Date: _____

Your Name: _____

# HUBBARD BROOK RESEARCH FOUNDATION
# ENVIRONMENTAL LITERACY PROGRAM

## NECAP Practice Test
## Task & Answer Booklet

## Grade 11

## Science Inquiry Task

---

## Road Salt Contamination

Prepared by S. Turtle (HBRF) with input from G. Wilson (HBRF), A. Bailey (USFS), P. Benoit (LHS), B, Church (LHS), and K. Murray (LHS). Template created by K. Murray (LHS). Data provided by Dr. G.E. Likens, Principal Investigator of Mirror Lake Chemistry Study, through funding from the National Science Foundation and the A.W. Mellon Foundation.

The Grade 11 mock 'Science Inquiry Task' NECAP question deals with the effect of road salt application to a highway on nearby lakes. Students will graph and analyze sodium and chloride concentration data over time to investigate contamination of lakes. The following resources from the Cary Institute of Ecosystem Studies (CIES) provide additional information for your students should you wish to build on the mock question to create a multi-faceted lesson.

**Content Information**

The first two resources are newspaper articles housed in the Cary Institute's EcoFocus archive, while the second two are PDFs. All are authored by CIES staff.

Salt makes roads safe but can pollute water

Salt nixes ice - at a price

To Salt or Not to Salt? (2005)

Road Salt: Moving Towards the Solution (2010)

**Lessons**

The following lessons come from various curricula developed by CIES staff:

How much salt?

Students will know at what level of salt concentration aquatic organisms are affected, and be able to explain the results of an experiment to determine these levels.

Why is it so salty?

Students will know how the application of road salt impacts water quality and be able to discover the different sources of salt as well as the amount of time that salt stays in the aquatic ecosystem.

Conductivity Connection: Road Salt & Electrolytes

Students will use a conductivity probe to compare conductivity data between sport drinks and stream water containing road salt to identify safe levels of electrolytes in both substances.

Conductivity Connection: Elements, Compounds & The Chesapeake

Students will be able to compare several months of conductivity data from 2 Baltimore streams to an in-class simulation of how chemical compounds affect stream water quality, in order to propose one REAL solution to local water pollution issues.

**Directions:**

This Inquiry Task will measure your ability to think scientifically. This task will ask you to form hypotheses, plan and critique investigations, analyze data, and develop explanations.

First you will read a short story, and then you will make predictions based on the information in the story. You will have 75 minutes to answer the questions about the story.

Write your answers in the spaces provided. Explain the reasons for all of your answers. You may include drawings or labeled diagrams to help explain your answers.

| Part 1: Planning an Investigation. | Part 2: Evaluating Explanations and Making Predictions. | Part 3: Developing Explanations and Applying What You Learned |
|---|---|---|

Word Bank

| | |
|---|---|
| **Lake watershed** | Area of land that drains into a lake. |
| **Ion** | An atom that has a positive or negative charge because it has fewer or more electrons than protons. |
| **Cation** | A positively charged ion. |
| **Anion** | A negatively charged ion. |
| **Hectare** | An area of 10,000 square meters. |
| **Sodium** | symbol Na, atomic number 11, atomic mass 22.99 |
| **Chlorine** | symbol Cl, atomic number 17, atomic mass 35.45 |

Read the story below.

## Road Salt Contamination

The New Hampshire highway department is going to lengthen Interstate 93 (I 93) through a northern New Hampshire town to help reduce the number of large trucks driving on the town's narrow main street. The plan is for the road to be open in three years. The road will be constructed within the watershed of two lakes that are used for recreation purposes and as wildlife refuges. Students from the local high school are concerned that highway runoff will be contaminated with road salt and that this runoff will be transported through nearby streams to the lakes hurting the water quality.

The students collect information of the physical characteristics of the two lakes and their watersheds and organize this information into the table below. They used maps to determine the percentage of incoming stream water that may be contaminated by road salt. They also determined the surface area and average temperature of each lake.

Students learn that road salt used by the highway department contains primarily sodium chloride (NaCl). They also learn that on average the highway department uses approximately 18 tons of road salt for every lane mile per year to keep the interstate clear of snow and ice. They remembered from chemistry class that sodium chloride breaks apart into the ions sodium ($Na^+$), a cation, and chloride ($Cl^-$), an anion, when dissolved in water. They also remembered that chloride was a heavier element compared to sodium.

Students decide to monitor the sodium and chloride concentrations of the two lakes starting this year, three years before the road opens, to determine if they become contaminated by road salt after the highway is completed.

**Table 1. Physical characteristics of Lake A and Lake B**

| Lake | % of incoming streamwater potentially contaminated by road salt | Lake surface area (hectare*) | Average lake depth (m) |
|---|---|---|---|
| LAKE A | 10.0 % | 11.5 | 12.1 m |
| LAKE B | 5.0 % | 14.7 | 12.7 m |

*1 hectare = 2.47 acres = 10,000 meters$^2$



GO ON

**Part I**
**Planning Investigations**

1. After examining the data in Table 1, provide an explanation for why the students think they should study both lakes instead of just one.

