During this unit, students will investigate and understand the geologic processes of weathering, erosion and deposition as they change the landscape of Earth.

Weathering is the breakup of minerals and rocks by chemical and physical means. Erosion moves the weathered products from one location to another. The features left behind are erosional landforms. During deposition, the weathered products are put down in a new location making depositional features. One of the most important products of weathering is the formation of soil. Discuss the relationship between erosion and deposition as it applies to gravity, wind, waves, running water, and glaciers. Identify examples of features formed by each process.

The classic features made by rivers are V-shaped valleys, alluvial fans, and deltas. River systems and their drainage basins are connected to the water cycle, sources of fresh water, and water quality. Students should be able to identify the major watersheds in Virginia with emphasis on the Chesapeake Bay and its tributaries. Groundwater zones, porosity, permeability, karst topography, the water cycle, freshwater resources, and water quality are interrelated topics in this unit.

This is a good place to mention Virginia’s provinces. Discuss how weathering, erosion and deposition are responsible for the Blue Ridge Mountains shrinking (intrusive igneous rocks exposed) and the coastal plain’s development. Our location is ideal for studies on soil and water conservation and water quality.
STAGE 1 – Desired Results

UNIT 5 BIG IDEAS:

- Weathering, erosion, and deposition (sedimentation) are interrelated processes that build up and break down Earth’s surface.
- Geologic processes produce characteristic structures and features.
- The movement of water above and below Earth’s surface produces characteristic features that influence the availability of freshwater resources.

Enduring Understandings:

- Weathering, erosion, and deposition (sedimentation) are interrelated processes that form a cycle of forces that wear down and build up the Earth’s surface.
- Water is continuously passed through the hydrologic cycle.
- Soil is one of man’s most valuable resources.

Essential Questions:

- How do weathering, erosion, and deposition (sedimentation) affect the surface of the Earth?
- How does Earth’s water supply change?
- Why is the conservation of soil important?

Instructional Focus: 5.1 Weathering, Erosion, and Deposition

Standards of Learning: ES.7 The student will investigate and understand geologic processes including plate tectonics. Key concepts include:

- a) geologic processes and their resulting features; and

Essential Knowledge and Skills:

- Define and give examples of weathering, erosion, and deposition. (5.1.1)
- Distinguish between physical (mechanical) and chemical weathering. (5.1.2)
- Recognize factors that affect the rate of weathering. (5.1.3)
- Explain the erosional and depositional features that result from gravity and mass movement (landslides, mudflows, and avalanches), running water (rivers and runoff), waves (beaches and sandbars), glaciers (U-shaped valleys and lakes) and wind (dunes). (5.1.4)

Virginia Beach Objectives:

Virginia Department of Education Expectations

- Define and give examples of weathering, erosion, and deposition. (5.1.1)
- Distinguish between physical (mechanical) and chemical weathering. (5.1.2)
- Recognize factors that affect the rate of weathering. (5.1.3)
- Explain the erosional and depositional features that result from gravity and mass movement (landslides, mudflows, and avalanches), running water (rivers and runoff), waves (beaches and sandbars), glaciers (U-shaped valleys and lakes) and wind (dunes). (5.1.4)
| 5.2 Soil Formation | ES.8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include: a) processes of soil development; | • Explain the process of soil formation to include key terminology: soil horizons, soil profiles, humus (organic material) and leaching. (5.2.1) • Describe types of soil to include residual soil, transported soil, and humus. (5.2.2) • Compare and contrast A, B, and C soil horizons found in mature and immature soils. (5.2.3) |
| 5.3 Groundwater | ES.6 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include: a) fossil fuels, minerals, rocks, water, and vegetation; ES.8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include: b) development of karst topography; c) relationships between groundwater zones, | • determine the sources of clean water in their community and analyze consumption and supply data. • interpret a simple groundwater diagram showing the zone of aeration, the zone of saturation, the water table, and an aquifer. • interpret a simple hydrologic cycle diagram, including evaporation, condensation, precipitation, and run-off. • locate the major Virginia watershed systems on a map (Chesapeake Bay, Gulf of Mexico, and North Carolina sounds). • analyze the formation of karst in terms of rock | • Interpret the hydrologic cycle, including evaporation, condensation, precipitation and run-off and describe its importance to humans.(5.3.1) • Identify the sources of fresh water on the Earth’s surface including their phases in the hydrologic cycle. (5.3.2) • Explain how geologic processes, such as erosion, and human activities, such as waste disposal, can pollute water supplies. (5.3.3) • Describe the process of stream development and the associated landforms. (5.3.4) • Locate and identify the major Virginia watershed systems (including rivers) on a map (Chesapeake Bay, Gulf of Mexico, and North Carolina sounds). (5.3.5) • Interpret a simple groundwater diagram showing the zone of aeration, the zone of saturation, the water table, and an aquifer. (5.3.6) • Describe groundwater sources (such as aquifers and springs) and relate them to porosity and permeability. (5.3.7) • Explain the development of karst topography to include key terminology: carbonate rocks, cavern, |
| d) identification of sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle; |
| e) dependence on freshwater resources and the effects of human usage on water quality; and |
| f) identification of the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries. |

| groundwater type, solubility and permeability, uplift, the water table, and chemical and physical weathering. |

- analyze the presence of groundwater in various types of rock terrains, including areas found in each of the physiographic provinces of Virginia. |
- analyze the relationship between salt-water intrusion in the ground water in certain areas of eastern Virginia and buried crater structures. |

| sinkhole, carbonation, stalactite, and stalagmite. |

- Locate the region of karst topography in Virginia as the Valley & Ridge Province where limestone/dolomite is common. (5.3.9) |
- Analyze the formation of karst topography in terms of rock type, solubility, permeability, uplift, water table and weathering. (5.3.10) |
- Analyze the presence of groundwater in various types of rock terrains, including areas found in each of the physiographic provinces of Virginia. (5.3.11) |
- Analyze the relationship between saltwater intrusion in the groundwater in certain areas of Eastern Virginia and buried crater structures. (5.3.12) |
- Determine the sources of clean water in their community and analyze consumption and supply data. (5.3.13) |
<table>
<thead>
<tr>
<th>Students will know…</th>
<th>Students will be able to…</th>
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<tbody>
<tr>
<td>♦ Factors – speed, volume, slope influence cutting ability – meanders.</td>
<td>♦ Describe the relationship among weathering, erosion, and deposition.</td>
</tr>
<tr>
<td>♦ Weathering is the process by which rocks are broken down chemically and physically by the action of water, air, and organisms.</td>
<td>♦ Interpret a simple groundwater diagram showing the zone of aeration, the zone of saturation, the water table, and an aquifer.</td>
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<tr>
<td>♦ Erosion is the process by which Earth materials are transported by moving water, ice, or wind.</td>
<td>♦ Identify characteristics of karst topography and the processes involved in the development of karst topography.</td>
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<tr>
<td>♦ Deposition is the process by which Earth materials carried by wind, water, or ice settle out and are deposited.</td>
<td>♦ Interpret a simple hydrologic cycle diagram including evaporation, condensation, precipitation, and runoff.</td>
</tr>
<tr>
<td>♦ Weathering, erosion, and deposition are interrelated processes.</td>
<td>♦ Locate the major watershed systems on a map (Chesapeake Bay, Gulf of Mexico, and North Carolina Sounds).</td>
</tr>
<tr>
<td>♦ Weathering accelerates erosion and thus increases the rate of deposition.</td>
<td>♦ Identify and describe the major types of soil.</td>
</tr>
<tr>
<td>♦ The potential for erosion is greatest in areas of high relief.</td>
<td>♦ Relate climate to soil formation.</td>
</tr>
<tr>
<td>♦ The potential for deposition is greatest in areas of low relief, especially in standing water and in the ocean.</td>
<td>♦ Use a topographic map to determine the direction of a river’s flow.</td>
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<tr>
<td>♦ Permeability is a measure of the ability of a rock or sediment to transmit water or other liquids.</td>
<td>♦ Use sequential maps to investigate rates of change caused by weathering, erosion and deposition.</td>
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<tr>
<td>♦ A substantial amount of water is stored in permeable soil and rock underground.</td>
<td>♦ Explain why Virginia Beach consists of young unconsolidated sediments.</td>
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<tr>
<td>♦ Water does not pass through impermeable materials.</td>
<td>♦ Analyze how the use of freshwater resources affects water quality.</td>
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<tr>
<td>♦ Geological processes, such as erosion and human activities (such as waste disposal), can pollute water supplies.</td>
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<tr>
<td>♦ The three major regional watershed systems in Virginia lead to the Chesapeake Bay, the North Carolina Sounds, and the Gulf of Mexico.</td>
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<tr>
<td>♦ Karst topography is developed in areas underlain by carbonate rocks, including limestone and dolomite.</td>
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<tr>
<td>♦ Where limestone is abundant in the Valley and Ridge province of Virginia, karst topography is common.</td>
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<tr>
<td>♦ Karst topography forms when limestone is slowly dissolved away by slightly acidic groundwater.</td>
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<tr>
<td>♦ Karst topography includes features like caves and sinkholes.</td>
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<tr>
<td>♦ Soil is formed from the weathering of rocks and organic activity.</td>
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<tr>
<td>♦ Soil is loose rock fragments and clay derived from weathered rock mixed with organic material.</td>
<td></td>
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<tr>
<td>♦ Running water is the major cause of erosion.</td>
<td></td>
</tr>
<tr>
<td>♦ Down slope movement of Earth materials is caused by gravity.</td>
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<tr>
<td>♦ Features of erosion and deposition caused by waves include deltas, beaches, and sandbars.</td>
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<tr>
<td>♦ Features of erosion and deposition caused by glaciers include U-shaped valleys, lakes, and moraine.</td>
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<tr>
<td>♦ Features of erosion and deposition caused by wind include blowouts, dunes and loess.</td>
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</tbody>
</table>
- Virginia’s Coastal plain consists of young unconsolidated sediments eroded from the western higher elevations.
- Virginia’s coast line is shaped by the action of waves.
- The composition and structure of soil are dependant on the resources, topography and climate.
- Renewable resources can be replaced by nature at a rate close to the rate at which they are used. Water is a renewable resource.
- Explain the types of deposition specific to streams and rivers (such as alluvial fans and deltas).
Stage 2 - Assessment Evidence

**Title of Performance Assessment**  The Ogallala Aquifer

**Description of Assessment Task**

In the Ogallala Aquifer Assessment Task, students consider an environmental issue utilizing a case study. Through class discussions, students analyze geological processes at hand. Students then individually analyze information in light of evidence presented. Each student is assigned a stakeholder who analyzes the key issue at hand and finds possible solutions for their case study. In groups, students then discuss each case and build a consensus on how to handle the problem. Collaboratively, students find an innovative solution to the problem that will meet everyone’s needs.

**Standards of Learning**

SOL ES.6.a  
SOL ES.8.b  
SOL ES.8.c  
SOL ES.8.e

**Virginia Beach Objectives**

ES 5.1.4, ES 5.3.2, ES 5.3.3, ES 5.3.7, ES 5.3.8, ES 5.3.11

**Science Practices**

This performance task allows students to ask and evaluate questions that challenge the premise(s) of an argument and the suitability of a solution. Additionally, define a design problem that involves the development of a process or system with interacting components and criteria and constraints that includes social, technical, and/or environmental considerations. Students also apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

**4 C’s**

Students engage in dialogue using the evidence presented in their case study and brainstorm possible solutions individually *(critical thinking and creativity)*. Students also collaborate on one solution to the issue presented *(collaboration)* and communicate their findings verbally and in writing *(communication)*.

