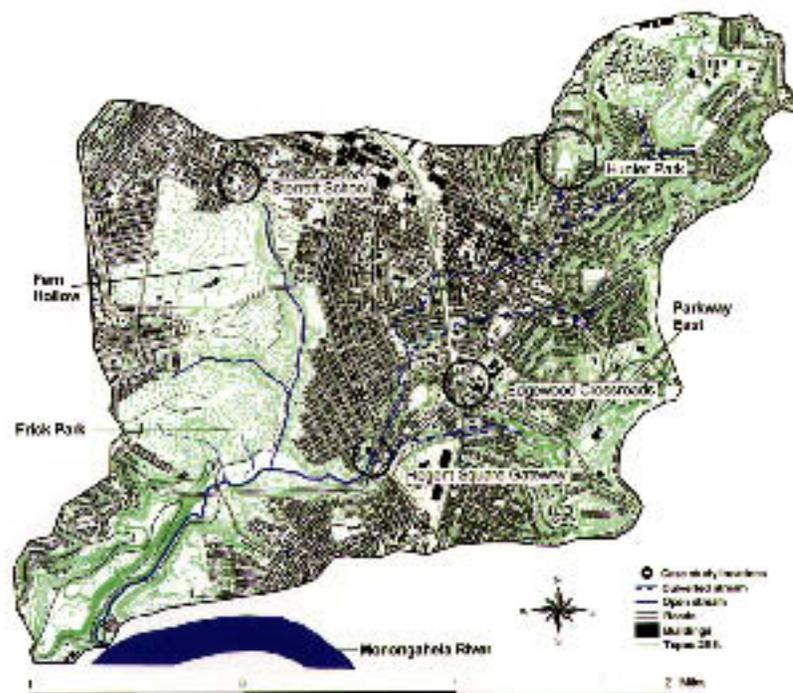


Ecology and Environmental Education
Modules and Reference materials for Teachers
7th grade

Urban Watersheds and Brownfields

Case Study: Nine Mile Run Watershed



Funded by
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Office of Environment and Ecology

Developed by
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2000

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Urban Watersheds and Brownfields

Why an Urban Watershed?

The majority of people live in an urban setting. Traditional city planning minimizes nature and celebrates the structure and infrastructure of culture. There is an emerging consciousness about the relationship between quality of life and the environment. This text will provide students with the method, technique and knowledge to enter into an inquiry on the subjects of urban water and nature. From this inquiry, they will develop critical thinking skills necessary for citizenship and the potential for a life-long interest in natural resources and the issues of urban pollutants. Our goal is to help them understand and develop their own ideas about nature and culture and the range of concepts which inform sustainable development.

- Understanding a watershed entails knowing the topography and geology of the landscape. Topography tells us how water moves across the surface of the earth and the geology can tell us how water moves through soils.
- Understanding your watershed is knowing your place in the cycle of water, and understanding natural systems and constructed cultural systems which move water.
- Understanding your watershed is knowing there are watersheds in every place on the planet and in turn your watershed and daily actions are connected to the planet by the movement of weather and water.

Why an Urban Brownfield?

Go to any city in the modern world, and try to reach the river or the bay. More likely than not you will find your way blocked by fences protecting the ruins of industrial culture. The abandoned properties are considered wasteland, existing in a social and economic limbo, as their value and location is debated. By all accounts, they seem to be stagnant for ten or twenty years or more. How stagnant are they? From the waterside, we will find an emerging growth of amazing plants. Often kingfisher, hawks, and herons have begun to indicate a functioning food chain of smaller herbivores, amphibians, and fish which are returning to the waters once used as the sink for industrial waste.

Brownfields are important spaces in cities all over the world: the Ruhr valley of Germany, the coal and steel regions of England, the rustbelt of America. These places are awakening and have increasingly become the site of redevelopment interests. With an awareness of their natural and recreational value, they can also become the site of a new civic discourse about the form and function of the rivers and open spaces in cities. When exploring an urban industrial culture, we have to understand the challenges as well as the opportunities if we are to be participants in the weaving of the post-industrial future.

