End-of-Unit Synthesis Activity: The Salt Problem

This activity addresses most of the learning goals from this unit. It requires students to work in groups to apply the major concepts related to groundwater and watersheds to solve a common problem.

This activity serves as a synthesis of many of the objectives in the unit. It is intended to be a culminating experience that allows students to apply many of the groundwater and watershed concepts to a single problem. This activity is also an end-of-unit assessment opportunity. However, the teacher should provide guidance and take advantage of teaching opportunities during the task. In other words, if students are having trouble, treat this activity as a learning opportunity rather than as a test.

Overview:
Students are given a map and cross-section of a hypothetical location and asked to use the maps and cross-sections to answer questions. Students can work in groups to solve the problems, but must write their own explanations.

Learning Goals
The following table shows the unit objectives and unit assessments addressed by this activity.

Objective	Assessment
O3 Use an understanding of watersheds to explain how water moves through river systems. (using)	A3 Given a map of Michigan, explain how a pollutant would affect different locations.
O4 Apply an understanding of permeability to explain the movements of groundwater through confined and unconfined aquifers. (using)	A4 Given a stratigraphic cross-section of a groundwater system, explain how a pollutant will affect different aquifers and wells.
O5 Develop/build models that explain how water moves through a groundwater system and watershed (constructing).	
O6 Explain how water cycles through the natural and engineered systems (telling the story)	
O7 Build/develop a model to investigate different sources for and methods for cleaning up groundwater pollution. (constructing)	A7 Present a model and describe the source of pollution and clean-up method used.
O8 Evaluate land use scenarios for potential groundwater and surface water pollution sources and impacts. (reflecting)	A8b Given several land use proposals for a specific location, explain the impacts of the proposed action on runoff and infiltration.
IO2 Be able to make sound interpretations of data and experiences.	
IO5 Develop shared understanding through small and large group discussions.	

Materials:

Per Student	Per Group	Per Class
Student Assessment Resource Sheet		
Map of Sparkling Lake		Map of Sparkling Lake Overhead Transparency
Map of Sparkling Lake Showing Groundwater Contamination		Map of Sparkling Lake Showing Groundwater Contamination Overhead Transparency
Cross-Section of Sparkling Lake		Cross-Section of Sparkling Lake Overhead Transparency
Cross-Section of Sparkling Lake Showing Groundwater Contamination		Cross-Section of Sparkling Lake Showing Groundwater Contamination Overhead Transparency
	Materials for making a poster.	

Teacher Directions

1. Provide all students with materials.
2. Present an overview of the task, using the overhead transparencies. The following paragraph is included in the student packet:

The town of Harper (population 10,000 people) is a small, working class town in the Mid-West. Harper is a local business center, serving the small farms in the area. Many people in Harper have jobs in the local businesses. Outside Harper there are many small farms.

People here work hard and play hard. During the weekend, families like to fish and hunt in the areas around Sparkling Lake and Trout Lake. Families take hikes and picnics in the area. During the winter, Sparkling Lake is a popular ice-fishing spot.

Harper is located in an area that gets lots of snow in the winter. The state Department of Transportation (DOT) keeps the roads in the area clear so that people can drive, get to their jobs, and go about their daily business during the winter. The state often spreads salt on the roads to melt the ice and make the roads safer to drive on. The state DOT maintains a snowplow shed and salt storage facility on County Road M.

Harper gets its drinking water from the groundwater. Three important wells are located in the Sparkling Lake area. These wells are labeled on the maps and cross-sections as X_1, X_2, and X_3. Two of these wells are fairly shallow (X_1 and X_3) and take water from the Glacial Aquifer. Well X_2 is deeper and takes water from the Sandstone Aquifer

Recently, water quality measurements from Sparkling Lake show increasing concentrations of salt in the water. Salt is harmful to fish and other aquatic plants and animals. The town of Harper and the state is worried that the salt used on the roads may be part of the problem. The town of Harper has hired you and your group to analyze the situation.

