Iron Investigators

Adapted from: #435 Reading River Sediments, A Simulated Mining Activity for Molybdenum. Lab-Aids, Inc. 1996.

Grade Level: Intermediate and Advanced

Duration: 40 minutes

Setting: Classroom

Summary: Students test hypothetical sample sites to determine where abandoned mine drainage is coming from.

Objectives: Students will be able to identify common effects and indicators of abandoned mine drainage (AMD), particularly the presence of iron in waterways. They will use basic topographic map skills to efficiently locate the source of AMD.

Vocabulary: abandoned mine drainage (AMD), yellow boys, topographic map

Related Module Resources:
- "What is Acid Mine Drainage?"
- "Coal Mine Drainage and Aquatic Life"
- "Abandoned Mine Reclamation in Pennsylvania"
- "Saving our Mountain Streams"
- Module Activity: "Is There AMD in this Stream?"

Materials (Included in Module):
- 15 wet erase markers [Main Box]
- 15 Sample Site Number Envelopes each containing 24 cards [Iron Investigators Module Activity Envelope]

Iron Investigators Box:
- 22 Ruby Ridge quadrangle topographic maps
- 24 sediment samples
- 15 Chemplates
- Lab-Aids dollars
- 21 Spatulas
- 3 Iron test solution

Additional Materials (NOT Included in Module):
- none

ACADEMIC STANDARDS:

7th Grade

4.1.7.B Understand the role of the watershed.
- Explain factors that affect water quality and flow through a watershed.

12th Grade

4.1.12.C Analyze the parameters of a watershed.
- Interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed.
- Apply appropriate techniques in the analysis of a watershed (e.g., water quality, biological diversity, erosion, sedimentation).

BACKGROUND:

Abandoned mine drainage (AMD) is the largest cause of pollution in Pennsylvania. There are over 250,000 acres of abandoned coal mine lands, coal refuse piles and old mine shafts spanning 45 of Pennsylvania's 67 counties. In these mining areas, pyrite ("fool's gold"), which is normally buried in the ground, is exposed to water and oxygen. Pyrite contains iron and sulfur; when mixed with oxygen and water, sulfuric acid is created. As water moves through these mines, the drainage picks up the sulfuric acid along with metals such as iron, aluminum and/or manganese. The resulting AMD may destroy a stream. It can stain the rocks, discolor the water, and kill the plants and animals of the stream.

To identify AMD, there is no single set of standards that will work all of the time. Instead, one may have to look for one or more of the many typical characteristics to identify AMD.

1) Color: The most common color is an orange/red caused by iron coating the rocks. These streams are called "**yellow boys**." If aluminum is present, the color of the stream will be white. The most polluted mine drainage will actually be clear; it has such a high acidity that all of the pollutants have completely dissolved.

2) pH: Usually mine drainage has a pH less than 6. Alkaline mine drainage exists, though, with a pH greater than 7.

3) Dissolved oxygen: Most mine drainage has low levels of dissolved oxygen (less than 3 mg/L).

4) Sulfates: Typically mine drainage has high levels of sulfates (greater than 50 ppm).
5) Iron: High iron levels (greater than 5 ppm) are almost always associated with AMD. Levels can exceed 100 ppm. If it is a yellow boy stream, iron may not be detected by a test at all but that is because the iron is coating the rocks.

Iron is one of the most consistent signs of AMD. The yellow, orange, red, or brown coating the iron may form on a stream's rocks can be detrimental to the organisms that live there. Habitat on the bottom of the stream is lost and the organisms and their eggs may suffocate. These organisms help to form the bottom of the food pyramid; if they are killed, many other organisms such as fish will lose their food supply. Iron is of concern when it comes to drinking water as well. The standard set by the Environmental Protection Agency is 0.3 mg/L. High levels are not hazardous to human health but they will give water a disagreeable taste and can turn tea and coffee an inky black. Iron-laden water can stain vegetables washed in it as well as damage sink fixtures, tableware, and laundry.

Methods exist for alleviating some of the problems created by abandoned mine drainage. Treatment can occur at the source of the problem (the abandoned mine) or at some point along the affected stream. Finding the abandoned mine may be easier if the resulting stream is a yellow boy. If the water is clear, however, the process is complicated. Knowing where the source is could help government regulatory agencies determine who is responsible for the clean up of the site. Also, to remedy certain types of AMD, the source of the AMD must be located; remediation must be done right at the source.