Shifting paradigms

We are at the end of the conservationist paradigm. Modernist culture was built on the belief that nature's value increased as its distance from cities and human culture increased. Restoration Ecology is an emerging paradigm which integrates the concept of conservation or preservation of nature with a more active restorative relationship to nature. Restoration Ecology puts humanity and culture into a relationship with ecosystem and environment. Indeed, at this point in time, it is quite clear that humans are a particularly dynamic force of nature with the propensity to affect the world's climate. Researchers in the arts, humanities, sciences, and engineering are studying the relationship between humanity and nature. This reality has prompted the U.S. National Science Foundation to begin two innovative Long Term Ecological Research (LTER) Programs. Baltimore, Maryland and Phoenix, Arizona were chosen as the sites for these programs two years ago. Scientists like Steward Pickett of the Institute of Ecosystems Studies (and director of the Baltimore LTER) are calling for the integration of the biological and social sciences¹. Pickett has begun to synthesize and explicate the relationship between humans and ecosystems. Organizations like the Institute for Ecosystems Studies and the Society for Ecological Restoration are nurturing these new relationships and interdisciplinary knowledge by publishing texts and conducting international conferences.

Our knowledge of the historical landscape is changing as well. Geographers like Michael Williams of the University of Oxford in England are uncovering evidence which indicate a previously un-thought of level of density and management of the North American environment by indigenous peoples.

Note: See the *National Geographic*, Vol. 198, No 2, August 2000 for an overview of the Sydney Olympics and its focus on ecological restoration, brownfield recovery, and an innovative approach to an urban water system.

Science Web sites:

Institute for Ecosystem Studies, (See the VIII Cary Conf) www.ecostudies.org/

Society for Ecological Restoration www.ser.org/

Baltimore LTER baltimore.ubbc.edu/lter/

Art and Humanities Web sites

Helen Meyer Harrison and Newton Harrison

www.kah-bonn.de/13/0e.htm

Artist Mel Chin and USDA Agronomist Rufus Chaney

www.soils.wisc.edu/~bsrsk/doildscience326/revival.html

Hilary Frost-Kumpf's overview of "Reclamation Art"

slag garden.cfa.cmu.edu/weblinks/frost/Frosttop.html

¹ Pickett, S.T.A., "Humans as Components of Ecosystems: A Synthesis" p.310 in the edited text, "Humans as Components of Ecosystems: The Ecology of Subtle Human Effects and Populated Areas" Edited by, McDonnell, M.J., Pickett, S.T.A., Springer-Varlag NY, 1993

What to expect?

We present an inquiry-based, interdisciplinary approach to urban ecology, art, science, and the environment. Implicit in this program is a sense of engagement and civic responsibility as we develop skills in guided-inquiry, perception, and the application of qualitative analysis. The program is not a set of off-the-shelf activities for teachers to apply, but rather a series of guidelines using new and existing educational tools to enable an initial study of post-industrial landscapes. These modules touch on new and emerging relationships in academia, philosophy, art, and science. If we have done our job well, you will find yourself curious about these new ideas and soon you will develop your own variations and extensions to each of the modules that follow.

We begin our program by building upon observations of the students' immediate surroundings. We have designed the activities so that students are given the time to see, observe, and discover first. We build on the content and context of their discoveries. The program modules are guided by the proposed academic standards of the State of Pennsylvania for Environment and Ecology, Art, and Science. The methods of guided-inquiry and assessment uses integrated tools of both art and science.

Nine Mile Run, Pittsburgh Pennsylvania: A Case Study

Nine Mile Run is a historic stream valley in Pittsburgh, Pennsylvania, identified by Frederick Law Olmsted Jr. as an ideal site for a city park in 1910. Between 1920 and 1972, twenty stories of steel mill slag were dumped on the site by the steel industry. In 1996, the city of Pittsburgh targeted the property for a new community and an extension of a major city park.