3. Point out that the line cross-sections match the maps along line A-A'.
4. Remind students how to fold the maps and connect them to the cross-sections to show a block-diagram. For this activity, students will have to fold the maps along the line A-A'.
5. Remind students to read the directions to answer the questions.
6. Remind students to use their best small-group working strategies to complete the activity as a group.
7. Provide groups with guidance and answer questions to help them understand the task.
8. Question 9 requires students to prepare a poster.

Directions from Student Page:

> Prepare an informational poster that will explain the salt contamination problem at this site and your proposed solution. Assume that your audience does not know how salt contamination happens.

Rubric for Assessment

Question #	Answer we are looking for	Adequate Answer	Inadequate Answer
1 What information do you think your group will need to analyze this situation?	Students should say they need to know what it looks like underground, and a map and cross-section showing where the contamination is located. They might tell you they need test-wells drilled to find out where the contamination is.	Correctly identifies that they need maps and cross-sections and data of where the salt is in the ground.	Does not identify either maps, cross-sections or salt data.
2 Where would you expect to find salt contamination (V, W, Y, Z)? Be sure to explain why you would expect to find salt contamination in each spot and cite your evidence for your answer.	V: You would not find salt contamination at V because there are no rivers flowing into Muskelundge Lake. Also, the isoconcentration lines indicate that the groundwater is flowing away from Muskelundge Lake. W: You would probably find some salt contamination in Trout Lake because County Road M crosses Rock Creek and the Blue River. Rock Creek flows into the Blue River and the Blue River flows into Trout Lake. Snow contaminated with salt would melt into both rivers and flow into Trout Lake. Y: You would probably find salt contamination in Sparkling Lake because the iso-concentration lines for the salt contamination indicate that the salt contamination plume in the groundwater is flowing from the DOT salt storage shed towards the lake. The iso-concentration lines intersect the lake, indicating that contaminated groundwater is recharging into the lake. There is also the possibility of overland flow from Highway 51 into Sparkling Lake. Z: You would find salt in this location because contaminated water flowing out of Sparkling Lake via Clear Creek and out of Trout Lake would both flow past point Z. There is also the possibility of overland flow from Highway 51 to point Z.	Correctly identifies which points would be contaminated. Partial explanations indicate some understanding of the direction of surface water flow and the direction of groundwater flow.	Does not correctly identify which points would be contaminated &/or explanations do not correspond with data.

Question #	Answer we are looking for	Adequate Answer	Inadequate Answer
3 Which aquifers are currently contaminated by the salt? Explain how the aquifers are contaminated. Explain your answer and cite evidence for your answer.	The salt iso-concentration lines indicate that the Glacial Aquifer is currently contaminated with salt. The salt is dissolved in melting snow from the road. It seeps into the pore spaces of the sediment next to the road when it rains or as the melting snow seeps into the ground. Near the DOT snowshed, rain falling on the salt pile could dissolve salt and carry the salt into the ground.	Correctly identifies the Glacial Aquifer as contaminated but does not provide evidence. Partial explanations of how the aquifer got contaminated are correct.	Does not identify the correct aquifer contaminated and/or does not provide correct explanations for how the aquifer got contaminated.
4 Will the salt contamination affect the Sandstone Aquifer? Why or why not? Be sure to site evidence for your answer.	No, the salt will not affect the Sandstone aquifer because the shale layer is impermeable. Therefore, contaminated water will not seep into the Sandstone Aquifer unless it moves through the well at X_2.	Identifies impermeable layer but provides only a partial (although correct) explanation.	Incorrectly answers the question or does not provide any evidence.
5 A & B Explain at least 2 ways that the salt could get into Sparkling Lake at Y. Explain the source & the process.	Salt could get into Sparkling Lake through overland flow of contaminated water from Highway 51. Salt could also seep into Sparkling Lake from contaminated groundwater flowing into the lake from underground.	Identifies only 1 way correctly.	Does not identify any correct ways.
5 C & D Explain at least 2 ways that the salt could get into the Glacial Aquifer. Explain the source & the process.	Salt can seep into the Glacial Aquifer from the road or salt shed when snowmelt or rainwater with dissolved salt seeps into the ground. Salt can also seep into the glacial aquiver from rivers and lakes that are contaminated with salt.	Identifies only 1 way correctly.	Does not identify any correct ways.