To pinpoint the source of AMD pollution, government agencies or environmental consulting companies head to the field to collect samples. Samples can be taken along strategic spots in the river system. The closer the section of a river is to the abandoned mine, the greater the concentration of pollutants. If these scientists do not discover traces of the metal at a given point, they can be fairly sure that there are no metal deposits upstream of that point. Testing is costly so it is essential that the testing agency strategically select sample sites. One way that testing companies select sample sites and determine the relative upstream/downstream location of those sites is to locate them on topographic maps. **Topographic maps** are specialized maps that give graphic representations of earth surface features, indicating their relative positions and elevations. The brown lines are called contour lines and they indicate elevation. For the purposes of this activity, students need only understand how to read the elevation of contour lines and to remember that water (and the traces of iron it carries) always travel downhill, perpendicular to contour lines.

OVERVIEW:

Students will use basic topographic map reading skills and understanding of watersheds to come up with a strategy to find the source of iron from an abandoned mine. They will be in competition with each other for the best utilization of time and money in their search.

PROCEDURE:

Teacher Preparation:

1. Locate the Ruby Ridge quadrangle topographic maps, 24 sediment samples, Chemplates, Lab-Aids dollars, sample site number cards, spatulas, and iron test solution in the module. Organize the aforementioned materials (except for the samples) in such a way as to facilitate their distribution to students. Set up the samples in a convenient location (where the students can line up to receive samples from the teacher) and set up a place to collect the money from the companies.

2. Make photocopies of the Detecting Water Pollution Data Sheet for your students.

Student Activity:

1. Stimulate a discussion about AMD, its indicators and how its source can be determined, particularly by testing for iron in affected waterways.

2. Briefly discuss basic topographic map skills. Explain that the brown lines are called contour lines and they indicate elevation. For the purposes of this activity, students need only understand how to read the elevation of contour lines and to remember that water (and the traces of iron it carries) always travel downhill, perpendicular to contour lines.

3. Divide the class into "companies" of 2-4 students. Explain the scenario: Students are part of an environmental consulting company hired by the local water company to find the source of elevated iron levels recently detected at their drinking water facility. Their goal is to find what is most probably the site of an abandoned coal mine from which drainage is entering the local watershed.

4. Distribute a Ruby Ridge quadrangle topographic map, a set of sample site number cards, $5000 of Lab-Aids dollars, a bottle of iron test solution, and a Chemplate to each group. In addition, each student should receive a student worksheet.

5. Companies need to name themselves and should come up with a plan to quickly and efficiently test different sample sites. Sample sites each cost $500 to test. With $5000 to spend, companies will only be able to test a maximum of 10 sites. The goal of each company is to be the first to find the most likely spot that iron is entering the water in the shortest amount of time, using as little money as possible. Winners are the company that finds the iron source the quickest and the company that spends the least amount of money finding the hot spot.

6. Allow companies to begin testing by sending a representative with a Chemplate, money, and the correct sample site cards to purchase samples from the teacher. (Note: Sample site cards are used to keep the samples that are bought confidential, since there are always people poking around and listening in on other companies in hopes of stealing cheap information.)

7. Students should line up to buy their samples from the teacher as they become ready to purchase their first sample(s). This line should continue throughout the activity to reduce quarrels over which group should get their sample(s) first.

8. The teacher should stockpile the money, look at the sample site number card(s), and distribute samples accordingly. A sample consists of one spatula-full of sediments from its respective storage container. The samples should be placed into separate wells on the Chemplate. If the representatives purchase more than one sample, it is up to them to remember the order of the samples on their Chemplate.

9. The representatives should then return to their groups with the samples. One drop of iron test solution should be placed on each sample. Groups should wait 10-15 seconds for a full color development and then compare the color to the data chart (identical to the one below) on the student worksheet.

Color	**Iron Concentrations (parts per billion)**
Yellow	less than 0.1ppb
Blue	0.1-1.0ppb
Blue-Green	1.1-10.0ppb
Red	greater than 10.0ppb

10. All results should be recorded in the data table on the student data sheet.

11. Continue sampling until all companies either find where the iron is coming from or run out of money. As they finish, have the representatives turn in their papers. The teacher should write the current time at the top of the papers as they are turned in.

12. Use this answer key to check students' work after all companies have found the iron "hot spot". The hot spot is defined as the site with the highest concentration of iron.

Color	**Test Site Numbers**
Yellow	1-15, 23
Blue	20-22, 24
Blue-Green	17-19
Red (the hot spot)	16

NOTE: Chemplates can easily be rinsed off into a bucket to catch sediments. The water can be poured down the drain or dumped outside before dumping the settled sediments in the trash or outside.

