When discussing water quality, one is usually referring to how much pollution or dirt is in the water, the salinity of the water, the temperature of the water, and so on. Water quality is important because we drink water, we recreate in the water (swim, eat fish that accumulate pollutants, etc.), and plants and animals need specific water parameters in which to live. Changes in water quality can have significant effects on plants and animals. Measuring water quality is important so we know what is in our water, when it is in the water, where it is coming from, and how we can treat it.

Estuaries are dynamic environments by their very nature. Water quality parameters such as salinity, water temperature, turbidity (or water clarity), pH, and dissolved oxygen can change on a tidal, daily, weekly, monthly, or yearly basis as changes in tides, weather, and rainfall occur. The high degree of variation in water quality in an estuary makes them difficult environments to live in. Aquatic plants and animals that live within an estuary are well adapted to deal with a constantly changing environment.

There are several parameters that should be included when discussing water quality. A few of them are listed below.

Salinity

Salinity is the measurement for the amount of salt in water. The units for salinity are parts per thousand (ppt), which means that for every thousand molecules/parts of water, there are 35 molecules/parts of salt. Ocean water has a salinity of approximately 35 ppt. Freshwater has a salinity of 0 ppt – there is no salt in freshwater. Water that is a mixture between salt and freshwater is called brackish water. Brackish water is the type of water that is found in an estuary. The water in estuaries follows a salinity gradient, with waters closer to the ocean having higher salinities (30-35 ppt) and waters further from the ocean or closer to freshwater streams and rivers having lower salinities (0-5 ppt). Salinity within an estuary can change with the tides, currents, or amount of rainfall. Salinity is important because plants and animals have a certain range of salinities they can survive within. Salinity is a factor that influences where different types of organisms live. Scientists use a data sonde, buoy, or hand held refractometer to measure salinity.

Temperature

Water temperature refers to how hot or cold water is. Temperature can be measured in either degrees Fahrenheit or degrees Celsius. Temperature is an important factor because it can influence where different types of organisms live because organisms have specific ranges of temperature they can tolerate. Temperature is measured using either a data sonde or buoy or a hand held thermometer.

pH

pH measures the amount of hydrogen ions in water. This is the measurement for whether something is an acid or a base. pH ranges from 0-14, with values of 0-6.9 indicating an acid, 7 being neutral, and 7.1-14 indicating a base. There are no units for pH. The pH of water is important because organisms have a certain range of pH they can survive within. pH values outside of this range can be detrimental to the organisms. pH levels higher or lower than "normal" may indicate that there is a pollutant in the water. Scientists use a datasonde or buoy or tablet test to measure pH.

As a loose rule, the pH of water is usually between 6.5 and 8.5. The Virginia Water Quality standard for pH is 6.0-9.0. The following guidelines can be followed when referring to pH measurements and water quality:

6.5-7.5 = excellent
6.0-6.4 and 7.6-8.0 = Good
5.5–5.9 and 8.1–8.5 = Fair
<5.5 and >8.6 = Poor

The guidelines above are for freshwater environments and are from *Mitchell, M.K. and W.B. Stapp. 2008. Field Manual for Water Quality Monitoring. Kendall/Hunt Publishing Company, Dubuque, Iowa.*

Dissolved Oxygen (DO)

Dissolved oxygen (DO) refers to the amount of oxygen dissolved in the water. DO can be measured in two units. Parts per million (ppm) means that for every million molecules/parts of water there are a certain number of oxygen molecules (for example 4 ppm would mean there were 4 molecules/parts of oxygen per million molecules/parts of water). Percent Saturation (% saturation) is the amount of oxygen dissolved in the water sample compared to the maximum amount that could be present at the same temperature. For example, water is said to be 100% saturated if it contains the maximum amount of oxygen at that temperature. A water sample that is 50% saturated only has half the amount of oxygen that it could potentially hold at that temperature. Sometimes water can become supersaturated with oxygen because of rapidly tumbling water. This usually lasts for a short period of time but can be harmful to fish and other aquatic organisms.