2. No salt will be used on the road until it is complete. Explain why it is important to start collecting data three years before the highway is even completed.



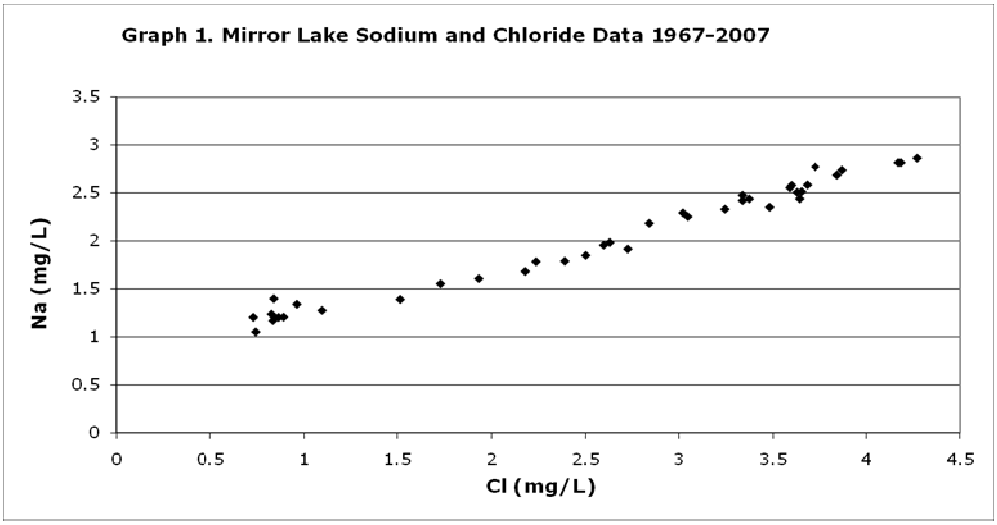
GO ON

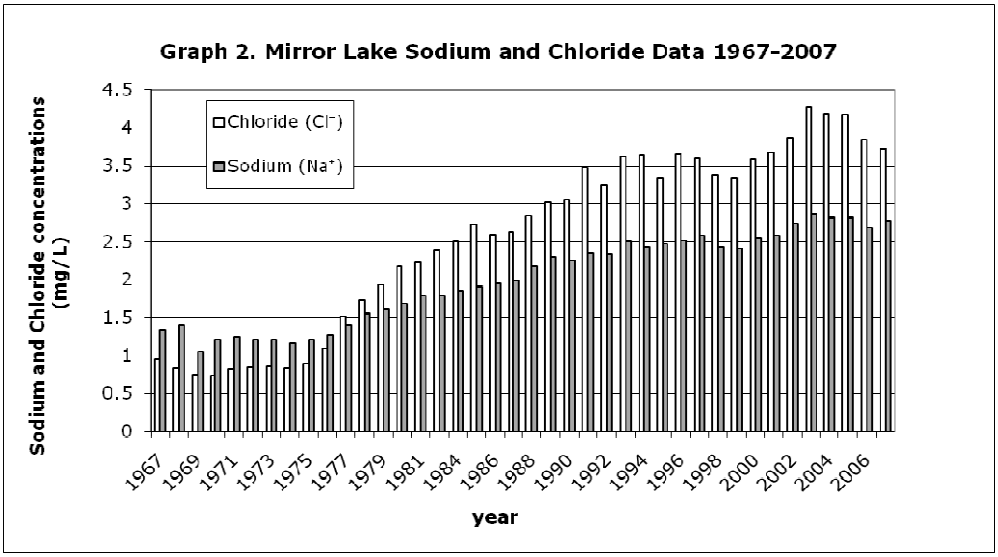
## Part 2
## Evaluating Explanations and Making Predictions

The students use the internet to learn if other NH lakes have been contaminated by sodium and chloride in road salt from highway runoff. They found data describing sodium and chloride concentrations and physical characteristics from the Hubbard Brook Ecosystem Study at Mirror Lake. Interstate 93 runs through the watershed of this lake. They found data for Mirror Lake from 1967 to 2007. They also learned that Interstate 93 opened in 1970. This data will help them predict what might happen to Lakes A and B.

The students organized the sodium and chloride data into the graphs below.

**Graphs 1 and 2: Long term sodium and chloride data for Mirror Lake. Hubbard Brook Experimental Forest, Woodstock, NH. (Likens, G. E.)**






GO ON

3. Which graph best represents the change in sodium and chloride concentration on water quality over time? Explain why the graph you chose best represents the data.

The students organized the physical data from all three lakes into Table 2 so they could make comparisons.