Question #	Answer we are looking for	Adequate Answer	Inadequate Answer
6 Explain whether or not the salt would get into the drinking water at the following locations. X1, X2, X3	X1 is currently drawing water from below the salt contamination plume. However, the contamination plume will likely seep deeper over time and reach the bottom of the well. Also, well draw down could contribute to pulling contaminated water into the well. X2 is in the Sandstone Aquifer, which is below and impermeable layer. Salt will not contaminated this aquifer. X3 - It appears that this well is up-gradient from the salt plume. The salt contamination is moving away from this well.	Correctly identifies salt contamination but provides only partial (correct explanations).	Does not correctly identify which wells could be contaminated or has missing or incorrect explanations.
7 Which location do you think would be the best location for the salt storage pad (υλ ν)?	Site λ might be the best location because it is furthest from surface water sources. However, it would also have the confounding effects of two nearby roads also shedding salt-contaminated water. Any new pads would need to be sheltered and lines to prevent runoff and seepage of salt into the groundwater. (Note: other answers may be acceptable if good reasons are provided)	Provides a site with partial explanation.	No explanation/reasons provided for site selection.
8 Propose a potential course of action for cleaning up the salt contamination and limiting future salt contamination of the surface and groundwater supply	Many answers are acceptable as long as the explanations and reasons draw upon the concepts learned in the unit. Example: Retro-fit the DOT salt shed so that it has a roof to keep rainwater from falling on the salt, dissolving it and sending contaminated water into the surface and groundwater. Include a pad so that salt-contaminated water will not seep into the ground. Salt water from wells could probably be treated to make it drinkable. The DOT could switch to gravel to use on roads instead of salt. This would reduce the salt dissolved into the water. A more expensive treatment would be to install extraction wells near the DOT storage shed, then extract and treat contaminated water before returning it to the system.	Provides only partial explanations	Provides not explanation.

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Name:_____ Period: _____

End-of-Unit Synthesis Activity: The Salt Problem

Purpose: You have been learning a lot about watersheds and groundwater. Now it is time to put together all that you have learned to solve a problem that is common in our area.

Directions:

1. Read the introduction below.
2. Lay out the following maps and cross-sections
   A & B go together
   A. Map of Sparkling Lake
   B. Cross-Section of Sparkling Lake

   C & D go together
   C. Map of Sparkling Lake Showing Groundwater Contamination
   D. Cross-Section of Sparkling Lake Showing Groundwater Contamination
3. Fold both maps along the line A-A'. The cross-section for each map fits along line A-A'. If it helps you, you may put the maps and cross-sections together to make a block diagram, as we have done in previous activities in this unit. However, you will need to see the entire map to complete the tasks.
4. Read the questions.
5. Work as a group to answer the questions.
6. Each person must write his or her own answer to the questions.

Introduction

The town of Harper (population 10,000 people) is a small, working class town in the Mid-West. Harper is a local business center, serving the small farms in the area. Many people in Harper have jobs in the local businesses. Outside Harper there are many small farms.

People here work hard and play hard. During the weekend, families like to fish and hunt in the areas around Sparkling Lake and Trout Lake. Families take hikes and picnics in the area. During the winter, Sparkling Lake is a popular ice-fishing spot.

Harper is located in an area that gets lots of snow in the winter. The state Department of Transportation (DOT) keeps the roads in the area clear so that people can drive, get to their jobs, and go about their daily business during the winter. The state often spreads salt on the roads to melt the ice and make the roads safer to drive on. The state DOT maintains a snowplow shed and salt storage facility on County Road M.