Aquatic organisms need DO to survive just as humans and terrestrial animals need atmospheric oxygen to survive. Low DO in water can result from several things, including eutrophication and high water temperatures. Cold water can hold more oxygen than warm water, so when water warms up in summer months it loses its ability to contain high levels of DO. Eutrophication is the condition in which excess nutrients in the water lead to the overgrowth of phytoplankton. When phytoplankton blooms occur as a result of eutrophication, the massive amounts of phytoplankton that die of natural causes sink to the bottom and undergo decomposition. The process of decomposition uses up oxygen from the water, thus depleting DO and causing conditions known as hypoxia (oxygen depleted water) and dead zones (areas where there is not enough oxygen in the water to support life). DO can be measured using a data sonde or buoy or a tablet test.

Aquatic organisms generally cannot survive in waters with DO values lower than 4 ppm. DO percent saturation values of 80-120% are considered to be excellent and values less than 60% or over 125% are considered to be poor. Below are some general guidelines to follow when measuring DO:

DO in ppm:
0-4 = poor (animals generally cannot survive in water with DO less than 4 ppm)
4.1-7.9 = fair
8.0-12.0 = good

DO in % saturation:
This information is from *Mitchell, M.K. and W.B. Stapp. 2008. Field Manual for Water Quality Monitoring. Kendall/Hunt Publishing Company, Dubuque, Iowa*, and is for freshwater habitats.

91-110 = Excellent
71-90 = Good
51-70 = Fair
<50 = Poor

<u>Turbidity</u>

Turbidity is the measurement for the amount of particles (sediment or algae/phytoplankton) in the water or how clear the water is. High turbidity values mean the water is very turbid, has lots of particles in it, or is not very clear. Low turbidity values mean the water is clear and does not have many particles in it. Turbid water is caused when sediments enter the water or become suspended in the water. This is often the result of erosion, run off, phytoplankton blooms, or disturbance of the bottom (such as dredging, wave action, walking on the bottom, etc.). Turbidity is an important parameter of water because underwater plants require clear water so sunlight can reach them and animals need clear water to see in. High amounts of sediment or phytoplankton in the water can also clog the gills of filter feeders, such as oysters, and can suffocate the organisms. Turbidity can be measured using a secci disk, a turbidity meter, a turbidity tube, or datasonde or buoy. The units of turbity vary depending on the method of measurement.

A turbidity reading of 0 NTU (on a turbidity meter) indicates completely clear water. Below are some general guidelines to follow when measuring Turbidity with a turbidity meater (in NTU units) (This information is from *Mitchell, M.K. and W.B. Stapp. 2008. Field Manual for Water Quality Monitoring. Kendall/Hunt Publishing Company, Dubuque, Iowa*, and is for freshwater habitats.):

0-10 NTU = Excellent
10.1-40 NTU = Good
40.1-150 NTU = Fair
>150 NTU = Poor

Pollutants (nutrients, toxics):

There are many types of pollutants in our waters. The term pollutant can include chemicals, litter, and nutrients. Our health and the health of aquatic and terrestrial organisms depends on clean, pollution-free water. To test for pollutants, scientists usually use a niskan bottle to take a water sample and then take the sample back to the lab to be analyzed with special equipment. Some pollutants, such as nutrients can be tested for using a tablet test.

Nutrients are considered a pollutant when they are found in amounts in excess of what would naturally occur in the water. Sources of excess nutrients include fertilizers, septic systems, sewage treatment plants, animal waste, and industrial waste. Much of the nutrients from these sources enter the water when rainwater causes it run off the land and into the water. Two problematic nutrients in the Chesapeake Bay are Nitrogen and Phosphorus. Excess nutrients in the Bay cause a condition known as eutrophication. Eutrophication is when excess nutrients in the water cause the overgrowth of phytoplankton. Phytoplankton blooms make the water turbid, they block out sunlight needed for underwater plants, and they can cause oxygen depletion in the water. When the phytoplankton from a bloom die they sink to the bottom and undergo decomposition. The process of decomposion uses up oxygen from the water, thus depleting DO and causing conditions known as hypoxia (oxygen depleted water) and dead zones (areas where there is not enough oxygen in the water to support life). Phosphate and Nitrogen can be measured either in ppm (parts per million) or mg/L.