**Table 2. Physical characteristics of Mirror Lake**

| Lake | % of incoming streamwater potentially contaminated by road salt | Lake surface area (hectare) | Average lake depth (m) |
|---|---|---|---|
| MIRROR LAKE | 3.0 % | 15 | 11.0 m |
| LAKE A | 10.0 % | 11.5 | 12.1 m |
| LAKE B | 5.0 % | 14.7 | 12.7 m |



GO ON

4. For this question, use the concentration of sodium and chloride data collected at Mirror Lake and the data describing the physical characteristics of Lake A and Lake B. Form a hypothesis predicting the effect of highway runoff on the sodium and chloride concentrations of the Lakes A and B. (Be sure to include if your predictions are the same for both lakes.)

**Part 3**
**Developing Explanations and Applying What You Learned**

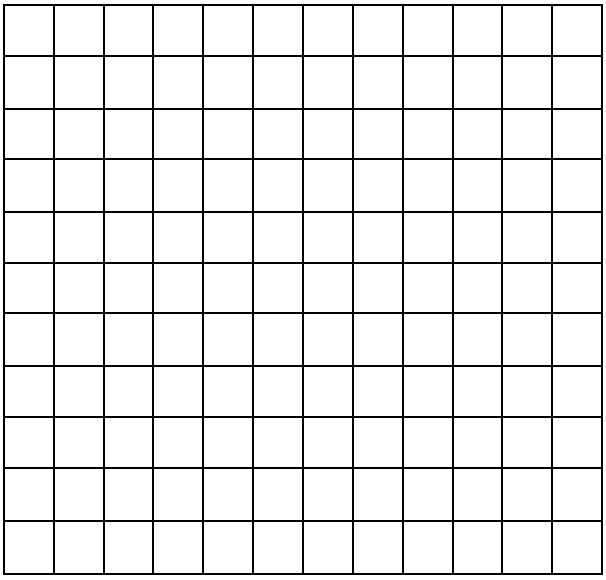
**Directions:** Use the data from Table 2 (on page 6) and Table 3 (below) to answer questions 5, 6, 7 and 8.

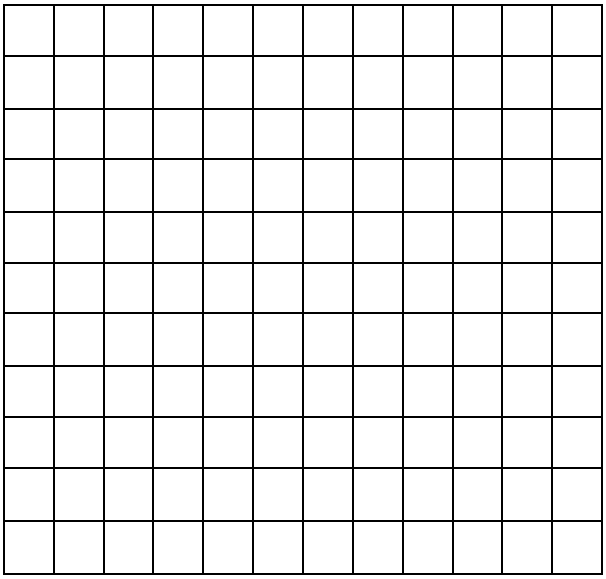
Students from the high school begin the project. Water chemistry data is collected for 6 years. The sodium and chloride data are displayed in the table below. The road opens in 2013.

**Table 3. Sodium and Chloride concentrations for Lake A and Lake B.**

| Year | Sodium (mg/L) | | Chloride (mg/L) | |
|---|---|---|---|---|
| | Lake A | Lake B | Lake A | Lake B |
| 2010 | 1.1 | 1.2 | 0.7 | 0.8 |
| 2011 | 1.4 | 1.3 | 0.9 | 0.8 |
| 2012 | 1.2 | 1.2 | 0.8 | 0.7 |
| 2013 | 2.2 | 1.7 | 3.5 | 2.2 |
| 2014 | 2.4 | 1.8 | 4.3 | 2.5 |
| 2015 | 2.9 | 1.9 | 4.7 | 2.8 |

5. Organize the data from Table 3 into a sodium graph and a chloride graph to show how the concentrations change over time in Lakes A and B. Make sure you include appropriate labels (title, X-axis, Y-axis, legend, etc.)







GO ON

GO ON

6. Explain how the results support or did not support the hypothesis predicting the effect of road salt on the sodium and chloride concentrations of Lake A and Lake B? Use the data from Table 3 to support your answer.

7. Describe the difference in chloride concentrations for Lakes A and B using the data from Table 3. Use the physical characteristic data from Table 2 (page 3), to explain why these concentrations are different between the two lakes.

8. The data from Mirror Lake and from the students' study of Lake A and Lake B indicate that chloride contamination is generally higher than sodium contamination in both lakes. Give a possible reason why these chemical concentrations might be different. Use information provided in the beginning narrative to help.

**X X X X X X X X**


Note: The water budget of lakes has been simplified for this exercise. Water enters lakes via precipitation directly into the lake, surface runoff directly into the lake (not via a stream), stream water, and groundwater. For the purposes of this exercise, we just used stream water inputs in order to keep the focus on the data inquiry.