Nine Mile Run Web site
<http://slaggarden.cfa.cmu.edu>

Who we are...

Over the last three years, research fellow at the STUDIO for Creative Inquiry, Carnegie Mellon University have collaborated with The Pittsburgh Children's Museum to develop classroom activities that invite school children to consider the future form and function of Nine Mile Run. Teachers and families were encouraged to carry out investigations of this brownfield (a steel slag dump), its watershed, and attendant site opportunities. We conducted an intimate study of the site. We began to see that the name "dump" kept us at a distance, where we were likely to miss the opportunity that can be found on such abandoned properties. We were interested in-coding this place with a new name so it could emerge as an opportunity. We used art, the humanities, engineering, science, and community outreach to create a discussion and a new story for this urban open space.

The Urban Watershed modules were designed, developed, and tested in classrooms. They were written by a collaborative team of three people; Reiko Goto, an environmental artist and research fellow at the STUDIO for Creative Inquiry, Carnegie Mellon University; Valerie Lucas, an artist and a classroom art teacher at the Homewood

Montessori School; and Marina Pantazidou, then assistant professor of Civil Engineering at Carnegie Mellon University. Marina is currently a member of the research faculty at the University of California at Berkeley.

Acknowledgements

A number of individuals and organizations contributed to the development of the modules and activities for the Urban Watersheds And Brownfields Modules.

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A personal story

By Reiko Goto

I was one of the four original co-directors of the Nine Mile Run Greenway Project. As we worked with our colleagues in the humanities, engineering, and sciences, I started to think about transferring the research process and information to a younger audience. I began by having a conversation with Jane Warner, Director of The Pittsburgh Children's Museum. Jane not only supported my idea but also introduced me to Valerie Lucas at Homewood Montessori school. Originally I was going to visit her art classes to introduce the Nine Mile Run site through some basic activities. After the first couple of meetings, Valerie asked me to work for a longer period of time with her 4th and 5th grade students. The issues surrounding Nine Mile Run were very complex, informational rather than experiential, and difficult to grasp for a young audience. Valerie spent a lot of time helping me develop the teaching concepts and methods. We began to develop simple activities (Which became the basis for our work with Marina Pantazidou) that we both felt were bold enough to be effective in a classroom setting. The second year, I tested and expanded our original ideas at Dickson Intermediate School and John Minadeo School. I must thank those schools and the classroom teachers who were very patient and supportive. Inviting me to lead their class in a guided-inquiry on a post-industrial landscape was not always easy for the teachers and was often challenging for the students.

The interdisciplinary approach and guided-inquiry based learning are very subtle methods which show best results over the long term. The teachers I worked with needed to see results in the short term. I read and looked at all students' writing and artwork. I tried to document all the work, as much as possible. Creating a web site and having exhibitions for students helped teachers and other audiences see what each student was thinking about, and the depth of understanding that was emerging from their curiosity and personal inquiry. The students' voices took on a new dimension when I presented some of their concepts at community meetings and workshops about Nine Mile Run. The students came to this damaged landscape with no preconceptions, yet understood the challenges. They were able to spin wild and complex concepts about how to make it better. The students work - writing, drawings, and models were always fresh and truthful. It became clear to me as I was in the midst of this work that it took generations to create the industrial era and it will take generations to resolve its problems. We can either listen to them now or wait 20 years and ask them again. Personally, I know in my heart that we must remember to listen to the voices of children.

How to use this book

Which grade level am I looking at?

The text is targeted for 7th grade but it is relevant to the 5th, 6th, 8th, and 9th grades.

How are the modules organized?

Under the main heading Ecology and Environmental Education Modules: *Urban Watersheds and Brownfields*, there are five modules which are organized by the following titles:

1. Watersheds
2. Water Cycle and Watershed Interaction
3. Stream Environment
4. Brownfields to Greenfields
5. Artifacts of a Watershed

Each module is divided into sub-modules with sequential activities. For example, Module 1: *Watersheds*, includes 1.1: *Hand Land*, 1.2: *What is in the Watershed* and 1.3: *Hand-Land Painting*. All are outlined in the table of Contents.