As a general rule, Nitrate and Phosphate levels below 1 ppm are considered “good”. Nitrate values >10 ppm in drinking water is considered unsafe. Phosphate and Nitrogen can be measured either in ppm (parts per million) or mg/L. Below are some guidelines to follow when measuring Phosphorus and Nitrogen in mg/L (from *Mitchell, M.K. and W.B. Stapp. 2008. Field Manual for Water Quality Monitoring. Kendall/Hunt Publishing Company, Dubuque, Iowa.* – for freshwater habitats):

Phosphate (mg/L)
0-1 = Excellent
1.1-4 = Good
4.1-9.9 = Fair
>10 = Poor

Nitrate (mg/L)
0-1 = Excellent
1.1-3 = Good
3.1-5 = Fair
>5 = Poor

<u>Data Sheet</u>

Record the data from your water quality tests here.

****Remember to record the units for each measurement!!!**

Group 1

Sample	pH	Nitrogen	Phosphorus	Salinity
A				
B				
C				
D				
Unknown Sample:				

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<u>Data Sheet</u>

Record the data from your water quality tests here.

****Remember to record the units for each measurement!!!**

Group 2

Sample	pH	Nitrogen	Phosphorus	Salinity
A				
B				
C				
D				
Unknown Sample:				

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<u>Data Sheet</u>

Record the data from your water quality tests here.

****Remember to record the units for each measurement!!!**

Group 3

Sample	pH	Nitrogen	Phosphorus	Salinity
A				
B				
C				
D				
Unknown Sample:				

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<u>Data Sheet</u>

Record the data from your water quality tests here.

****Remember to record the units for each measurement!!!**

Group 4

Sample	pH	Nitrogen	Phosphorus	Salinity
A				
B				
C				
D				
Unknown Sample:				

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<u>Data Sheet</u>

Record the data from your water quality tests here.

****Remember to record the units for each measurement!!!**

Group 5

Sample	pH	Nitrogen	Phosphorus	Salinity
A				
B				
C				
D				
Unknown Sample:				