DISCUSSION:

How did you use the topographic map to determine testing sites?
Answers will vary but should include use of contour lines and knowledge of how water flows over the land. See background information.

What were some of the strategies you used to be the fastest and cheapest company?
Answers will vary.

What happened to the iron concentrations the farther one got from the source?
In general, pollution decreases in concentration as it moves down through the watershed and further away from its source.

If site 3 was the abandoned mine, how would sites 1 and 2 be affected? What about sites 4-9?
Sites 1 and 2 would not be affected and would have no iron concentrations in them. Sites 4, 6, and 7 would likewise not be affected. Sites 5, 8, and 9 would have decreasing concentrations of iron, respectively. This occurs because sites 5, 8, and 9 are downstream from site 3.

If the abandoned mine were between the words "Bear" and "Ridge" on the map, how would the different sites be affected?
Sites 10, 11, 22, and 23 would have decreasing concentrations of iron, respectively. Site 14 would also show iron concentrations, while site 13 would not show iron concentrations.

EVALUATION:

- Describe how water moves in relation to contour lines.
- Explain how contamination moves through a watershed.
- Describe how distance traveled relates to concentration of contaminants.
- Identify some potential risks to watersheds due to mining.
- Identify common indicators and effects of AMD.

EXTENSIONS AND MODIFICATIONS:

- Pick a new site for an abandoned mine. Make color-coded dots on note cards for the new concentrations at the sites. Use the color-coded note cards as results that would have been found if tested at the sites. Place the cards in envelopes. Play again, distributing envelopes to groups as they buy them.
- Use a copy of the watershed you live in to designate an abandoned mine and other sites. Number the sites according to the answer chart. Use the sediments and chemicals provided or use color-coded note cards as described above.
- Have groups of students create their own game and switch with other groups.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

DATA SHEET: IRON INVESTIGATORS

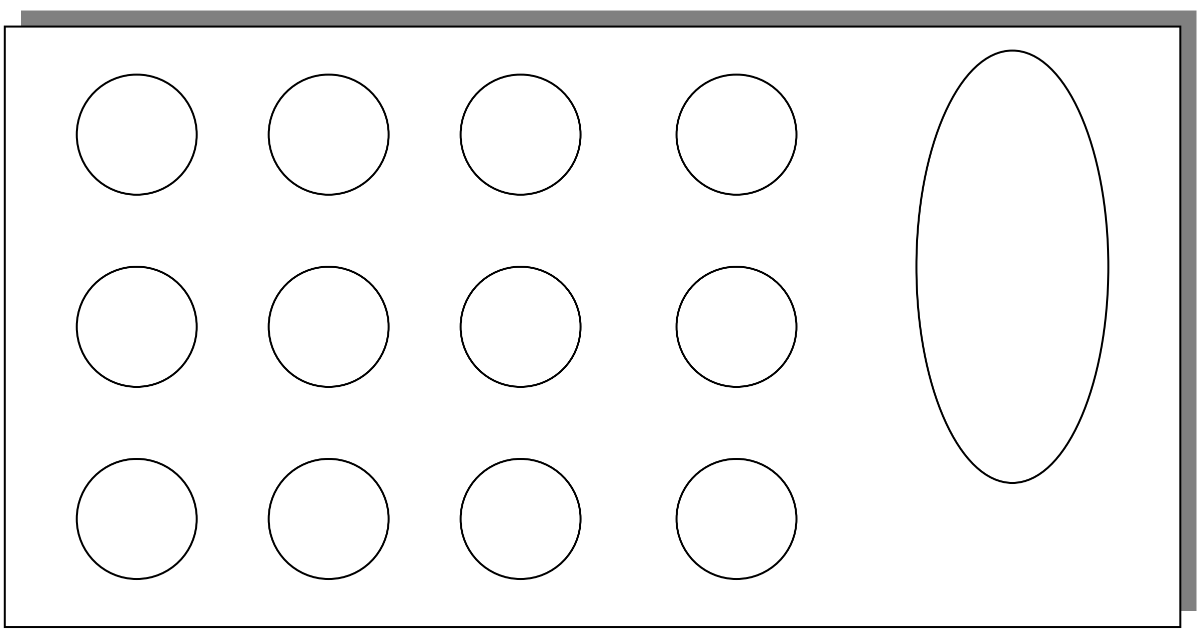
Name____Date______________

Group Partners____

Company Name____

Color	**Iron Concentration (parts per billion)**
Yellow	less than 0.1ppb
Blue	0.1-1.0ppb
Blue-Green	1.1-10.0ppb
Red	greater than 10.0ppb

Test Site Number	**Color**	**Concentration Range**



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