- **Overview** introduces the topic of the modules.
- **Background** provides pertinent information about the topic.
- **Objectives** state what the students will learn within the context of each module.
- **Concept** provides main ideas and principal knowledge.
- **Standards** related to each module are listed in accordance with the Proposed Pennsylvania Academic Standards for Environment and Ecology, Art, and Science. Teachers might consider interdisciplinary collaboration with colleagues as they teach each module.
- **Lesson Plan** is specific to each module and designed sequentially. Each is guided by key questions that led the participant through the learning activities in each module.
- **Key Questions** are included at the beginning and at the end of each module, to provide opportunities for discussion, reflection, and assessment.
- **Glossaries** define important vocabulary words at the end of each module.
- **Appendices** provide background information and reading for some module topics.

What do I need to do for the activities?

- **Preparation** shows what kinds of materials and how much each student / group needs, and the estimated duration for each activity. It is located before the Lesson Plan.

How do I guide my students?

Lesson plans and students activities are inseparable in the actual classroom. Teachers are not only introducing the topic, but more importantly guiding the students' curiosity. It is very important that teachers follow each activity with questions about how this process relates to their daily life and the day to day functions of the adult world.

Lesson Plan — What teachers do

Class setting gives teachers some ideas how they arrange the classroom and students.

Discussion is guided by *key questions* (presented in italicized letters) and a script for class interaction.

Instructional materials could be copied on clear acetate for overhead projection.

- Key words are important vocabulary words in each module. They are italicized in the text, and gathered as a list in the lesson plan. They could be presented on a large sheet of paper, and introduced during the discussion. The definition of each key word is in glossary in the end of the each module.

Activities — What students do

Most of the students' activities are guided inquiry-based activities which require careful observation, the development of a hypothesis, exploring materials, and sharing the results. Teachers must ask students to record their process.

How long does it take?

We tested modules at the Homewood Montessori School over the last two years. We planned to go through the module activities within six weeks. The modules have been presented successfully in both 50 minute and 90 minute class periods. Val Lucas found that the longer class period is the ideal, more importantly it allowed her to perfect the use of the hands on activities and experiments before moving to a shorter time period. With some classes we followed the order of modules carefully; with others we changed the order to respond to the students response and interest. We strongly suggest careful planning and awareness of your own classroom dynamic.

How do I know what my students are learning?

By Valerie Lucas

Together, the modules in this document present opportunities for ongoing performance-based assessments which focus on the students' acquired knowledge and perceptions of a watershed. Each module is organized by Key Questions that require inquiry, exploration, articulation of hypothesis, and reflection of observation results. This inquiry-based model requires that students keep a portfolio to document their activities, experiments, artwork, and writing. Key words are defined in the glossary and may be used for vocabulary tests. Reproducible Activity Cards are included throughout to document the students' participation and results. Reflection Questions prompt the students to recall the processes, issues, and concerns, addressed within the specific modules. Reflection, can also lead to unexpected questions, connections and new areas of exploration. A rubric guides students through a self-assessment of their artwork. At any time the teacher may choose to incorporate any of the information in a self-designed test. It is hoped that this document would be presented as a sequenced unit of instruction, enabling students to acquire an authentic learning experience, both within and outside the classroom.



Module 1.1: *Watershed*

Hand Land

Refers to the Movement of Surface Water

Overview

Hand Land offers students an opportunity to learn about watersheds through guided-inquiry and artistic activities. Students will learn the physical definition of a watershed by observing the general watershed characteristics of high, middle, and low topography which are visible on one's own hand. In a watershed, water flows from the highest point to the lowest point, terminating in a collective source such as a river, lake, or ocean. (Some water also sinks into ground water and some evaporates.)