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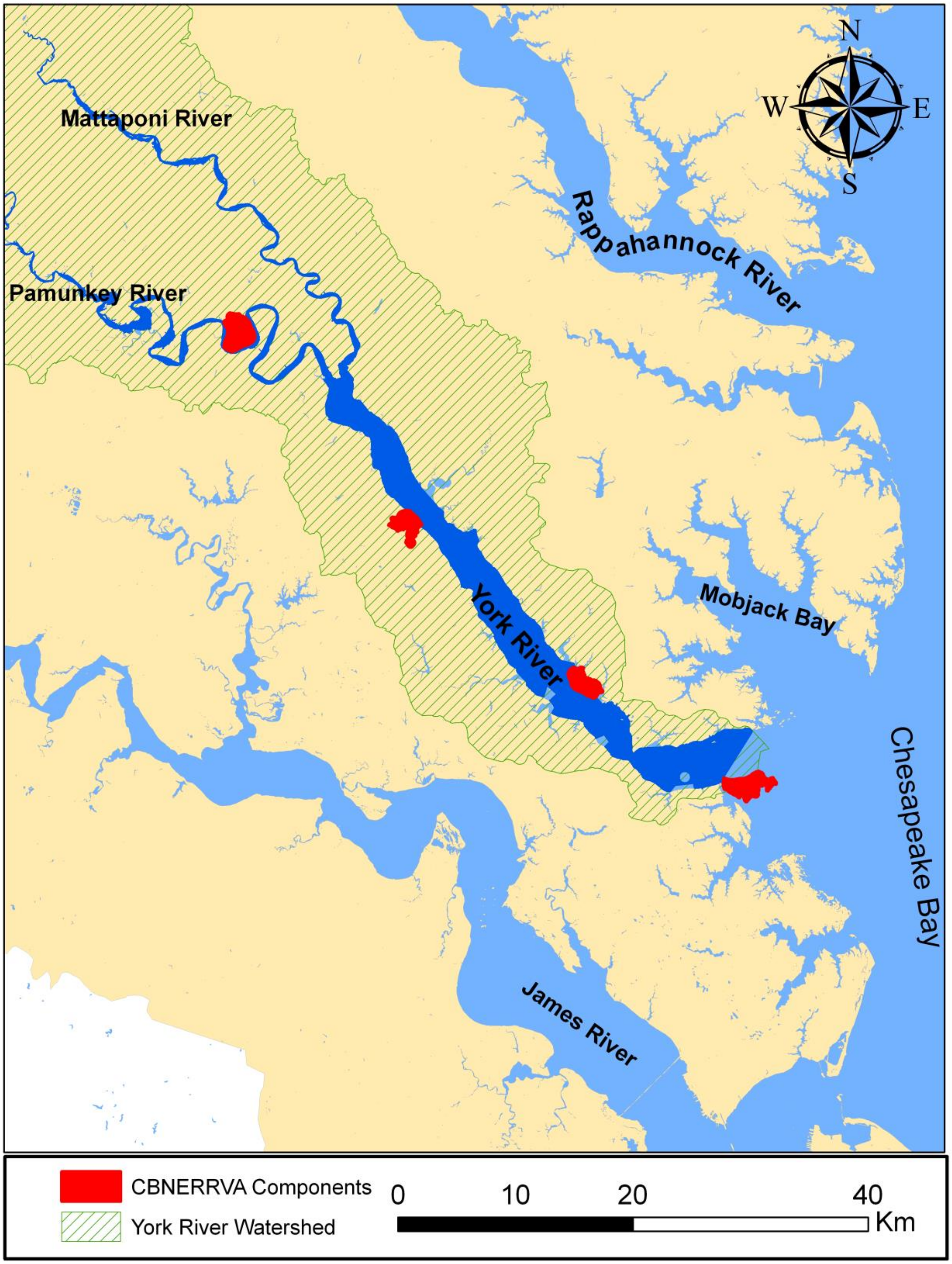
Map of the York River



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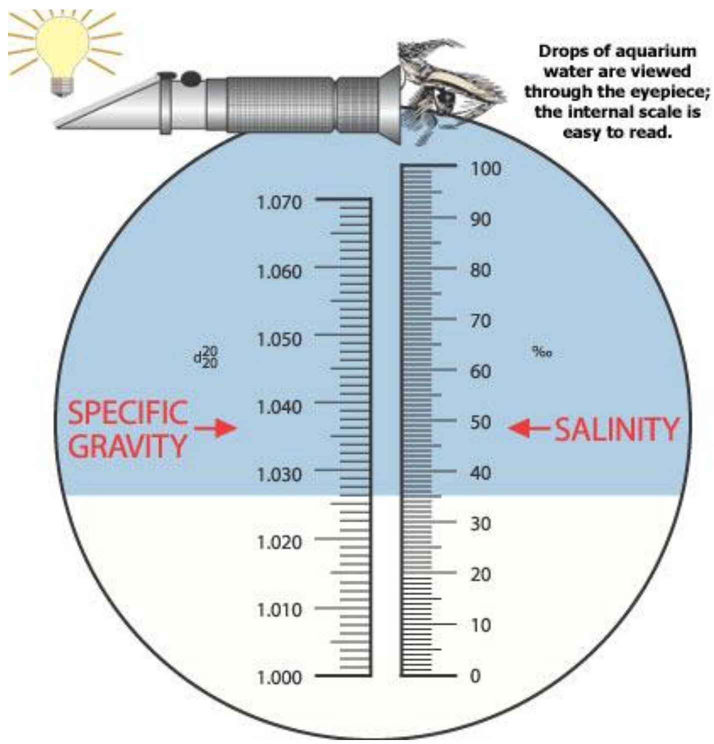
How to Use a Refractometer to Measure Salinity