**Assessment Outcomes/Performance Expectations**

- Explain the relationship between water consumption and rate of recharge.
- Discuss the factors that contribute to groundwater contamination.
- Explain how groundwater depletion rates harm ecosystems and influence biodiversity.
- Evaluate how groundwater regulations and environmental needs can be in conflict with one another.
- Describe how human activities and pollution impact clean water resources.

**General Teacher Instructions**

It may take students between 90 and 180 minutes to complete this task. Prior to the task, students should become familiar with the issues surrounding the Ogallala Aquifer by watching this video. As students watch the video, they may consider the following: (1) Why should everyone be concerned with the issues surrounding the Ogallala Aquifer? (2) How is the water table in the Ogallala Aquifer affected by its geographic location? (3) Explain how the root of the problem with the Ogallala Aquifer is that the rate of depletion is much higher when compared to the rate of recharge. (4) How do human and natural factors impact water resources? Students will focus on the similarities between the cases. Guiding questions may be: Is there a common concern shared by everyone? Is there an action you would all like to see? On which points can you all agree? This task was modified from the Project Learning Tree Environmental Issues Edition. The teacher may choose to have a class discussion with the introduction and assign the roles to students. Students may individually answer the guiding questions regarding their role. Working in their teams, students will adopt shareholders’ roles, debate views, and develop a team resolution. Students will then individually write a resolution that will be presented to the governor.
Calibration for Scoring Student Work and Examination of Data

Scoring performance based assessments should occur in PLC’s. Research shows that when teachers “use, score, and discuss results of high-quality performance assessments over time, both teaching and learning improve” (Darling-Hammond, 2014, p. 11). It is recommended that teams follow the Team Protocol for examining data found on the Secondary Science SharePoint site. A summary is also included below.

- One person serves as the facilitator and shares an overview of the process.
- Each team member is given 5-7 minutes to look over a sample of student responses (teachers may choose to look over 3 or 4 very strong responses and 3 or 4 weaker responses). Each team member reflects on the following and then shares their thoughts with the group:
  - I wonder if…
  - I predict that…
  - Some possibilities for learning that the data might offer are…
- After all members have shared their thoughts, they are provided 8-10 minutes to jot down their observations:
  - What do you observe in the responses?
  - What important points in the responses initially “popped out” at you?
  - What patterns or trends did you notice?
  - What surprising or unexpected features are present in the responses?
- The team shares their responses to the above questions for 5-10 minutes.
- The team chooses three student responses to evaluate as a team. Each teacher evaluates the responses based on grading criteria established and provided in this document for 5-10 minutes.
- Each team member takes turns discussing each responses, how the response was evaluated, and why. The team discusses any discrepancies in grading and decides on how the performance assessment task will be evaluated. The purpose of this step is to overcome rater bias.
- Next, teachers grade their student’s responses and bring data to the meeting on a different date.
- On the second meeting, teachers discuss the results. Teachers are provided with 5-10 minutes to reflect on the following question: “What are the implications for teaching, learning, and improving student achievement in the area(s) we have been examining?” The purpose of this step is to make connections between what needs to be done, what should be changed, and what is working. The following questions should be taken into account as team members individually record their ideas:
  - What have we learned from the data?
  - What steps should be taken next?
  - What are appropriate strategies or solutions that will address the needs implied in the data?
  - What does the dialogue make you think about in terms of your own practice?
  - In what areas should we change what we are doing?
  - What other data or information would help us determine if our solutions are working?
- After individual think time, the team engages in dialogue for 10-15 minutes in which all members share their thoughts. Each idea is considered and recorded on chart paper.
- Team members take another 5-10 minutes to form consensus on one or two major issues identified and one or two strategies to address these issues. The team also decides upon the method(s) to be used to assess whether the strategies have successfully addressed the issues.

Materials

- Student handouts, role cards, computer with projector

Resources

- Ogallala Aquifer Institute information: http://waterplan.state.wy.us/BAG/newy/briefbook/200307lowry.pdf

Assessment Task with Student Directions

See next page.
From babbling streams to raging oceans, water is one of the most common substances on Earth, but in some places it is becoming priceless. – Ronald Wall

Do you use Ogallala water? The underground Ogallala Aquifer, also known as the High Plains Aquifer, once held as much water as Lake Huron (three billion acre-feet*). If pumped out over the United States, the aquifer would cover all 50 states with one and one-half feet of water. The aquifer is like a bucket full of wet gravel with all the pore spaces filled with water and a bedrock seal on the bottom. As the largest groundwater system in North America, the aquifer runs under parts of eight states: southern South Dakota, eastern Wyoming, most of Nebraska, eastern Colorado, western Kansas, western Oklahoma, western Texas, and eastern New Mexico.

When the practice of irrigation became popular after World War II, people believed the Ogallala was an inexhaustible resource fed from an underground river originating in the Rocky Mountains. Farmers and landowners pumped extravagant amounts of water without any thought of conservation. A fourfold rise in use occurred between 1940 and 1970. By the 1970s, the Ogallala watered one fifth of the total land under irrigation in the United States. Today, approximately 95 percent of the water pumped from the aquifer is devoted to irrigation. The water irrigates crops such as alfalfa, corn, cotton, and wheat, much of which is used to feed livestock.

The shaded area on the map represents the aquifer (see Figure 1): When the aquifer started to show signs of depletion, communities across state lines began negotiating. University of Kansas reported that “Farmers around Sublette, Kansas, figured in 1970 they had about 300 years of water left. In 1980 they reckoned they had 70 years’ supply; in 1990, less than 30. Half the accessible water was gone by 1993. While it took many millennia to fill, the Ogallala’s usefulness to humankind will almost surely last less than a century.”

Regional decision makers continue to struggle with the issue. They face the dual challenges of continued growth and economic dependence on the resource. To date, people have not limited their use of the aquifer to sustainable levels. Instead, citizens have pumped out water faster than it can be replenished. The Ogallala holds fossil water, which is water that has accumulated over the past 10,000 to 25,000 years. The only method of recharging this aquifer is the slow percolation of water through the soil. Because most of the High Plains soils are not very porous, recharging may occur at a rate of only an inch or so per year. Ogallala water supports a significant portion of the nation’s food supply. Yet, far too many people rely on greater groundwater yields than would be possible with the natural recharge rate. Farmers drained the aquifer at a rate of 1 percent per year in the late 1970s, drawing water 10 times faster than the
aquifer could recharge under the best conditions. From the 1940s to 1980, the aquifer declined an average of 10 feet, with some areas in Texas declining nearly 100 feet. However, during the 1980s, the aquifer declined only another foot because of improved irrigation practices and new technologies. According to water scientists at the Kansas Geological Survey, about 40 percent of the aquifer should be able to support pumping for the next 100 years, if water is used at the 1978–98 rate of withdraw. (Data for the remaining area of the aquifer were incomplete; therefore, the team at KGS was unable to project depletion rates for the entire aquifer.)

*An acre-foot is equivalent to the volume of water required to cover 1 acre to a depth of 1 foot.

Several stakeholders have are concerned about the Ogallala Aquifer. Your teacher will provide instructions with the roles. Key questions/items that should be considered with each role are below. You will also be asked to write a resolution that will be presented to the governor regarding the issue from multiple perspectives as well as the solution your group came up with. Your response should be posted on Edmodo so that feedback from peers may be obtained prior to submitting the final response.

1. **Your role:** ______________________________

2. **Discuss what is at risk in the case you were assigned?**

   ____________________________________________

   ____________________________________________

   ____________________________________________

3. **What competing interests are at stake?**

   ____________________________________________

   ____________________________________________

   ____________________________________________

4. **What issue is a point of debate or dispute?**

   ____________________________________________

   ____________________________________________

   ____________________________________________

5. **Who are the players concerned and what are their positions?**

   ____________________________________________

   ____________________________________________

   ____________________________________________

6. **What values and beliefs do they hold regarding the issue?**

   ____________________________________________

   ____________________________________________

   ____________________________________________

7. **What are possible solutions to this case?**

   ____________________________________________

   ____________________________________________

   ____________________________________________
Role #1—Citizens Alliance for the Aquifer

Concern #1—The Citizens Alliance for the Aquifer (CAA) has several concerns regarding managing the Ogallala Aquifer. CAA is a consortium of more than 1,500 individuals and businesses from several states in the High Plains region. Our consortium’s mission is to hear—and to represent to public officials—the concerns of citizens throughout the region.

The following is a summary of the multiple issues that we believe must be taken into account as a multistate resolution is sought:

- Multistate cooperation with regard to the remaining resources of the Ogallala Aquifer
- Scientific research on the ecological repercussions of artificial groundwater recharge using reclaimed wastewater
- Economic incentives for sustainable practices
- Locally enforceable regulation (because the region is too large for regulation by a few federal agents)
- Ecological impact statements on the effects of aquifer mining on wildlife
- Increased access to the playa lakes for recreational purposes (e.g., game bird hunting)
- Subsidies to offset economic losses of farmers who must dig deeper for water
- Monitoring of feedlots to reduce nitrogen waste seepage and pesticide seepage
- For new construction, impact fees that are based on projected water usage of new households
- Full-scale assessment (e.g., feasibility, available markets) of drought-tolerant crops
- Federal assistance to offset the rising cost of drilling for water
- Equity in subsidies for all farmers or incentives for water-use reductions
- A framework of regular communications with citizens
Role #2—Colorado High School Student

Concern #2—I think we need to stop wasting the remaining water and to find out what it would take to let the aquifer recharge.

The Ogallala Aquifer once held enough water to fill Lake Huron. However, we are using the water faster than it is being replenished. In some places, the aquifer is almost empty. Once drained, the aquifer will take an estimated 6,000 years to refill. Agriculture is the primary drain on the aquifer and is the topic we need to focus on while seeking a solution to the overuse problem.

The Ogallala Aquifer, which stretches from Texas to South Dakota, is the main source of water for all the High Plains. The aquifer is being depleted at an alarming rate in many areas. At current use rates, the aquifer will be dry in 30 or 40 years. That is during my lifetime!

I have read that many farmers are using inefficient watering methods. They use sprinklers that spray water from such heights that much of it evaporates before it reaches the plants. Farmers who irrigate with ditches pour too much water onto the crops, and the excess water sits there until it evaporates.

Some solutions for those wasteful practices are readily available. Because the water evaporates from the high sprinklers before reaching the crops, why not install lower sprinklers? If the water is closer to the plants, less will evaporate. To keep from wasting water in ditch irrigating, the farmer could buy gypsum blocks, which are a valuable device that is buried in the ground near the roots to monitor available soil moisture. With this method, you can always tell how much water you are using and how much water you need. Given the status of water resources, there is no excuse for wasting any.

Unless methods for conserving water are implemented in the High Plains, the water supply could run out in a matter of years, which would be an undesirable outcome not only for the farmers but also for those of us who depend on their produce for food.

I do not understand why nothing is being done when we know about this problem and that it is only getting worse. What if the water is gone by the time I am 50? What will I do? Will I have to move away? What about all the families who live in the High Plains states? Will everyone have to move? A lot of people can’t afford to just move—the poorest will be left behind. We need to redefine the agricultural industry, keeping the jobs but stopping the wasting of water. What about all the people in the United States who rely on beef and grain from the High Plains? What will happen if the industry falls apart in 50 years? We need to produce food on our own land here in the United States so that we are not dependent on foreign countries. Depending on foreign food would make us very vulnerable as a nation. Does everyone realize how important this matter is? I am eager to do what I can to work toward a solution; that is why I came to this summit.