Harper gets its drinking water from the groundwater. Three important wells are located in the Sparkling Lake area. These wells are labeled on the maps and cross-sections as X_1, X_2, and X_3. Two of these wells are fairly shallow (X_1 and X_3) and take water from the Glacial Aquifer. Well X_2 is deeper and takes water from the Sandstone Aquifer

Recently, water quality measurements from Sparkling Lake show increasing concentrations of salt in the water. Salt is harmful to fish and other aquatic plants and animals. The town of Harper and the state is worried that the salt used on the roads may be part of the problem. The town of Harper has hired you and your group to analyze the situation.

Name:_____ Period: _____

Questions:

1. What information do you think your group will need to analyze this situation?

2. Surface Water Salt Contamination
   A. Using the maps, where would you expect to find salt contamination (V, W, Y, Z)?
   B. Explain why you would expect to find salt contamination in each spot and cite your evidence for your answer.

Map Location	**Contamination? (Yes or No)**	**How did the contamination get there?**	**How do you know? (Evidence)**
Example: W	Yes	From Blue River and Rock Creek	County Road M crosses both rivers. Salt in snow on County Road M would run-off into the rivers. The rivers would flow into Trout Lake.
V			
Y			
Z			

3. Aquifer Contamination
   A. Which aquifers are currently contaminated by the salt?
   B. Explain how the aquifers got contaminated. Cite evidence for your answer.

Aquifer	**Contaminated? (Yes or No)**	**How do you know? (Evidence)**
Example: Limestone Aquifer	No	
Glacial Aquifer		
Sandstone Aquifer		

4. Sandstone Aquifer
   A. Will the salt contamination affect the Sandstone Aquifer? Yes or no? _____

   B. Why or why not? Be sure to site evidence for your answer.

Why?	**Evidence**

5. Groundwater-Surface Water System
   A. Explain 2 ways that the salt could get into Sparkling Lake at Y.
   B. Explain the source & the process.

How could salt get into Sparkling Lake?	**Source - Where did it come from?**	**Process - How did it get there?**
1.		
2.		

C. Explain at least 2 ways that the salt could get into the Glacial Aquifer.
D. Explain the source & the process

How could salt get into the Glacial Aquifer?	Source - Where did it come from?	Process - How did it get there?

6. Drinking Water System
   A. Explain whether or not the salt would get into the drinking water at the following locations. If the water could get into the drinking water, explain how. If the salt will not get into the drinking water, explain why. Be sure to cite evidence for your answers.

	Yes or No?	How	Evidence
Could the salt get into the well at X_1?			
Could the salt get into the well atX_2?			
Could the salt get into the well atX_3?			

7. Land Use
   A. The Department of Transportation (DOT) wants needs another salt storage pad because there are more new roads in the area and the people need safe ice-free roads in the winter. Which location do you think would be the best location for the salt storage pad (♦λ ν)? _____
   B. Explain your reasoning and cite evidence to support your position.