1. Place 4-5 drops of water on the blue “window” on top of the refractometer.
2. Close the lid. Make sure there are no bubbles under the lid.
3. Point the refractometer towards a light source (sun or inside light).
4. Look through the refractometer like you would binoculars or a microscope. If the scales inside the viewing field are blurry or too small to see you can focus the refractometer by rotating the end of it (the part you are looking through).
5. Inside the refractometer you will see two scales (one on the left, one on the right). You should look at the scale on the right-hand side. Part of the viewing field inside will be blue, part will be white. You want to find the number on the right-hand side scale where the blue and white parts meet (the dividing line between blue and white). This will be your salinity in parts per thousand (ppt). The diagram below shows a salinity of 35 ppt.



6. When you are finished, wipe the water sample off of the “window”, rinse the refractometer with fresh water, and dry with a towel.

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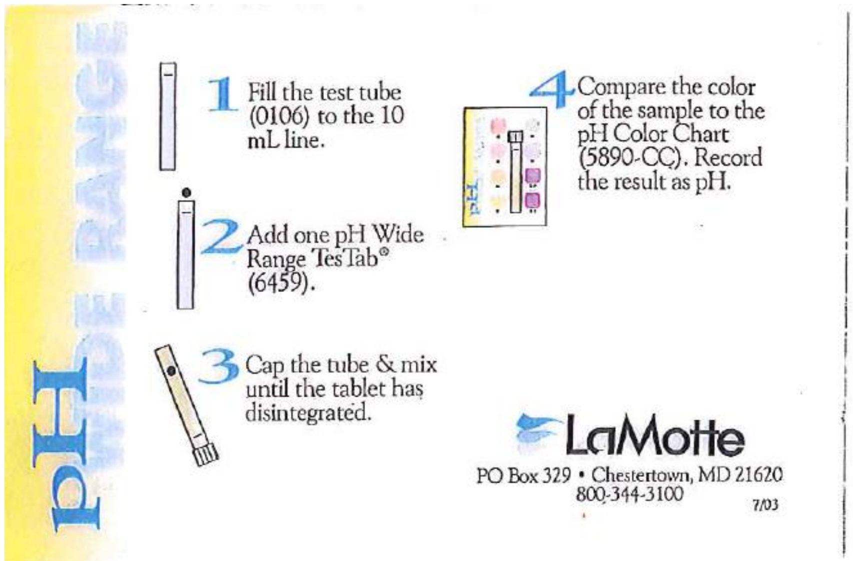
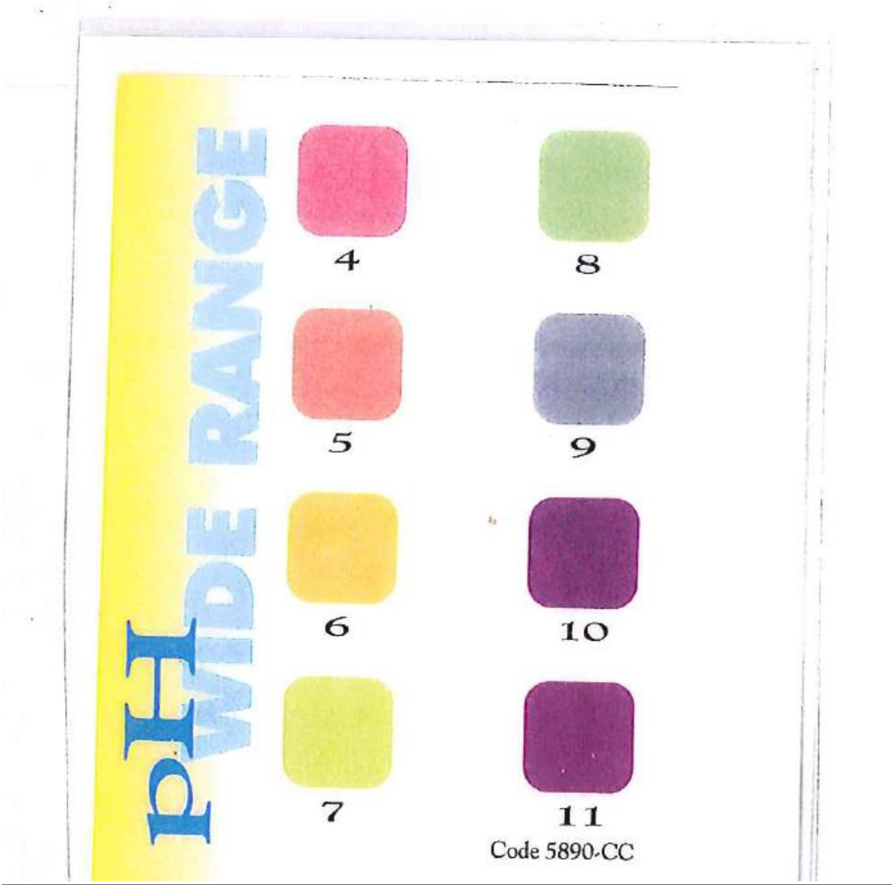
Instructions for Completing pH Tablet Test