Sources:
www.bvsd.k12.co.us/schools/cent/Newspaper/southernHills/Ogallala.home.html
Role #3—Ecologist from Nebraska

Concern #3—I believe we threaten our species and others by disturbing the web of life that we don’t fully understand. We’re all connected.

The loss of water from the aquifer is not just about humans running out of water for their use. The repercussions affect the wider ecological community. Underground water reserves are connected to aboveground water sources. We need to look at the entire system when considering the environmental impacts of depleting this resource. When withdrawals exceed recharge rates, the result is lower water tables and (often in the summer) slower, lower, and warmer streams.

Those factors affect species living in the streams. Insect larvae are a critical link in the stream food web. Those and other species are extremely sensitive to variables like temperature, nutrient concentrations, contaminants such as pesticides, dissolved oxygen, and flow rate. Less water in streams reduces habitat for species and impairs water quality. When streams run too slowly, creatures that depend on the flushing of contaminants such as pesticides can be poisoned. When streams run too low, creatures that have grown dependent on higher rates cannot survive.

I am particularly concerned about trout. Higher water temperatures in the summer reduce reproduction rates. The fish depend on groundwater contributions to stream flow; the temperature of the groundwater keeps their eggs from overheating in summer and from freezing in winter. Groundwater and waters on the surface are intimately connected; I doubt that we have even begun to understand the complexity and interrelationships of the system. In this semiarid climate, the impacts of depleting groundwater resources are likely magnified.

My point is simple. Groundwater moves toward and connects to water on the surface. Ecology is about systems. When we try to divide up issues and are not seeing them in context, or as a whole, we make mistakes. Our knowledge is limited, so we must use all we know to make the best possible decisions. We can’t ignore “minor details.” For example, eliminating trout habitat doesn’t just affect recreational fishing. Simply put, if trout are affected, other species will be also. And speaking personally, I believe that trout are valuable simply because they are trout. I do not want a world where fish do not swim free in our rivers. They are a part of my quality of life; my health and well-being are tied to theirs.

Role #4—Meat Industry Representative from Texas

Concern #4—Folks, millions of people rely on Ogallala water, including my company’s employees and their families, the farmers of the High Plains, and most meat-eating Americans. The economy of the region depends on the aquifer’s water. Restricting our ability to pump water will cause financial problems for many of us.

Most of the water pumped from the Ogallala is used to irrigate crops, much of which are grown to feed livestock. Throughout the 1980s and 1990s, the largest beef-packing company of the High Plains increased employment from 9,500 to 52,000 people, and sales grew from $4.6 billion to $16.9 billion. In October 2001, the company merged with the world’s largest poultry producer, making it the nation’s largest meat-packing company. The company, which processes beef, pork, and poultry, now claims the largest percentage of the U.S. market, serving as the nation’s (and perhaps the world’s) largest beef processor. I represent the company.

The previous chief executive officer of this company based in the High Plains also served on the board of directors for several organizations, including a federal reserve bank, a major energy company, a petroleum corporation, and the National Livestock and Meat Board. Clearly, the meat industry is big business in the United States, and upper-level meat industry executives are major players on the national and international business scene.

My company now provides thousands of jobs across the United States, keeps meat and grain farms in business, and feeds the nation. We have been a responsible neighbor, constructing wastewater treatment systems to reduce ammonia discharge into the Missouri River and resolving water quality issues at former facilities in Texas.

Source:
Center for Study of Responsive Law, 2005 (E).
Role #5—Farmer from Kansas

Concern #5—Mostly what I want people here to keep in mind is that the sustainable farming practices have not been proven over generations to not harm farmers’ livelihood, and I simply cannot afford to take that risk with my operation.

My family relies on support payments from the government. With the federal economic incentives, we can turn a profit and make a living. Federal programs do not recognize the crop rotation system that the sustainable agriculture folks propose. My family would receive nothing if I implemented those suggestions. You all seem to have this nostalgic attachment to the American farmer, but then you don’t seem to know one when you’re looking at her or him. My family has farmed this land for generations, and my students are learning to farm this land after me. We maintain the way of life you say is being lost in this country, so I don’t understand why you aren’t willing to provide more support for the regular farmer who can’t afford to take the risks you suggest.

I represent the people who are the backbone of this region’s economy. Let’s not forget what this issue is about. Families, cities, entire states, and a nation depend on our grain and meat industries. If I switched to more sustainable practices, I understand that for the first few years I would likely have lower yields. I am aware that this approach might be offset by the costs of fertilizers and pesticides, but it is still a risk. I barely make a living some years as it is. You say there is little difference—even with increased labor costs—but, again, I can’t take that risk.

Don’t get me wrong; I am interested in the increased water-holding capacity of sustainable practices. But I have already invested in a large-scale irrigation system and can hardly imagine running drip irrigation lines across all those acres! Farming is a business. There’s no time to do all that by hand. If I didn’t have a family to support, maybe I could take more risks. Someday in the future, maybe my students will have to grow wheat or farm some new way because pumping the water will be too expensive.

I say, “No more regulations on farmers.” We aren’t the ones overpopulating this region. What about all those people watering their lawns and golf courses? What about all the people eating the food we produce? Farmers cost the government less per acre than suburban people. We don’t need the infrastructure that they do. In the suburbs, water and sewer lines run to every house, on every quarter of an acre. Has anyone compared water use per acre on farms to the use in the suburbs? Why do people want to blame farmers so fast? Maybe they don’t want to look at their own way of living. I don’t mean to offend anyone; I just want fair representation for farmers.

Source:
Guru and Horne 2005 (E).
Role #6—Agricultural Engineer from Wyoming

Concern #6—We need to think about the long-term sustainability and environmental impacts of water use in this globally significant agricultural area.

The Ogallala Aquifer, underlying half a million square kilometers of the central United States, could be the largest aquifer in the world. Although figures vary, it is estimated that the aquifer provides 20 percent to 30 percent of the total groundwater used for irrigation in the United States. It also provides domestic water to approximately 80 percent of the 2.3 million residents of the region. About 40 percent of those people live in the region's 10 largest cities. The region is a globally significant agricultural production area. More than half the land (54 percent) is used for agriculture. Wheat, cotton, and corn grown here amount to 15 percent to 20 percent of the total of each crop grown in the United States.

Eighteen percent of the cattle in the United States and a growing percentage of swine are also produced here. In 1995, regional water use for irrigation and meat processing amounted to almost 20 billion gallons per day. One-fifth came from surface waters (85 percent of which came from the Platte River in Nebraska), and four-fifths came from aquifers. Excluding the Platte River, 92 percent of the water used in the High Plains is supplied by groundwater, and about 95 percent of this water irrigates crops. The rest is used for domestic drinking water, livestock, mining, and industry, in that order.

Regional water-quality issues of concern include the following:
- Nutrient enrichment or pollution of groundwater from the operations of feeding confined animals
- Effects of agricultural and urban land use practices on general groundwater quality—specifically, the potential degradation of drinking water
- Deterioration of groundwater quality as a result of infiltration of degraded surface water
- Effects of focused recharge through playa lakes on local groundwater quality

Groundwater is being depleted globally because, in some areas, it takes centuries to recharge. Some aquifers are rechargeable, but others that contain fossil waters that had been formed when the Pleistocene ice sheets melted are considered a nonrenewable resource. Rates of recharge vary widely, from hundreds to tens of thousands of years. Some scientists consider the Ogallala to be nonrenewable. It does not recharge quickly enough to sustain current use levels. By the 1970s, farmers were already draining the aquifer 10 times faster than the recharge rate in some areas. For nonrenewable groundwater sources, sustainable or appropriate rates of extraction are difficult issues to discuss. Almost any extraction may be nonsustainable, and appropriate rates of extraction are difficult—if not impossible—to determine. At what rate should groundwater pumping be allowed? For what purpose? And who, if anyone, will safeguard the needs of future generations? In the Ogallala Aquifer, for example, the water may be lowered significantly over the next century.

Source:
Jackson et al. 2001 (8).
Role #7—Toxicologist from Nebraska

Concern #7—Poor agricultural practices are contaminating the water quality of the aquifer.

The Ogallala Aquifer’s water supply is being depleted at alarming rates. At the same time, the remaining water quality is becoming increasingly polluted because of poor agricultural practices. Agricultural runoff is the greatest nonpoint source of water pollution in the United States. Salt, fertilizers, pesticides, chemicals, and animal wastes are contaminating the aquifer and consequently affecting soil productivity and our health.

Unlike municipal or sewage water, irrigation does not permit improvement of water quality before it returns to the source. This situation leads to changes in the amounts of dissolved salts and adds agricultural chemicals and eroded sediments to both the soil and the aquifer. For instance, nitrates found in the fertilizers used on farms and home lawns seep into groundwater, that water can be harmful when consumed by children and pregnant women. Pesticides have also seeped into groundwater; in some areas, they have exceeded water quality standards established by the Environmental Protection Agency. There are no known economical ways to remove the pesticides once they have entered groundwater sources. Animal wastes from confined feeding operations of cattle, hogs, and chicken are another major source of water pollution, which, in turn, decreases the soil’s productivity.

The water of the Ogallala Aquifer is generally still suitable for irrigation. However, levels of dissolved solids or salts, fluoride, chloride, and sulfate are above the EPA’s drinking water standards. Federal monitoring occurs in any community that relies on groundwater for drinking, but in other areas, such monitoring is infrequent or nonexistent because of the associated high costs.

Better management and monitoring are needed to help safeguard the water quality of the Ogallala Aquifer and to ensure that future generations can safely use the water for drinking and irrigation.

Source:
Guru and Horne 2005 (E).
Role #8—Economist from South Dakota

Concern #8—Conserving the Ogallala Aquifer is essential to the economy of the High Plains.

The economy of the High Plains is centered on three sectors: crops, livestock, and meat processing. Each of those sectors is highly dependent on water drawn from the Ogallala Aquifer. Irrigated crops provide food for livestock, which, in turn, is the primary input for meat-processing plants. Because of the aquifer’s slow rate of recharge, the High Plains economy relies on a finite resource.

Water is fundamental to the region’s livelihood, and policies affecting water use ultimately change the scope and distribution of economic activity, plus the use of land and other natural resources. For instance, the U.S. Department of Agriculture’s Farm Service Agency instituted the Conservation Reserve Program in 1985. This voluntary program, which is available to agricultural producers, helps protect environmentally sensitive land. Participants plant long-term, resource-conserving groundcover to improve water quality, to control soil erosion, and to enhance wildlife habitat. This method reduces water runoff and sedimentation and, therefore, protects both groundwater and water on the surface. In return, participants receive rental payments and other financial assistance.

Legislators should focus on the economics of water conservation when drafting new policy initiatives. We must conserve for economic efficiency, which means that resource use should yield the greatest net benefit to society. However, private costs of pumping are less than the social costs of withdrawing water—so excessive pumping occurs. Colorado, Kansas, and New Mexico have adopted policies to deny new water permits if water availability in surrounding wells would be significantly reduced. However, no such restrictions occur in Texas, where the Texas Supreme Court ruled that “the owner of the land is the absolute owner of the soil and percolating water.”

Sources:
Peterson, Marsh, and Williams 2003 (E).
U.S. Department of Agriculture Farm Service Agency 2003 (E).
Performance Expectations:

**Development**: The writer provides accurate, specific, and purposeful scientific facts and concepts that are extended and expanded to fully explain the topic.