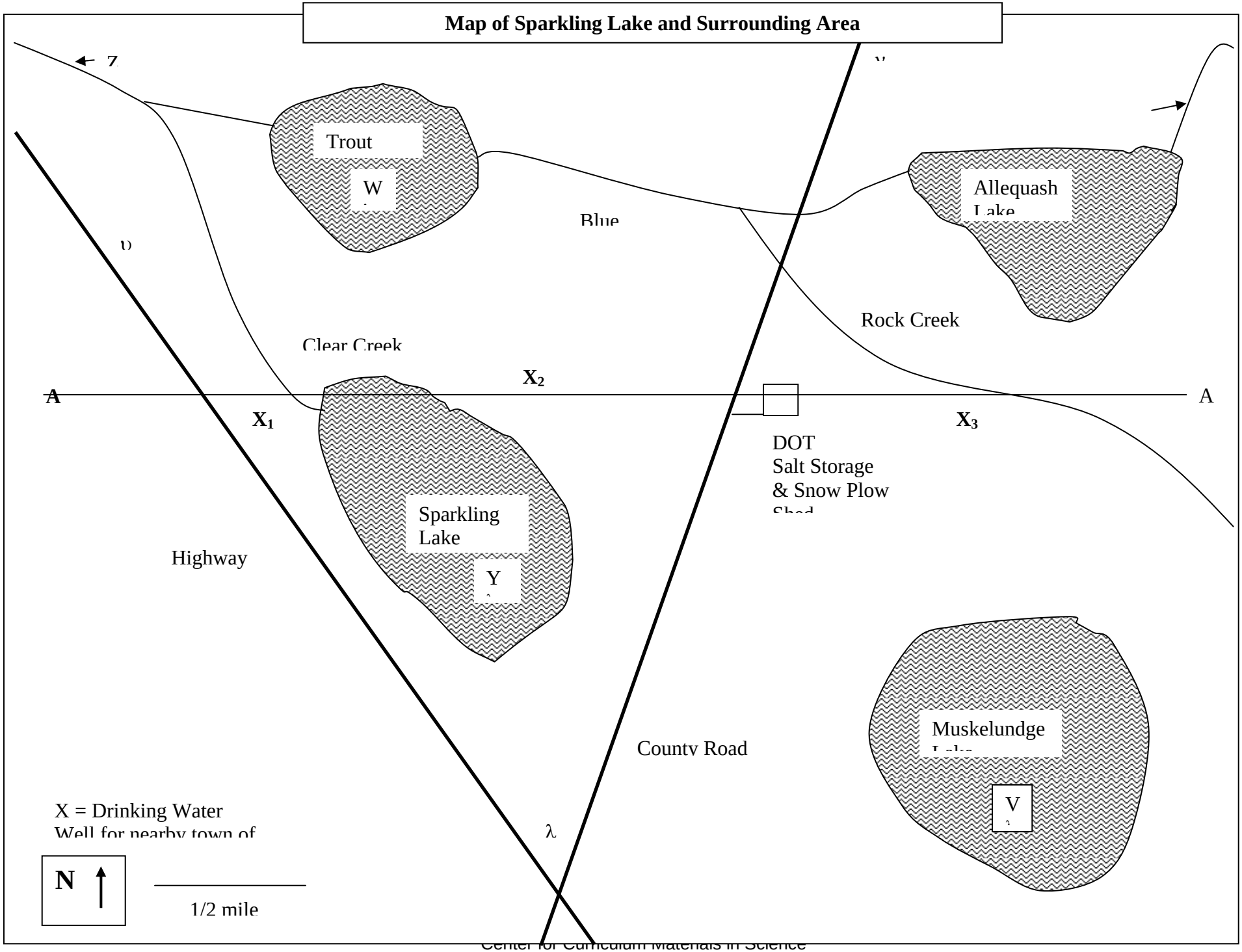
Reason	Evidence

8. Potential Solution
   A. Propose a potential course of action for cleaning up the salt contamination and limiting future salt contamination of the surface and groundwater supply.
   B. Be sure to justify your proposal and explain why you think it would work.