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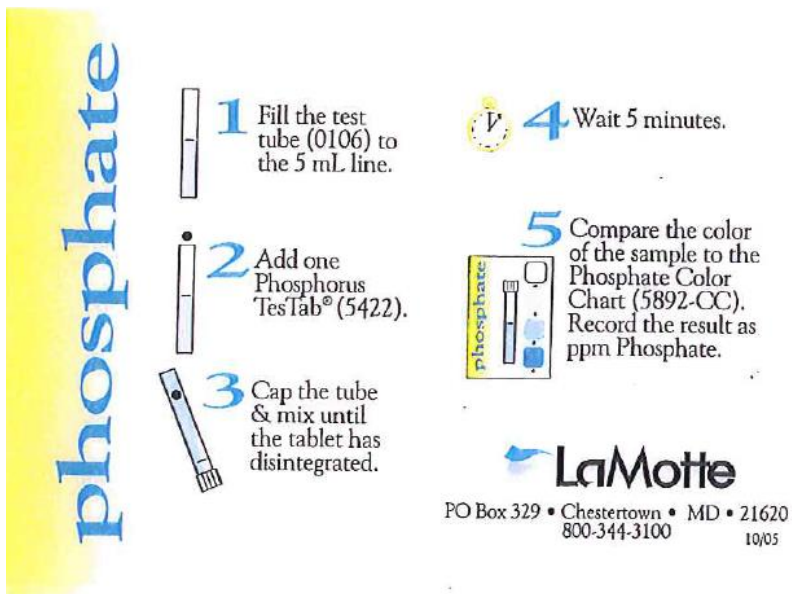
Instructions for Completing Phosphate Tablet Test