**Organization**: The writer establishes an organizational plan and consistently maintains it.

**Task Components**: The writer provides all information requested accurately and in full detail.

**Language**: The writer consistently provides scientific vocabulary and language choices to enhance the task. There are no errors in the mechanics (spelling and grammar).

**Development**: The writer provides scientific facts and concepts that adequately explain the topic with some extension of ideas. The information is usually accurate and purposeful.

**Organization**: The writer establishes and maintains an organizational plan, but the plan may have some minor flaws.

**Task Components**: The writer provides most information requested accurately and in full detail.

**Language**: The writer frequently provides scientific vocabulary and uses language choices to enhance the task. There are a few errors in the mechanics (spelling and grammar).

**Development**: The writer provides scientific facts and concepts that inadequately explain the topic. The information is sometimes inaccurate, general, or extraneous.

**Organization**: The writer generally establishes and maintains organizational plan.

**Task Components**: The writer provides most information requested accurately with some details missing.

**Language**: The writer sometimes provides scientific vocabulary and uses language choices to enhance the text. There are significant errors in mechanics (spelling and grammar).

**Development**: The writer provides insufficient scientific facts and concepts to explain the topic. The information provided may be vague or inaccurate.

**Organization**: The writer either did not establish an organizational plan, or if an organizational plan is established, it is only minimally maintained.

**Task Components**: The writer provides information requested with errors and missing details.

**Language**: The writer seldom, if ever, provides scientific vocabulary and uses language choices to enhance the text. There are many errors in the mechanics (spelling and grammar).

Comments

Goals

Actions

1. What process did you go through in this assessment?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

2. Which performance expectations did you meet? What evidence do you have that you mastered them?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

3. How would you rate your work using the rubric on the previous page? What do you need to take into account next time?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

4. What did you learn through the performance task that can inform your future work?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

5. What does this piece reveal about you as a learner?

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________

6. One thing I would like to improve upon is…

_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
_______________________________________________________________________________________
Water Treatment

Every community has a method for pre-treating drinking water from a ground or surface water source. Sometimes the term water purification is used for this treatment, but this term incorrectly suggests that the end result of this process will be pure water, with no impurities. A better term to describe this process is water treatment. In order to be assured that water from a well, stream, or lake has enough impurities removed by water treatment to be used as drinking water, it must go through several water treatment steps. These steps may include settling, filtration, or chlorination. Far from making the water “pure,” the treatment will in many cases simply reduce some impurities to a level found to be acceptable by government agencies. Some typical EPA (Environmental Protection Agency) standards for drinking water are shown in this table.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>&lt; 500 mg/L</td>
</tr>
<tr>
<td>Turbidity</td>
<td>&lt; 5 NTU</td>
</tr>
<tr>
<td>Chloride</td>
<td>&lt; 250 mg/L</td>
</tr>
<tr>
<td>Nitrate</td>
<td>&lt; 10 mg/L</td>
</tr>
<tr>
<td>Copper</td>
<td>&lt; 1.3 mg/L</td>
</tr>
<tr>
<td>Lead</td>
<td>&lt; 0.015 mg/L</td>
</tr>
</tbody>
</table>

In this experiment, you will treat an untreated water sample supplied by your teacher. You will use a number of different methods, including settling, filtration and pH adjustment, to treat your water sample. Before and after the treatment, you will monitor three different indicators of water quality: pH, total dissolved solids (TDS), and turbidity, to see if each quality improves.

Here is a brief summary of each of the three measurements you will be making:

- **pH** is a measurement of how acidic or basic a water sample is. The pH scale ranges from 0 to 14. Drinking water with a pH greater than 7 is basic, and with a pH less than 7 is acidic. It is quite common for drinking water to be slightly basic (between 7 and 8.5), due to the presence of hard-water minerals. EPA standards recommend that drinking water be in the pH range of 6.5-8.5. Because slightly acidic water can cause metal pipes to corrode, if drinking water has a pH less than 7, communities will sometimes adjust that pH to a value that is greater than 7.

- **Total dissolved solids** (TDS) is found to be in a wide range of levels in drinking water. The TDS level of a drinking water supply should be less than 500 mg/L, according to EPA standards; however, high level of TDS from dissolved ions is not usually considered dangerous or harmful, however, and at worst results in water being “hard” (hard to make soap suds), or gives it a slightly bitter or salty taste.

- **Turbidity** is a measurement of the cloudiness (or lack of clarity) of water. The EPA standard for turbidity of drinking water is a value of less than 5 Nephelometric Turbidity Units (NTU). Water with readings in this range will appear to be clear. To reach low levels of turbidity during water treatment, it is sometimes necessary to remove particles or suspended particulates by filtration, screening, or flocculation.

**OBJECTIVES**

In this experiment, you will

- Use a pH Sensor to measure the pH of the pre-treatment and post-treatment samples.
- Use a Conductivity Probe to measure the total dissolved solids (TDS) of the pre-treatment and post-treatment samples.
- Use a Turbidity Sensor to measure the turbidity of the pre-treatment and post-treatment samples.
- Use the test results to see how much the treatment improved the quality of the drinking water sample.
- Compare the drinking water sample to EPA standards shown in the introduction.

**MATERIALS**

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LabPro interface</td>
<td></td>
</tr>
<tr>
<td>Palm handheld</td>
<td>200 mL water sample (in 400 mL beaker)</td>
</tr>
<tr>
<td>Data Pro program</td>
<td>100 mL beaker</td>
</tr>
<tr>
<td>Vernier Conductivity Probe</td>
<td>funnel (top half of milk jug)</td>
</tr>
<tr>
<td>Vernier pH Sensor</td>
<td>100 mL beaker</td>
</tr>
<tr>
<td>Vernier Turbidity Sensor</td>
<td>wash bottle with distilled water</td>
</tr>
<tr>
<td>Turbidity Cuvette</td>
<td>plastic spoon</td>
</tr>
<tr>
<td>Turbidity Standard (StableCal® Formazin)</td>
<td>pH soaking solution in a beaker</td>
</tr>
<tr>
<td>Standard 100 NTU</td>
<td>baking soda and spoon</td>
</tr>
<tr>
<td></td>
<td>waste cup</td>
</tr>
</tbody>
</table>

**PROCEDURE**

**Important:** Do not drink the water that is being treated in this experiment.

1. Obtain a 200 mL sample (in a 400 mL beaker) of untreated water. In this step, you are going to stir the sample to simulate an *unsettled water* sample, and set aside about 40 mL of this sample for testing. To do this:
   a. Obtain a 100 mL beaker
   b. Use a spoon to thoroughly stir the untreated sample for about 15 seconds.
   c. Before the water sample has time to settle, quickly pour about 40 mL of the unsettled water into the 100 mL beaker. Set this 100 mL beaker aside for making *unsettled water* measurements in Step 6. Rinse and dry the spoon, and then place it in the 100 mL beaker.
   d. Set the remaining sample (in the 400 mL beaker) aside for making *settled water* measurements in Step 9. **Important:** This beaker will need to be undisturbed so that settling can occur during the next 10-15 minutes.

2. Connect your sensors and handheld to the LabPro.
   a. Plug the Conductivity Probe into Channel 1. The switch on the Conductivity Probe should be on the 0-2000 μS/cm setting.
   b. Plug the pH Sensor into Channel 2. **Important:** For this experiment your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the LabPro.
   c. Plug the Turbidity Sensor into Channel 3.
   d. Connect the handheld to the LabPro using the interface cable. Firmly press in the cable ends.

3. Press the power button on the handheld to turn it on. To start Data Pro, tap the Data Pro icon on the Applications screen. Choose New from the Data Pro menu or tap [New] to reset the program.

4. Set up the handheld and interface for a Conductivity Probe, pH Sensor, and Turbidity Sensor.
   a. On the Main screen, tap [Setup].
b. If the handheld displays TDS(mg/L) in CH 1, proceed directly to Step 4e. If it does not, continue to 4c to set up your Conductivity Probe manually.

c. Tap [CH1:] to select Channel 1.

d. Choose CONDUCT 1000(mg/L) from the list of sensors.

e. If the handheld displays pH in CH 2, proceed directly to Step 4h. If it does not, continue to Step 4f to set up your sensor manually.

f. Tap [CH 2:] to select Channel 2.

g. Choose PH from the list of sensors.

h. If the handheld displays TURBID(NTU) in CH 3, proceed directly to Step 5. If it does not, continue to Step 4i to set up your sensor manually.

i. Tap [CH 3:] to select Channel 3.

j. Choose TURBIDITY (NTU) from the list of sensors

k. You are now ready to calibrate the Turbidity Sensor in Step 5.

5. Calibrate the Turbidity Sensor.

First Calibration Point

a. Tap [Calibrate], then tap [Calibrate Now].

b. Prepare a blank by filling the glass turbidity cuvette with distilled water so that the bottom of the meniscus is even with the top of the white line. Place the lid on the cuvette. Gently wipe the outside with a soft, lint-free cloth or tissue.

c. Check the cuvette for air bubbles. If air bubbles are present, gently tap the bottom of the cuvette on a hard surface to dislodge them.

d. Holding the cuvette by the lid, place it in the Turbidity Sensor. Make sure that the mark on the cuvette is aligned with the mark on the Turbidity Sensor. Close the lid.

e. In the Value field enter “0” as the turbidity value of the water. You can enter this information using the onscreen keyboard (tap “123”), or by using the Graffiti writing area.

f. When the voltage reading stabilizes, tap [Keep Pt 1].

g. Remove the cuvette and set it aside for use in Step 8.

Second Calibration Point

h. Obtain the cuvette containing the Turbidity Standard (100 NTU) and gently invert it four times to mix in any particles that may have settled to the bottom. Important: Do not shake the standard. Shaking will introduce tiny air bubbles that will affect turbidity.

i. Wipe the outside with a soft, lint-free cloth or tissue.

j. Holding the standard by the lid, place it in the Turbidity Sensor. Make sure that the mark on the cuvette is aligned with the mark on the Turbidity Sensor. Close the lid.

k. In the Value field enter “100” as the turbidity value of the water.

l. When the voltage reading stabilizes, tap [Keep Pt 2].

m. Tap [OK] three times to return to the Main screen.

Part I Unsettled Water
6. You will now measure the TDS level of the *unsettled water* sample in the 100 mL beaker, using the Conductivity Probe. **Important:** For the unsettled sample only, you will need to stir the sample just prior to taking TDS readings.
   a. Place the tip of the electrode into the sample. The hole near the tip of the probe should be completely covered by the sample.
   b. Monitor the TDS reading on the main screen.
   c. When stable, record the TDS value (in mg/L) in the Data Table.
   d. Rinse the Conductivity Probe with distilled water.

7. You will now measure the pH of the *unsettled water* in the 100 mL beaker. **Important:** For the unsettled sample only, you will need to stir the sample just prior to taking pH readings.
   a. Raise the pH Sensor from the pH soaking solution.
   b. Hold the pH Sensor over the waste cup and rinse the tip with distilled water.
   c. Place the tip of the pH Sensor into the water sample. Make sure the glass bulb at the tip of the sensor is completely covered by the water.
   d. When the pH value displayed on the main screen is stable, record it in the Data Table.
   e. Rinse the tip with distilled water again.
   f. Return the pH Sensor to its soaking solution.