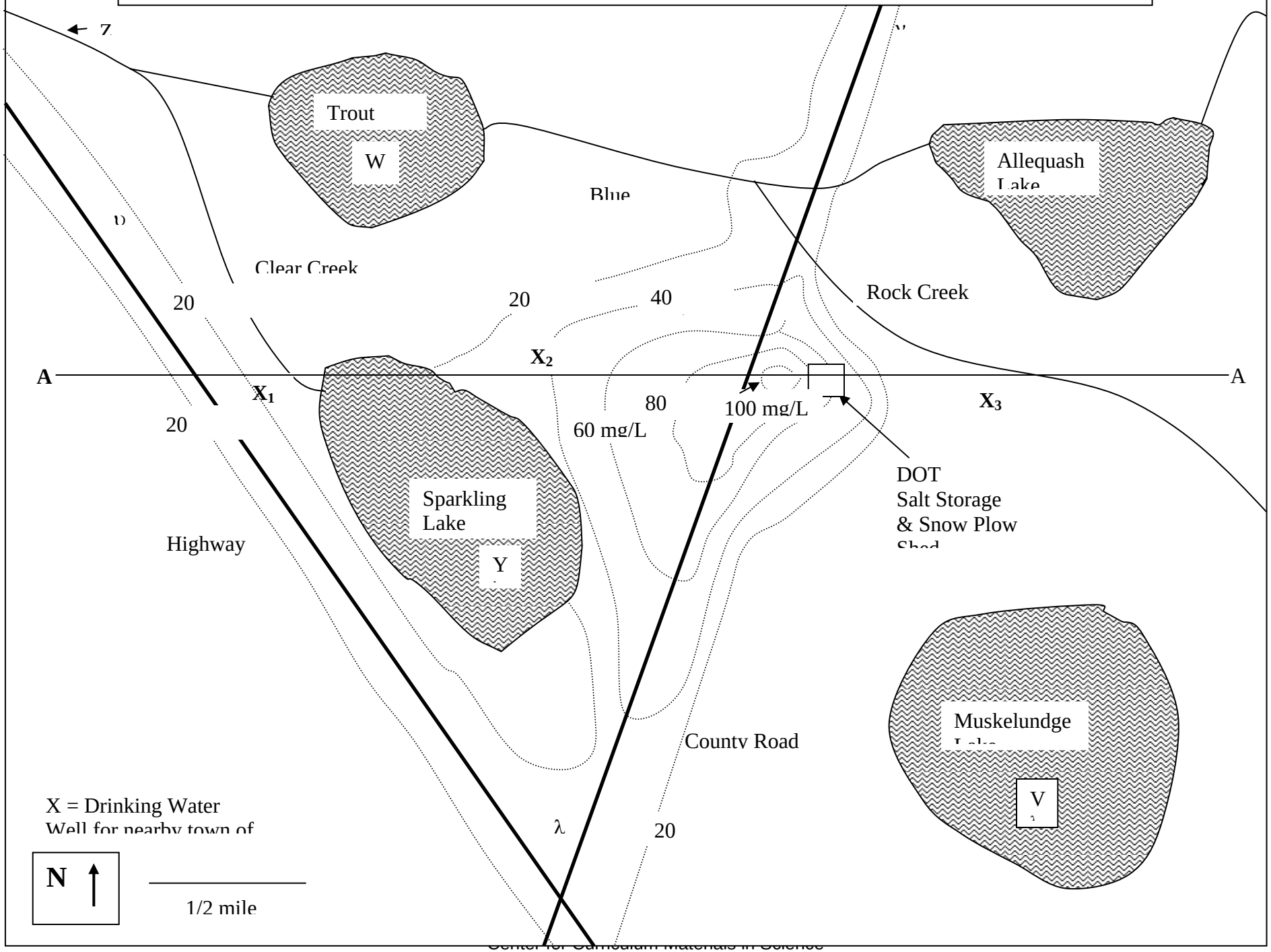
Solution:

Reason why this solution could work:

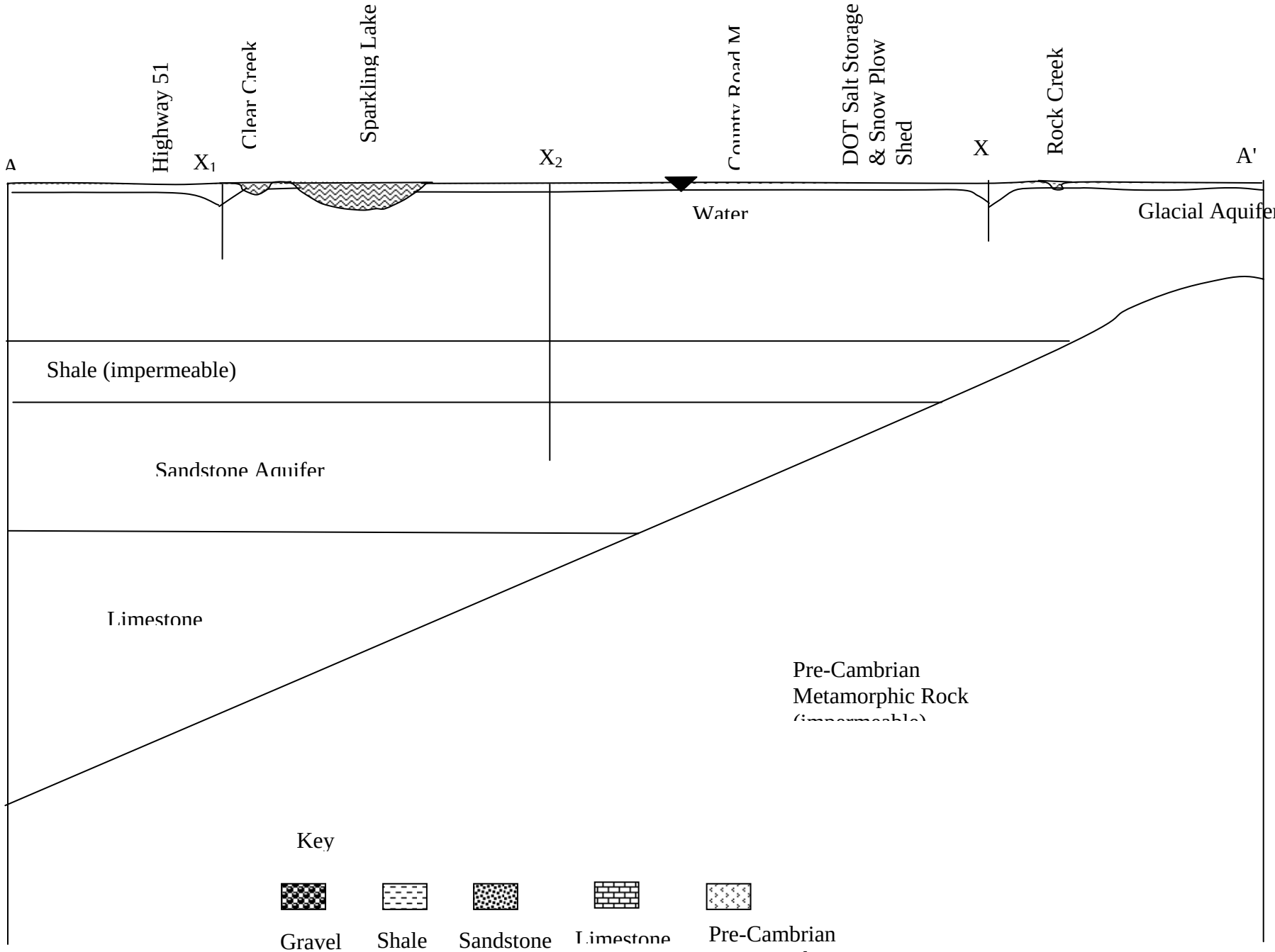
9. Student Directions: Prepare an informational poster that will explain the salt contamination problem at this site and your proposed solution. Assume that your audience does not know how salt contamination happens.


Map of Sparkling Lake and Surrounding Area
Trout
Allequash
Blue
Rock Creek
Clear Creek
A
A
X2
X1
X3
DOT
Salt Storage
& Snow Plow
Sparkling
Lake
Highway
County Road
Muskelundge
X = Drinking Water
Well for nearby town of
N
1/2 mile

Map of Sparkling Lake and Surrounding Area Showing Groundwater Salt Contamination



Cross Section A-A', Sparkling Lake



Cross Section A-A', Sparkling Lake