phosphate

1 Fill the test tube (0106) to the 5 mL line.

2 Add one Phosphorus TesTab® (5422).

3 Cap the tube & mix until the tablet has disintegrated.

4 Wait 5 minutes.

5 Compare the color of the sample to the Phosphate Color Chart (5892-CC). Record the result as ppm Phosphate.

LaMotte

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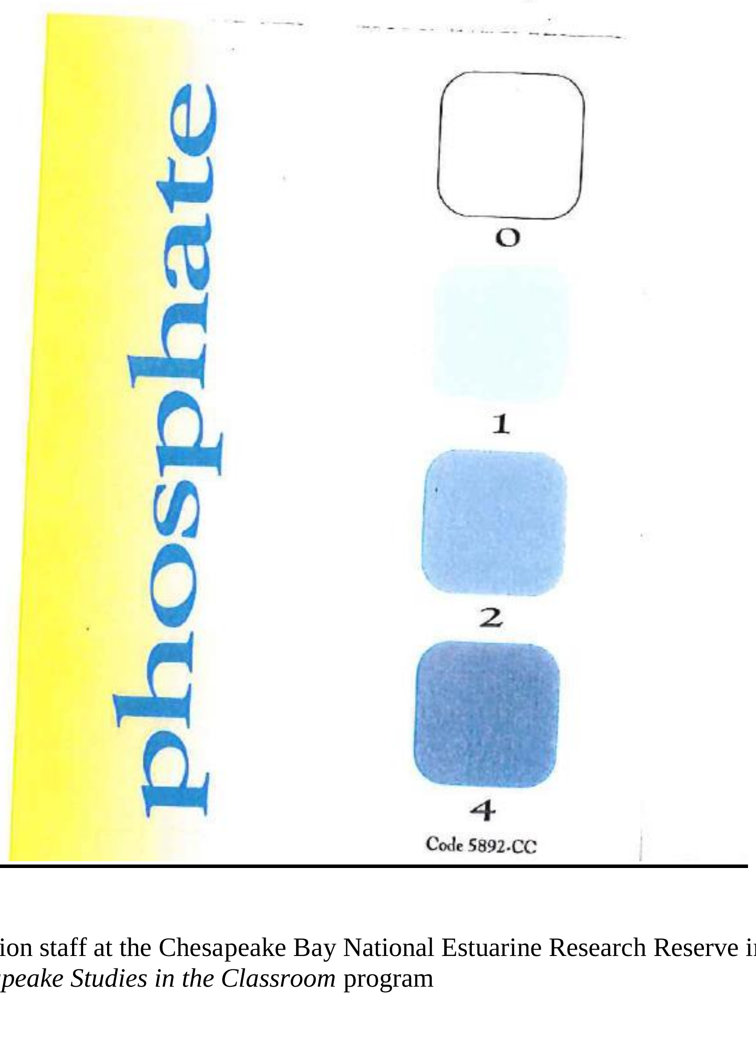

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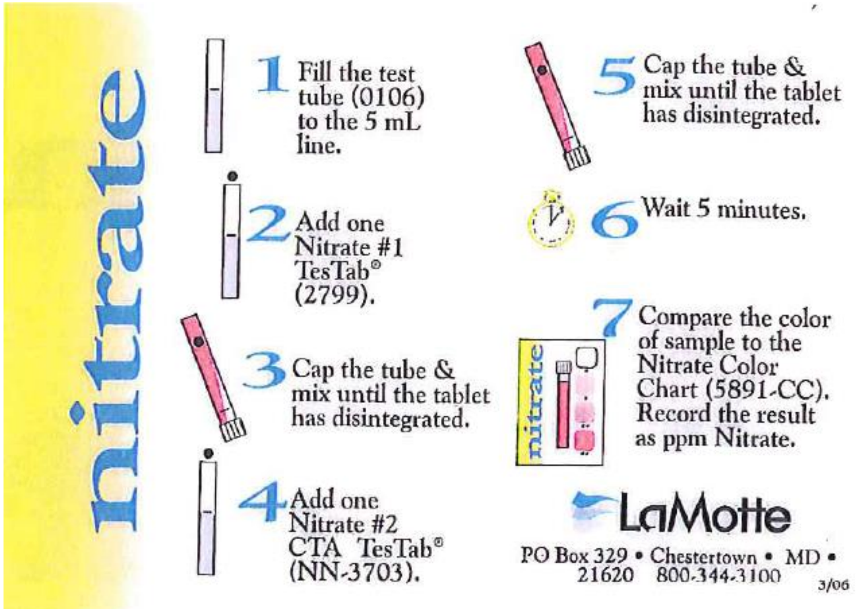
Instructions for Completing Nitrate Tablet Test