8. You are now ready to measure the turbidity of a sample of *unsettled water* in the 100 mL beaker using the Turbidity Sensor. **Important:** For the unsettled sample only, you will need to stir the sample prior to taking turbidity readings.
   a. Empty the distilled water from the cuvette used in Step 5.
   b. Rinse the cuvette with sample water, then fill it with sample water so that the bottom of the meniscus is even with the top of the white line. Place the lid on the cuvette. Gently wipe the outside with a soft, lint-free cloth or tissue.
   c. Check the cuvette for air bubbles. If air bubbles are present, gently tap the bottom of the cuvette on a hard surface to dislodge them.
   d. Gently invert the cuvette four times to mix any particles that may have settled.
   e. Holding the cuvette by the lid, place it into the Turbidity Sensor. Make sure it is in the same orientation in the cuvette slot that is was before. Close the lid.
   f. Monitor the turbidity value on the main screen. When this value is stable, record it in the Data Table and proceed to Step 9. **Note:** Particles in the water will settle over time and show a slow downward drift in turbidity readings. Therefore, take your readings soon after placing the cuvette in the sensor.

**Part II Settled Water**

9. You are now ready to make measurements on the *settled water* in the 400 mL beaker.
   a. Clean and dry the 100 mL beaker that was used in the previous step.
   b. Carefully decant 40 mL of liquid from the 400 mL beaker into the 100 mL beaker. As you pour, try to leave most of the settled solid behind.
   c. Repeat Steps 6-8, this time measuring the TDS, pH, and turbidity of the *settled water* sample in the 100 mL beaker.
   d. **Important:** Set aside the 400 mL beaker with the remaining water for use in Step 10. Discard the water in the 100 mL beaker. Clean and dry the beaker for use in Step 10.
Part III  Filtered Water

10. In this step you will filter the water, and then test the filtered water for TDS, pH, and turbidity levels.

   a. Place 10 coffee filters in the funnel (the top half of milk jug). Nest the filters loosely inside each other. Hold the funnel and filters above a sink or other large vessel, and slowly pour about 200 mL of distilled water through the filter to thoroughly rinse it.
   b. Set the funnel on top of the 100 mL beaker as shown here.
   c. Slowly pour the remaining settled water in the 400 mL beaker into the coffee filter. Pour all of the liquid into the filter. It is OK if most of the solid particles remain in the beaker. Do not let the water level go above the top edge of the filter paper.
   d. When most of the water has drained into the beaker, remove the funnel.
   e. Repeat Steps 6-8, this time measuring TDS, pH, and turbidity of the filtered water sample.
   f. Important: When you have finished making measurements, be sure to keep the remaining filtered water sample for Step 11.

Part IV  pH-Adjusted Water

11. In this step you will adjust the pH of the filtered water, and then test the pH-adjusted water for pH, TDS, and turbidity levels.

   a. Obtain the baking soda container and spoon.
   b. Place the pH Sensor into the filtered water sample from Step 10.
   c. Obtain a small amount of baking soda on the tip of the spoon. Important: In this step, you will want to add the baking soda in the smallest possible amounts you can; tap the tip of the spoon each time so that just a few grains are added. Add the first small amount of baking soda, stirring thoroughly. (Stir with the spoon you previously used for stirring, not the baking soda spoon.)
   d. Monitor the pH after each addition. Baking soda is a mild base, and should cause the pH value displayed on the main screen to increase.
   e. Continue to add baking soda in small amounts until the pH reaches 6.5, a level that is acceptable by EPA standards.
   f. Record the final adjusted pH value in your data table.
   g. Repeat Step 6 (TDS) and Step 8 (turbidity) for the pH-adjusted sample.
   h. When you have finished, discard all water samples as directed by your teacher.

DATA

<table>
<thead>
<tr>
<th></th>
<th>Unsettled water sample</th>
<th>Settled water sample</th>
<th>Filtered water sample</th>
<th>pH-adjusted water sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids, TDS (mg/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**PROCESSING THE DATA**

1. Examine your data and decide if each of the methods shown below improved the quality (I), decreased the quality (D), or had little or no effect (N). Place an I, D, or N in each of the spaces in the table below to indicate your answer.

<table>
<thead>
<tr>
<th></th>
<th>Settling</th>
<th>Filtration</th>
<th>Adjust pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Based on your results, does filtration appear to remove ions (such as Na$^+$ and Cl$^-$ ions in salt, or Na$^+$ and HClO$_3^-$ in baking soda) from a water sample? Explain.

3. What is the purpose of the pH adjustment in Step 11? Is the substance that is added, baking soda (sodium bicarbonate) an acid or a base? Did your solution end up with an acidic, neutral, or basic pH?

4. Were there any water qualities that appeared to get worse as the result of water treatment? Which? Is the change in this property necessarily a bad thing, overall? Explain.

5. Which of the three water quality characteristics, pH, TDS, or turbidity, met EPA standards before treatment? Which met EPA standards after treatment? If you had any that did not meet EPA standards after treatment, suggest ways that you might continue treatment to meet that standard.

6. Do the results of this experiment suggest that a “clear” appearance indicates high-quality drinking water? Explain.
EXTENSIONS

1. Test tap water (drinking water) from your area, and see how TDS, pH, and turbidity values compare to those you obtained in this experiment.

2. Test surface and ground water samples from wells, lakes and streams in your area, and see how TDS, pH, and turbidity values compare those you obtained in Extension 1 (tap water). You can sometimes tell if your community adjusts its water for pH by comparing pH and TDS levels of local surface or ground water with those of local tap water.

3. Obtain water-softening beads from a local water-treatment company, and see if the process of “softening” drinking water results in changes in pH or TDS.
Water Quality – pH

Water contains both hydrogen ions, H\textsuperscript{+}, and hydroxide ions, OH\textsuperscript{−}. The relative concentrations of these two ions determine the pH value.\textsuperscript{1} Water with a pH of 7 has equal concentrations of these two ions and is considered to be a neutral solution. If a solution is acidic, the concentration of H\textsuperscript{+} ions exceeds that of the OH\textsuperscript{−} ions. In a basic solution, the concentration of OH\textsuperscript{−} ions exceeds that of the H\textsuperscript{+} ions. On a pH scale of 0 to 14, a value of 0 is the most acidic, and 14 the most basic. A change from pH 7 to pH 8 in a lake or stream represents a ten-fold increase in the OH\textsuperscript{−} ion concentration.

Rainfall generally has a pH value between 5 and 6.5. It is acidic because of dissolved carbon dioxide and air pollutants, such as sulfur dioxide or nitrogen oxides. If the rainwater flows over soil containing hard-water minerals, its pH usually increases. Bicarbonate ions, HCO\textsubscript{3}\textsuperscript{−}, resulting from limestone deposits react with the water to produce OH\textsuperscript{−} ions, according to the equation:

\[
\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 + \text{OH}^- \]

As a result, streams and lakes are often basic, with pH values between 7 and 8, sometimes as high as 8.5.

The measure of the pH of a body of water is very important as an indication of water quality, because of the sensitivity of aquatic organisms to the pH of their environment. Small changes in pH can endanger many kinds of plants and animals; for example, trout and various kinds of nymphs can only survive in waters between pH 7 and pH 9. If the pH of the waters in which they live is outside of that range, they may not survive or reproduce.

<table>
<thead>
<tr>
<th>pH</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 – 3.5</td>
<td>Unlikely that fish can survive for more than a few hours in this range, although some plants and invertebrates can be found at pH levels this low.</td>
</tr>
<tr>
<td>3.5 – 4.0</td>
<td>Known to be lethal to salmonids.</td>
</tr>
<tr>
<td>4.0 – 4.5</td>
<td>All fish, most frogs, insects absent.</td>
</tr>
<tr>
<td>4.5 – 5.0</td>
<td>Mayfly and many other insects absent. Most fish eggs will not hatch.</td>
</tr>
<tr>
<td>5.0 – 5.5</td>
<td>Bottom-dwelling bacteria (decomposers) begin to die. Leaf litter and detritus begin to accumulate, locking up essential nutrients and interrupting chemical cycling. Plankton begin to disappear. Snails and clams absent. Mats of fungi begin to replace bacteria in the substrate. Metals (aluminum, lead) normally trapped in sediments are released into the acidified water in forms toxic to aquatic life.</td>
</tr>
<tr>
<td>6.0 – 6.5</td>
<td>Freshwater shrimp absent. Unlikely to be directly harmful to fish unless free carbon dioxide is high (in excess of 100 mg/L)</td>
</tr>
<tr>
<td>6.5 – 8.2</td>
<td>Optimal for most organisms.</td>
</tr>
<tr>
<td>8.2 – 9.0</td>
<td>Unlikely to be directly harmful to fish, but indirect effects occur at this level due to chemical changes in the water.</td>
</tr>
<tr>
<td>9.0 – 10.5</td>
<td>Likely to be harmful to salmonids and perch if present for long periods.</td>
</tr>
<tr>
<td>10.5 – 11.0</td>
<td>Rapidly lethal to salmonids. Prolonged exposure is lethal to carp, perch.</td>
</tr>
<tr>
<td>11.0 – 11.5</td>
<td>Rapidly lethal to all species of fish.</td>
</tr>
</tbody>
</table>

\textsuperscript{1}The pH value is calculated as the negative log of the hydrogen ion concentration: pH = –log [H\textsuperscript{+}].
Changes in pH can also be caused by algal blooms (more basic), industrial processes resulting in a release of bases or acids (raising or lowering pH), or the oxidation of sulfide-containing sediments (more acidic).

To gain a full understanding of the relationship between pH and water quality, you need to make measurements of the pH of a stream, as described in this test, and also determine the stream’s alkalinity, as described in Test 11 in this manual. Alkalinity is a measurement of the capacity or ability of the body of water to neutralize acids in the water. Acidic rainfall may have very little effect on the pH of a stream or lake if the region is rich in minerals that result in high alkalinity values. Higher concentrations of carbonate, bicarbonate, and hydroxide ions from limestone can provide a natural buffering capacity, capable of neutralizing many of the H⁺ ions from the acid. Other regions may have low concentrations of alkalinity ions to reduce the effects of acids in the rainfall. In the Northeastern United States and Eastern Canada, fish populations in some lakes have been significantly lowered due to the acidity of the water caused by acidic rainfall. If the water is very acidic, heavy metals may be released into the water and can accumulate on the gills of fish or cause deformities that reduce the likelihood of survival. In some cases, older fish will continue to live, but will be unable to reproduce because of the sensitivity of the reproductive portion of the growth cycle.

**Expected Levels**

The pH value of streams and lakes is usually between pH 7 and 8. Levels between 6.5 and 8.5 pH are acceptable for most drinking water standards. Areas with higher levels of water hardness (high concentrations of Mg²⁺, Ca²⁺, and HCO₃⁻) often have water with higher pH values (between 7.5 and 8.5).

**MATERIALS**

<table>
<thead>
<tr>
<th>LabPro interface</th>
<th>wash bottle with distilled water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm handheld</td>
<td>pH 7 buffer solution (optional)</td>
</tr>
<tr>
<td>Data Pro program</td>
<td>pH 10 buffer solution (optional)</td>
</tr>
<tr>
<td>Vernier pH Sensor</td>
<td>tissues or paper towels</td>
</tr>
<tr>
<td>250 mL beaker</td>
<td>small plastic or paper cup (optional)</td>
</tr>
</tbody>
</table>

**Collection and Storage of Samples**

1. This test can be conducted on site or in the lab. A 100 mL water sample is required.

2. It is important to obtain the water sample from below the surface of the water and as far away from shore as is safe. If suitable areas of the stream appear to be unreachable, samplers consisting of a rod and container can be constructed for collection.