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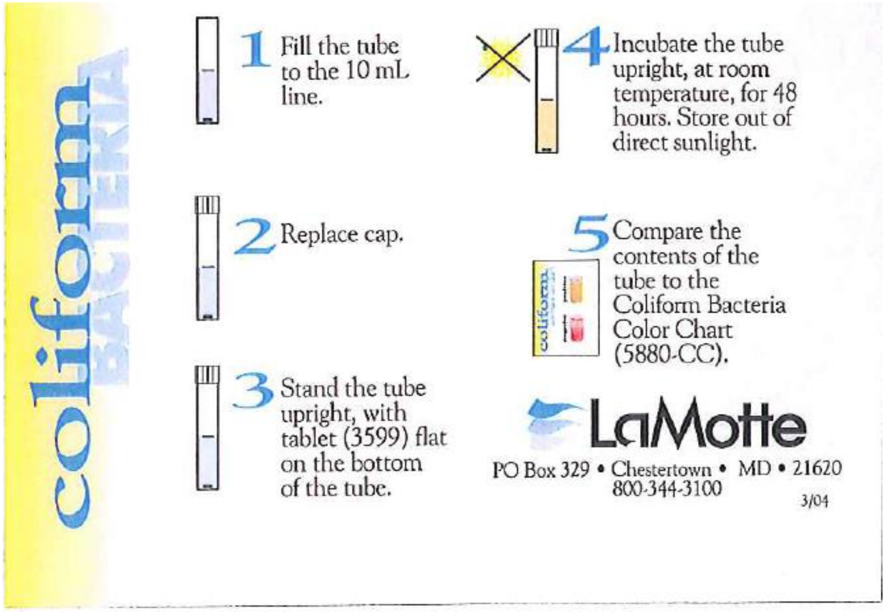
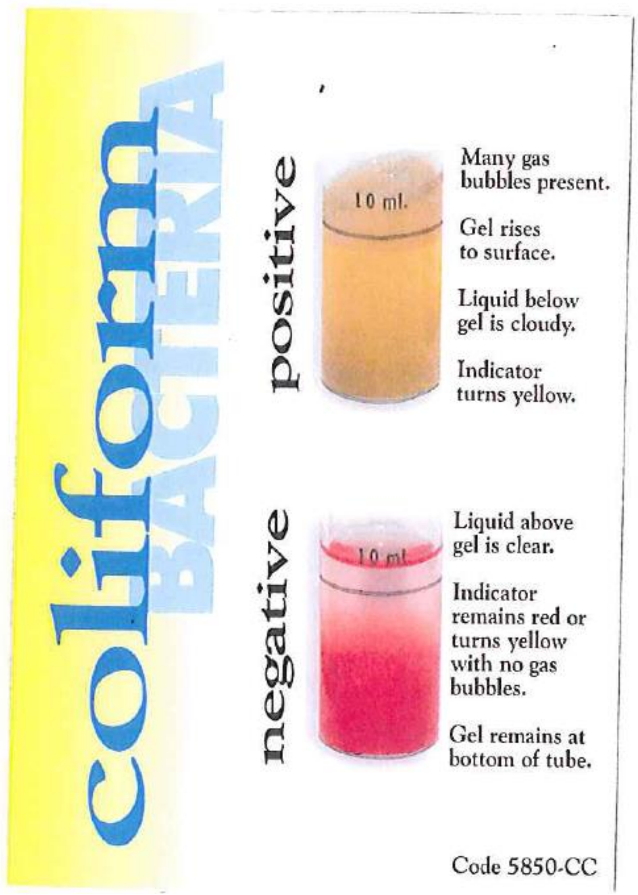
<u>Instructions for Completing Fecal Coliform Tablet Test</u>





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