3. If the testing cannot be conducted within a few hours, store samples in an ice chest or refrigerator.

**Factors that Affect pH Levels**

- Acidic rainfall
- Algal blooms
- Level of hard-water minerals
- Releases from industrial processes
- Carbonic acid from respiration or decomposition
- Oxidation of sulfides in sediments
PROCEDURE

1. Plug the pH Sensor into Channel 1 of the LabPro interface. Connect the handheld to the LabPro using the interface cable. Firmly press in the cable ends.

2. Press the power button on the handheld to turn it on. To start Data Pro, tap the Data Pro icon on the Applications screen. Choose New from the Data Pro menu or tap (New) to reset the program.

3. Set up the handheld and interface for the pH Sensor.
   a. On the Main screen, tap (Setup).
   b. If the handheld displays pH in CH 1, proceed directly to Step 4. If it does not, continue with this step to set up your sensor manually.
   c. Tap (CH1) to select Channel 1.
   d. Press the Scroll buttons on the handheld to scroll through the list of sensors.
   e. Choose PH from the list of sensors.

4. Set up the calibration for the pH Sensor.
   • If your instructor directs you to use the stored calibration, proceed directly to Step 5.
   • If your instructor directs you to manually enter the calibration values, tap (Calibrate) then tap (Manual). Enter the slope and intercept values, using the onscreen keyboard (tap “123”) or using the Graffiti writing area and tap (Keep). Tap (OK) to return to the Setup screen, then proceed to Step 5.
   • If your instructor directs you to perform a new calibration, follow this procedure.

   First Calibration Point
   a. Tap (Calibrate), then tap (Calibrate Now).
   b. Place the sensor tip into the pH-7 buffer.
   c. In the Value field enter “7” as the pH. You can enter this information using the onscreen keyboard (tap “123”), or by using the Graffiti writing area.
   d. When the voltage reading stabilizes, tap (Keep Pt 1).

   Second Calibration Point
   e. Rinse the sensor with distilled water and place it in the pH-10 buffer solution.
   f. Enter “10” as the pH. When the voltage reading stabilizes, tap (Keep Pt 2).
   g. Tap (OK) two times to return to the Setup screen.

5. Set up the data-collection mode.
   a. On the Setup screen, tap (Mode) then choose Single Point. In this data collection mode, the handheld will collect data for 10 seconds and then display an averaged pH value.
   b. Tap (OK) to return to the Main screen.
6. Collect pH data.
   a. Remove the pH Sensor from the storage bottle. Rinse the tip of the sensor thoroughly with the stream water.
   b. Place the tip of the sensor into the stream at Site 1, or into a cup with sample water from the stream. Submerge the sensor tip in the stream or in a cup to a depth of 3-4 cm.
   c. Tap **Start** to begin a 10 second sampling run. **Important:** Leave the probe tip submerged for the 10 seconds that data is being collected.
   d. Once data collection is finished, the averaged pH value will be displayed. Record the value in the data table.
   e. Tap **Collect Another Point** to take a second reading for this same sample. Record this value on the Data & Calculations sheet (round to the nearest 0.01 pH units).
   f. Tap **OK** to return to the Main screen.
   g. Rinse the sensor with distilled water and return it to the storage bottle when you have finished collecting your data.

**DATA & CALCULATIONS**

**pH Measurement**

Stream or lake: ____________________________  Date: ____________________________

Site name: ______________________________  Time of day: _______________________

Student names: __________________________________________

<table>
<thead>
<tr>
<th>Reading</th>
<th>pH (pH units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
</tr>
</tbody>
</table>

Field Observations (e.g., weather, geography, vegetation along stream) ______________________________

_________________________________________________________________________________________

_________________________________________________________________________________________

_________________________________________________________________________________________

Test Completed: _________________  Date: ______
Other suggestions:

Weathering, Erosion and Deposition

Goal:
Your task is to help NASA scientists find a meteorite hidden in a glacier that may contain evidence of extraterrestrial life by preparing a topographic map to include major features of erosion and deposition in Denali National Park located in Alaska*.

Role:
You are an expert topographer and glaciologist.

Audience:
Your target audience consists of senior NASA officials who are unfamiliar with the topography of the Mt. McKinley region of Denali National Park.

Situation:
You have been asked to prepare a detailed topographic map to include major features of erosion and deposition in Denali National Park. Because these features are glacial, you will need to include a color-coded key identifying arêtes, cirques, horns, hanging valleys, tills, moraines (all types), drumlins, eskers, outwash plains, and glaciers.

Product Performance and Purpose:
You need to obtain a topographic map of the region and make it user-friendly for the NASA scientists looking for the meteorite.

Standards and Criteria for Success:
Your map must meet the following standards:
  a. It must be neat and legible.
  b. It must include a color-coded key with the glacial features labeled.
  c. You need to include an informative pamphlet/brochure describing each of the glacial features to help the NASA scientists find the meteorite.

"Teachers may need to change the location of the specific area due to the availability of topographic maps at individual schools.

Key Criteria:
Weathering, Erosion and Deposition; Soil Formation; and Groundwater

Suggested Assessment Evidence

Pre-Assessment

- K-W-L about weathering, erosion, and deposition.
- True-False pretest on Earth’s water.
- Teacher-generated multiple choice pretest on soil formation.

On-going Assessment

Use frequent questioning strategies ranging from basic to upper level thinking skills. Suggestions include:

- What are the processes of erosion, deposition, and weathering?
- What are major sources of water?
  - What are major groundwater zones?
  - Why is groundwater a valuable resource?
  - What is the top of the zone of saturation called?
  - What happens to water in the zone of aeration?
  - How is the zone of saturation defined?
  - Why is groundwater considered a valuable resource?

- How do humans acquire water from an aquifer?
  - Why is it important that we protect aquifers from contamination?
  - What are the major uses for water drawn from aquifers?

- Why is fresh water so important to humans?
  - How do humans threaten their own freshwater resources?
  - What are some natural threats to a freshwater resource?

- What is the recycling process for water?

- What is karst topography?
  - What type of rock is needed for karst topography?
  - What property of limestone makes karst topography possible?
  - What are some topographic features created by karst topography?

- What are the components of a mature soil profile?
  - What factors affect the development of soil?
  - What are the major types of soil?
  - What are the processes that create soil?

- How is soil horizons defined?
  - How does Horizon A differ from Horizon B?

- What major type of climate is least productive in terms of soil development and why?
What are some extraneous factors that affect soil development?
How does topography affect soil development?

**Summative Assessment**
Quizzes, tests, summative projects

**Suggested Learning Activities and Resources**

**Weathering**
- TE Activity Weathering Walk, p. 343
- TE Activity Ice Wedging, p. 344
- CRF Quick Lab SE, p.345, Data Sheet
- TE Group Activity Finding Evidence, p. 345
- TE Demonstration Rusting, p. 346
- TE Discussion Weathering on the Moon, p. 346
- TE Activity Chalk Sculptures, p. 347
- Teacher Transparency 71 Chemical Weathering
- Video HRW Earth Science Video Weathering and Erosion
- Interactive Tutor CD Physical and Chemical Weathering
- TE Activity Create a Cave, p. 350
- SE, CRF Quick Lab Surface Area, p. 350
- Teacher Transparency 72 Surface Area
- TE, CRF Internet Activity National Parks, p. 349

**Erosion and Deposition**
- TE Bellringer Rocky Mountains vs. Appalachian Mountains, p. 357
- TE SciLinks Soil Erosion, Conservation, p. 358
- SE Graphic Organizer Spider Map Soil Conservation Methods, p. 360
- TE Reading Skills Builder, p. 362
- TE Discussion Protecting Against Mass Movements, p. 361
- TE Demonstration Solifluction, p. 362
- Teacher Transparency 74 Soil Erosion Vulnerability Map
- TE Activity Modeling Glacial Ice Formation, p. 419
- Teacher Transparency 83 Internal Plastic Flow
- TE Internet Activity Glacial Sounds, p. 420-421
- TE Glacial Erosion and Deposition Simulation, p. 423
- Teacher Transparency 84 Landforms Created by Glacial Erosion
- Teacher Transparency 85 Features of Glacial Deposition
- TE Internet Activity More Glacial Landforms and Features, p. 428
- TE Demonstrations Watching Sand Jump, p. 445
- Teaching Transparency 89 Types of Dunes
- TE Geography Connection Coastal Features, p. 457
- Teacher Transparency 90 Wave Erosion and Landforms
- SE Inquiry Lab Beaches, p. 464-465
- TE, CRF Landform Photographs
- SE Maps in action Coastal Erosion Near the Beaufort Sea, p. 466
- Teacher Transparency 91 Submergent Coastlines
Teacher Transparency 92 Coastal Erosion Near the Beaufort Sea
TE Scilinks Coastal Changes, p. 458

**Surface Water Erosion**
TE Group Activity Modeling the Water Cycle, p. 375
CRF, SE Quick Lab Modeling the Water Cycle, p. 377, Data Sheet
CRF Inquiry Lab Eutrophication
CRF Skills Practice Lab Stream Quality Modeling
Teacher Transparency 76 The Water Cycle
Interactive Tutor CD Ice, Water, and Vapor
Interactive Tutor CD The Water Cycle
CRF Inquiry Lab Sediments and Water, pp. 392-393, Data Sheet
SE Maps in Action SE World Watershed Sediment Yield, p. 394
TE Discussion Sediment Load and Land Use, p. 394
SE Mapping Expeditions What Comes Down Must Go…Where?, p. 838-839
Teacher Transparency 77 Stream Gradient and Channel Erosion
Teacher Transparency 78 Water Shed Sediment Yield
CRF Internet Activity Watersheds, p. 379,
Video HRW Earth Science Video Water and Erosion (River Systems)
Interactive Tutor Physical and Chemical Weathering
TE Demonstration Changing Land Use p. 383
TE Debate To Stay or Not to Stay, p. 384
CRF, SE Quick Lab Soil Erosion, p. 385, Datasheet
TE, CRF Internet Activity Restoring Rivers, p. 395

**Soil Formation**
TE Group Activity What is Soil?, p. 353
CRF Acid Rain and Soils
TE Discussion Local Soils, p. 372
CRF Making Models Lab Soil Profile
Teacher Transparency 73 Soil Horizons of Residual Soils
Teacher Transparency 75 Soil Map of North Carolina
TE Demonstration Soil Conservation, p. 360
TE Activity Soil and Plants, p. 360
TE Social Studies Connection, p. 361
CRF Internet Activity NRCS
Interactive Tutor CD Soils

**Ground Water**
CRF, SE Quick Lab Permeability, p. 398, Datasheet
TE Demonstration Comprehension Check, p. 398
TE Group Activity Model of an Aquifer, p. 399
Teacher Transparency 79 Porosity and Permeability
SE Skills Practice Lab Porosity, pp. 414-415
Teacher Transparency 80 Zones of Aquifers
Teacher Transparency 81 Topography and the Water Table
TE Debate Limited Development?, p. 417
TE, CRF Internet Activity Your Watershed, p. 400
CRF Making Models Lab Making a Classroom Geyers

**Karst Topography**
TE, CRF Internet Activity Sinkholes, p. 417
CRF Inquiry Lab Cave Formations and Ecology
TE Bellringer, p. 405
TE, CRF Internet Activity Sinkholes
TE, CRF Using Figure Cave Formation, p. 406
SE Quick Lab Chemical Weathering, p. 405

**Water Quality**
TE, CRF Maps in Action Water Level in Southern Ogallala, p. 416
TE, CRF Internet Activity Sinkholes, p. 417
TE Impact on Society, Disappearing Land, p. 417

**Instructional Resources**

Text: Holt, Reinhart, Wilson, Earth Science

Weathering
- TE, pp. 342-352

Erosion and Deposition
- TE 357-386, 418-441, 445-467

Surface Water
- TE 375-386

Soil Formation
- TE pp. 353-356

Groundwater
- TE pp. 397-404.

Karst Topography
- TE pp. 405-408
- TE pp. 416-417
Websites:
- [http://www.wm.edu/geology/virginia/karst_topography.html](http://www.wm.edu/geology/virginia/karst_topography.html) (Geology of VA website)
- [http://www2.nature.nps.gov/geology/tour/caves.cfm](http://www2.nature.nps.gov/geology/tour/caves.cfm) (National Park Service website)
- [http://members.shaw.ca/karst.almighty/](http://members.shaw.ca/karst.almighty/) (fantastic slide show of karst topography)
- [http://www.karstconservancy.org/](http://www.karstconservancy.org/) (the Karst Conservancy)
- [http://www.watersheds.org/earth/karst.htm](http://www.watersheds.org/earth/karst.htm) (photos, movie, information website)
- [http://www.cancaver.ca/docs/karst.htm](http://www.cancaver.ca/docs/karst.htm) (Canadian Cave and Karst Information)
Stage 3: Learning Plan

Weathering
Weathering – the breakdown of rock into smaller pieces

Mechanical (Physical)

Changing of the rocks shape or form

Frost Action
Freeze – thaw – freeze – thaw
H₂O freezes and it expands by 9%

Extreme Temps – Cold & Hot
Expand & Contract

Plants & Animals – Roots, animal burrowing, humans

Exfoliation – Peeling off in parallel layers – domes on a large scale.

Chemical

Breakdown of rock by changing its chemical composition

Oxygen – O₂ combines with another substance Oxidation
RXU/Iron + O₂ Rock w/rust

Water

Hydrolysis/Carbon Dioxide
a) dissolves minerals
b) combines to make other minerals
c) Carbon dioxide: CO₂ + H₂O = Carbonic Acid
ex. Caverns

Acid Precipitation
By pollution
Sulfur Dioxide and Nitrogen enter atmosphere and mix with water in the clouds. Rains a weak acid – over time dissolves rock. Common in North Eastern part of United States.

Created by: Laura Eldredge & Meyon Burns
Rate of Weathering

Natural ________________ occurs very slowly. It takes _______________ years to weather _______________ of limestone. Certain _______________ and ________________ can accelerate or _______________ the weathering process.

**Climate**

Includes precipitation, temperature and evaporation.

**Chemical:** Warm temperatures, abundant rainfall and lush vegetation.

**Physical:** cool, dry climates. Faster when frost action is occurring.

**Rock Type and Composition**

**Sedimentary Rocks:** easily broken down

**Igneous and Metamorphic:** Harder to break down – harder minerals in them.

**Surface Area**

**Mechanical Weathering** breaks down the rock which makes more surface area.

Then **chemical weathering** will dissolve the rock faster then small it is.

**Topography And Variables**

**Level Ground**— flatter, less weathering

**Sloped Ground**— The steeper the slope the faster the weathering
Weathering –

Mechanical

Breakdown of rock by changing its chemical composition.

Oxygen –

Water

Frost Action

Extreme Temps –

Roots, animal burrowing, humans

Hydrolysis/Carbon Dioxide
a) dissolves minerals
b) 
c) 
ex. Caverns

By pollution
Sulfur Dioxide and Nitrogen enter atmosphere and mixes with water in the clouds. Rains a weak acid – over time dissolves rock. Common in North Eastern part of United States.
Rate of weathering
Natural __________________ occurs very slowly. It takes ____________ years to weather ______________ of limestone. Certain ______________ and ______________ can accelerate or __________ the weathering process.

Climate
Includes
____________________,
____________________,
____________________.
Chemical:

Physical:

Rock Type and Composition
Sedimentary Rocks:

Igneous and Metamorphic:

Surface Area
Mechanical Weathering

Then chemical weathering

Topography And Variables
Level Ground-

Sloped Ground –
Types of Soil

Using a Soil Textures Diagram (triangular graph), determine the soil types in the chart below.

<table>
<thead>
<tr>
<th>Soil Sample</th>
<th>Percentage of Sand</th>
<th>Percentage of Silt</th>
<th>Percentage of Clay</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>40</td>
<td>45</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>50</td>
<td>20</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>30</td>
<td>60</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>20</td>
<td>20</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>10</td>
<td>10</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

Questions:
1. Which soil type has the smallest-sized particles?

2. Which soil type would have the largest-sized particles?

3. What does the total percentage of all three soil types have to add up to? Why?

4. How does the soil type affect water retention?
### Weathering and Erosion Walkabout

<table>
<thead>
<tr>
<th>Examples of Weathering/Erosion</th>
<th>Location</th>
<th>Agent of Weathering/Erosion</th>
<th>Type of Weathering/Erosion</th>
<th>Cause(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worn path on grass leading to outside door</td>
<td>NW corner of school</td>
<td>Abrasion</td>
<td>Mechanical Weathering</td>
<td>Students walking on grass wore away grass causing pathway</td>
</tr>
</tbody>
</table>
**Questions:**

1. Were you able to find examples of both chemical and physical weathering?

2. Which type of weathering was found most often?

3. Were you able to find examples of erosion? If so, name a location and cause for this erosion.

4. Were you able to find examples of mass wasting such as creep or slump? If so, name these.

5. How does the climate of Virginia Beach affect weathering and/or erosion?

Created by: Sandy Jackson
Soil Screen Sieve Lab

Purpose

1. to separate soil samples and examine the individual characteristics
2. to examine the permeability of the soil types.

Procedure

1. Separate the soil samples by crushing the soil aggregates using your fingers.
2. Arrange the screen sieves with the largest screen on the top, and proportionately decreasing in size to the closed bottomed container.
3. Place one 200 ml beaker on the balance beam and obtain its mass, record on data table. Now add the soil sample to the beaker and re-mass and record. Now place the contents in the uppermost sieve, cover it, and lightly shake it using a back-and-forth motion.
4. The particles are then carefully removed from each sieve and their separate masses obtained.
5. Record the masses in reference to the individual sieves:
   a) 1st sieve - #5 mesh – gravel
   b) 2nd sieve - #10 mesh – fine gravel
   c) 3rd sieve- #60 mesh – coarse sand.
   d) 4th sieve - #230 mesh – fine sand
   e) bottom pan – silt and clay
6. Construct a chart detailing the individual masses and respective percentage of the total soil sample. See the board. Percentages can be computed by adding all masses together for a Total Sample Mass. Then divide the TSM into each individual soil sample mass to obtain the percentage.
7. When finished, completely clean the sieves and begin with the second sample, recording the same data.

Construct a data table to show your results.

Questions (on your paper in complete sentences)

1. What is soil?
2. Which sample contained the greatest amount of coarse particles? Which the finest?
3. Give a brief overview of the samples in each sieve.
4. How does location affect soil properties?
Soil Permeability and Capillary Water

**Purpose**

To examine the permeability and capillary water in various earth materials.

**Procedure**

1. Obtain a 250 ml of the sample soil mixture.
2. Place the sample into the properly arranged screen sieves and separate the mixture as before.
3. Arrange the samples on three paper towels and label.
4. Obtain three funnels (with 3 pieces of filter paper), and three 250 ml Erlenmeyer flasks.
5. Place a filter in each of the 3 funnels, and add an equal amount of soil samples (use #2, #3, and #4) from each screen to the funnels.
6. Now fill a 50ml graduated cylinder with 50 ml of water.
7. Construct a chart on your paper that resembles the one on the board. Record the amount of time it takes for the water to pass through the funnel. Use the set up as seen in the illustration.
8. Now measure the amount of water left in the flask by pouring it back in the graduated cylinder, and recording your answer on the chart.
9. The capillary water or soil water can now be determined by subtracting the amount collected from the original 50 ml.
10. Organize all data in your chart.

**Questions and Conclusions** (put on separate paper with your data chart.)

1. What is permeability?
2. What is capillary water or soil water?
3. Rank the soil samples from fastest flow to slowest. Explain how this illustrates soil permeability.
4. Develop a theory as to why there was a difference in times in the above question.
5. Rank the samples according to capillary water from the highest to the lowest.
6. Why would crops have difficulty growing on an area of sand or gravel?
7. What is ground water?
8. Provided all other conditions were equal, if the three types of particles in this investigation formed the ground cover for three different areas, under which area would the ground water level be the highest?
Investigation: How Does Soil Vary From Place to Place?

Directions

1. Open Internet Explorer. Type in www.classzone.com
2. Choose your subject as “Science”
4. You will see a web page, with the following title bars at the top: “Investigations,” “Visualizations,” “Data Centers,” “Earth News,” “Resources.”
5. Click on “Investigations.” Click on Chapter 12 and choose “How Does Soil Vary from Place to Place.”
6. Answer the questions below as you do the investigation. Click on the next page when done and to all activities on each page.

Questions

1. Write 3 observations about the soil in the first photo

2. Fill in the chart for pages 3 and 4.

<table>
<thead>
<tr>
<th>State</th>
<th>Topsoil Depth</th>
<th>Similarities</th>
<th>Differences</th>
<th>Average Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Montana</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arizona</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hawaii</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Describe any pattern that exists between topsoil depth and average annual precipitation.

Graph of Topsoil and Precipitation
Mass Wasting/Problem Solving

Mass wasting – when large amounts of earth materials move downhill due to the force of gravity.

Types:  
- Mud slide – large amounts of mud flowing downhill.  
- Land slide – large amounts of land sliding downhill.  
- Avalanche – large amounts of snow and ice sliding downhill.  
- Creep – Slow movement of soil downhill.

Problem

The community of Mudville is built on a hillside. Geologists have determined that an annual rainfall of 81 inches will send the town plummeting to its ruin. Plot the data and predict the year that the town will slide away if the pattern persists.

Data

<table>
<thead>
<tr>
<th>Year</th>
<th>85</th>
<th>86</th>
<th>87</th>
<th>88</th>
<th>89</th>
<th>90</th>
<th>91</th>
<th>92</th>
<th>93</th>
<th>94</th>
<th>95</th>
<th>96</th>
<th>97</th>
<th>98</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (in.)</td>
<td>74</td>
<td>75</td>
<td>76</td>
<td>75</td>
<td>76</td>
<td>77</td>
<td>76</td>
<td>77</td>
<td>78</td>
<td>77</td>
<td>78</td>
<td>79</td>
<td>78</td>
<td>79</td>
<td>80</td>
</tr>
</tbody>
</table>

Graph

Conclusion: What year will Mudville slide downhill? __________
**Problem 2**

A landslide has occurred in the city of Studyville covering the school and trapping the students inside. The students are stuck at school until an opening can be cleared. The students begin digging at a rate of 100 tons of dirt an hour. Each hour they slow down because of lack of oxygen and remove 10 tons less each hour. If they must remove 550 tons of dirt in order to escape, will they escape and, if so, how many hours will it take them? Graph your results.

**Graph**

<table>
<thead>
<tr>
<th>Tons</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>

**Conclusion**

Will they survive? ___________

How many hours are needed to move 550 tons of dirt at this rate? ___________
Visualizations: Weathering, Soil and Erosion

Directions

After doing the Investigation “How Does Soil Vary from Place to Place?” Click the “HOME” button, and then choose “Visualizations” at the top of the page. Click on Chapter 12, “Weathering, Soil and Erosion” for the following:

1. View: Observing the Effects of Mechanical Weathering.
   What types of mechanical weathering would you expect to see in Virginia Beach?

2. View: Observing the Chemical Weathering of Feldspar to Clay.
   How does water affect a feldspar mineral?

   What color will it turn?

   What formed Arches National Park in Utah?

   What produced Carlsbad Caverns in New Mexico?

   How are desert monuments formed?

   Why does California have sea cliffs?

   How does a glacier change the shape of a valley?

   Yellowstone National Park’s river is cutting into what type of rock?

4. View: Chapter 14: Observe an Animation of a Cave Formation.
   How long does it take to form a cave?

   What causes a cavern to be exposed?

   State the 3 steps involved to form a cavern.

   1.
   2.
   3.
Investigation: How FAST DO GLACIERS FLOW?

Directions

1. Open Internet Explorer. Type in www.classzone.com
2. Choose your subject as “Science”
4. You will see a web page, with the following title bars at the top: “Investigations,” “Visualizations,” “Data Centers,” “Earth News,” “Resources.”
5. Click on “Investigations.” Click on Chapter 15 and choose “How Fast Do Glaciers Flow?”
6. Answer the questions below as you do the investigation. Click on the next page when done and to all activities on each page.

Questions

1. Valley glaciers have been called ________________________.

2. How could you measure the speed at which a glacier flows?

3. Predict which stakes you would expect to move the farthest in one week. Explain your answer.

4. Which stakes moved the farthest?
5. These data show how far the flags moved in one week. At this rate, calculate how far the glacier would flow in 52 weeks (1 year).

<table>
<thead>
<tr>
<th>Flag #</th>
<th>8/1/98</th>
<th>8/8/98</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>5.7</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>14.4</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>22.9</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>25.6</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>27.1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>26.4</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>26.3</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>23.0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>16.0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>8.7</td>
</tr>
</tbody>
</table>

6. Why do you think the center of the glacier moves faster than the sides?

7. What is the highest flow rates observed on the Lambert Glacier? Which part of it is moving the fastest?

8. Explain why measuring flow rate at just one point along a glacier is not a good indicator of its overall flow rate.
Visualizations: GLACIERS VISUALIZATIONS

Directions

After doing the Investigation “How Fast Do Glaciers Flow?” click the “HOME” button, and then choose “Visualizations” at the top of the page. Click on Chapter 15 and answer the following questions for each:

Chapter 15: Examine the Seasonal Migration of Snow Cover.
1. When are areas above the snow line covered with snow?

2. During which month does Mt. Rainier have the least amount of snow?

Chapter 15: Observe the Retreat of Ice Sheets from North America
1. Using the step feature, step to the time when the Hudson Bay became free of the ice sheet. How many years ago was this?

2. What has happened to the size of Hudson Bay from that time to the present day?

3. Which land area is still covered with the ice sheet from 18,000 years ago?

Chapter 15: Observe How Glaciers Erode Bedrock Surfaces
1. What causes striations?

2. What material makes up rock flour?

3. How can you determine if a glacier moved through a valley?

4. How does medial moraine form?

5. Looking at the picture, how many glaciers do you think merged together for the one in the picture? (Hint: they are separated by the dark moraines.)

6. Just because snow is on a mountain peak doesn’t mean a glacier will form. What will cause a glacier to form?

7. What is a cirque?
WHAT CONTROLS THE SHAPE AND MOTION OF SAND DUNES?

Directions

1. Open Internet Explorer. Type in www.classzone.com
2. Choose your subject as “Science”
4. You will see a web page, with the following title bars at the top: “Investigations,” “Visualizations,” “Data Centers,” “Earth News,” “Resources.”
5. Click on “Investigations.” Click on Chapter 16 and choose “What Controls the Shape and Motion of Sand Dunes?”
6. Answer the questions below as you do the investigation. Click on the next page when done and to all activities on each page.

Questions

1. What do you think controls whether sand dunes will form or not?

2. Which of the images shows sediments in motion? What is causing it to move?

3. What accounts for the absence of dunes in the image to the right?

4. Why are dunes forming against the hay bales but not in the open field?

5. Which of the images was taken in an area with abundant water?

6. Suggest two reasons for the presence of dunes in Image B but not in Image A.

7. From these images, predict the conditions required for dune formation.
8. List the 4 requirements for Sand Dune Formation.

   1.  
   2.  
   3.  
   4.  

9. What determines what type of sand dune will form?

10. Which planets or moons have dunes? State evidence to support your conclusions.
Visualizations: WIND and WATER Erosion

Directions

After doing the Investigation “What Controls the Shape and Motion of Sand Dunes?” click the “HOME” button, and then choose “Visualizations” at the top of the page. Click on Chapter 16, for the following:

Chapter 16: Observe an Animation Showing The Formation of an Arch.

1. What causes fractures in the rock?

2. What does weathering do to the cracks?

3. What is blasting a hole in the sandstone?

Chapter 16: Observing the Formation of Loess Deposits.

1. What is loess?

2. Where does this sediment come from?

3. What caused the loess deposits in Iowa?

4. How far can dust storms move particles?
Chapter 13: Observe How Sediment is Transported by Flowing Water.

1. Where are larger pebbles and boulders transported in a stream?

2. How are sand, silt and clay particles transported?

3. What type of material moves downstream in solution?

Chapter 13: Observe River Erosion Create Waterfalls and Chasms.

1. What causes the plunge pool to get larger?

2. What eventually happens to overhanging rocks?
HOW DOES STREAM FLOW CHANGE OVER TIME?

Introduction

Rivers are vital resources: we use them for our public water supply, to irrigate crops, to generate electrical energy at hydroelectric dams, and for recreation. Our ability to continue using rivers for these purposes requires us to monitor them. Successful management of rivers requires knowing how much water flows in a river and the factors that control flow amounts.

1. Describe three factors that control how much water is flowing in a river.

2. The amount of water flowing in a river is called the ________________.

3. Discharge is the volume of water that flows ___________________________. Discharge is usually reported as the number of _____________________ passing a point ____________________, abbreviated as cfs (cubic feet per second).

4. Each pair of images shows river conditions before and after an event that changed discharge. Consider what factors might have produced the change in discharge.

Rillito Creek, Arizona: ______________________________________________________

Mississippi and Wisconsin Rivers: _____________________________________________

Colorado River, Glen Canyon Dam: ____________________________________________

Stream Discharge at Hubbard Brook, NH:

5. What do the spikes in the graph indicate?

6. List the date and amount of discharge for the two highest peaks on the graph.

7. List the date and amount of precipitation for the two highest peaks on the graph.

8. What do you notice about the timing of the peaks of discharge and rainfall?
Look at the two graphs that deal with the **Rio Grande River near Taos, New Mexico**. Answer the following questions:

9. What do you notice about the timing of the peaks of discharge and temperature variation starting in March?

10. What do you conclude from this relationship?

11. What other data might you need to confirm your hypothesis?

Look at the graphs that deal with the **Colorado River at Glen Canyon Dam**. Answer

12. What do you notice about the timing of the peaks of discharge and rainfall? What do you conclude from this relationship?

13. What relationship exists between temperature and discharge? What do you conclude from this relationship?

14. What do you think is responsible for the regular shape of the discharge peaks?

**Student Interpretation**

The graphs below show discharge, precipitation, temperature, and snow depth for Hubbard Brook during February, 2000. Write a summary describing the factors that affected the discharge of Hubbard Brook in February 2000. Refer to specific peaks on the graphs.
<table>
<thead>
<tr>
<th>Type of Erosion</th>
<th>Erosion Features</th>
<th>Depositional Features</th>
<th>Main Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>Landslide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td>Loess:</td>
<td></td>
</tr>
<tr>
<td>Running Water</td>
<td>Rills → Gullies</td>
<td>Load</td>
<td>Immature River:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oxbow Lakes</td>
<td></td>
</tr>
<tr>
<td>Type of Erosion</td>
<td>Erosion Features</td>
<td>Depositional Features</td>
<td>Main Points</td>
</tr>
<tr>
<td>----------------</td>
<td>------------------</td>
<td>----------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Glaciers</td>
<td></td>
<td>Moraines:</td>
<td>Types:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. Lateral:</td>
<td>a. Valley:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b.</td>
<td>b. Continental:</td>
</tr>
<tr>
<td>Waves</td>
<td>How waves erode shoreline: 1.</td>
<td>Loess:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Depositional Features**

- Moraines:
  - Lateral:
  - Continental:

**Main Points**

- Types:
  - Valley:
  - Continental:
Web Quest: Erosion

1. List 5 Internet addresses you used in this search. Please put a star beside the one site you found to be the most useful.
   a. 
   b. 
   c. 
   d. 
   e. 

2. List two definitions of erosion that you found on different internet sites.

3. What types of erosion are there?
   a.  
   b.  
   c.  
   d.  
   e.  
   f.  
   g.  
   h.  
   i.  
   j.  

4. Find a picture or photograph of a delta. Draw a delta here:
   Website: ___________________________________________________________

5. Find a picture or a photograph of an alluvial fan. Draw it:
   Website: ___________________________________________________________
6. Locate a website that discusses the formation of a river.
Website: http://www.chs.k12.nf.ca/socstud/ssgrassroots/Rivers/stages.html
http://library.thinkquest.org/05aug/01448/index_files/river.htm

List the steps in the formation of a river and draw a picture of each. Describe what happens in each phase.

7. Define pothole as it relates to river erosion. How does a pothole form?

8. Go to http://www.youtube.com/watch?v=Gp39aQNnTww and watch the video. What has developed as a result of erosion?

9. Watch the video: http://www.youtube.com/watch?v=ZrzwxQshIn1Q&feature=related
Describe what happens to water as it moves through a meander.

Draw a picture of the cross-section of a meander showing the deepest area and the more shallow area. Label where you would find fine sediments and coarse sediments.

Define Reynold’s number:
Glacier Lesson Worksheet

Provide a brief answer to each of the questions below based on the images.

**Question 1** This view is looking up, over the toe of Carbon Glacier toward the peak of Mount Rainier in Washington. Why do you think there are rocks on top of the glacier? How did they get there?

**Question 2** This is a picture of the beach near Montauk Point on Long Island (at the eastern end of Long Island, New York). Usually rocks on a beach are well rounded by wave action. These are not. Where could they have come from?

**Question 3** This valley is in North Cascades National Park in Washington. What shape is this valley, and what gave it the shape?

**Question 4** This rock and wall is at the Cloisters Museum in New York City (on Manhattan Island). What are the "scratches" called, and how do they form? Why are they in New York City?

**Question 5** This picture shows two types of rocks on a mountaintop in northern New Jersey. This is a large boulder of a layered sandstone (a sedimentary rock) resting on granite bedrock (an igneous rock). Sandstone, like this boulder, is found on a mountain about 30 miles away. How this boulder might get here?

**Extra Brain Teaser** This view is looking north along the Hudson River in Southern New York. Although the "Hudson" is a "River" - early explorers of the region thought that the broad river might be a passage for boat travel across North America. Although they were disappointed, they did note that the Hudson River is salty all the way to its headwater regions near Albany, New York (nearly 200 miles from the ocean). Could you explain why the Hudson River is salty?