Hand Land is a metaphor about watersheds. In our Hand Land watershed, water flows from the wrist downward. The bones in the back of one's outstretched hand act as the *divides*, or high points delineating the watershed boundaries that cause water to flow in one direction or another. Students will observe water moving in small streams down the hand towards the lowest elevation on the edge of the hand, or into one of the other watersheds that lie between each finger.

Background

“The main instrument of landscape sculpture is, of course water, or shui. Water not only carves the mountains or valleys physically but flows through the earth conveying the chi. From the water, which flows on the surface in streams, rivers, and pools, dragons rise into the air, as the water itself evaporates. Wind or feng distributes the water vapor as clouds which, taking the form of dragons in the air, consolidate finally to precipitate life-giving rain onto mountains which are the traditional lair of these dragons. The elements wind and water are the essence of feng-shui, which affect the earth and life on it.”

Stephen Skinner, *The Living Earth Manual of Feng-Shui*.

When it rains, where does the rain-water go? Module 1 and module 2 are intended to teach the basic watershed concept. Module 1 focuses on the movement of surface water. In module 2, students experiment with a model of ground water, which reveals what is normally invisible to our eyes. In module 1, we will use students' hands as learning tools and encourage them to consider the way water moves in the hand-landscape. This module is relevant for both urban and suburban schools.

Module 1 Hand Land helps us see what happens as water flows over natural surfaces. Students will work in pairs and use their hands to represent the mountains, hills, and valleys that define watersheds. Students are partnered together, one as the hand-land model and one as the rainmaker. Ask them what they think will happen when water begins to fall on the land of hand. They are provided with paper, a pencil, and some dots to illustrate their hypothesis. The rainmaker will then test the hypothesis by slowly releasing water in random rain-like patterns across the partners hand. They will both



carefully observe how water moves across the hand-land. Students will learn about the relationship of topography to hydrology -- how the ridges in their hand affect the flow of water. They will compare how the ridges in their hand separate watersheds, and finally they will have developed an experiential and intimate physical understanding of the meaning of a watershed through the careful application of their own curiosity, focused experimentation, and meaningful personal experience.

Objectives

Students will:

- explain *topographical* representation
- explain the boundaries of watersheds
- simulate the movement of rainwater over land
- hypothesize about and record the flow characteristics of rainfall
- explain the concept of flow over land

Concepts

The back of each student's outstretched hand serves as the topographical model of a watershed throughout this module. This allows each student to experience *first-hand* the effects of water on the surface of the earth. In this module, students will create a contour drawing of their hand to record their predictions and experiments with water movement within watersheds. Students will use water-based watercolor paints to interpret their findings by controlling the graduated effects of *primary colors* (see colors in nature in module 5) to represent the changes in the topography of their hand.

Topics:

- *Creating a topographical model and drawings*
- *Where will the water go when it rains?*
- *Discovering the movement of water in a watershed*
- *Finding and defining a watershed boundary*
- *Interpreting one's scientific findings artistically*

PA Educational Standards

Related PA Proposed Environment and Ecology Standards: Watersheds

- Explain the role of the water cycle within a watershed
- Explain the water cycle
- Explain the water cycle as it relates to a watershed
- Understand the role of the watershed
- Identify and explain what determines the boundaries of a watershed
- Explain how water enters a watershed

Preparation

Student Materials

8.5 x 11" white paper
Pencil
6 color dot labels (1/4" in size, 450 pkg.)
Paper towel
Water
Eye dropper

Set Up

Each student needs his or her own pencil, paper, paper towel, and adhesive dots. Students work in pairs to share eyedroppers and water.

Estimated Duration

1 to 1 1/2 hours

Lesson Plan

Class Setting

The instructor prepares the above materials per team. The instructor has the following instructional materials ready with the description of the activities to the students.

Discussion

Review the water cycle using *Figure 1.1* as a reference. Trace the path of rainwater as it travels between the land and the atmosphere. See the background information in the *Appendix 1A: The Water Cycle*.

Key Questions:

- *What does this diagram demonstrate?*
- *What would you title this diagram?*

A watershed is like a natural bathtub. Using *Figure 1.2* to explain how rainwater enters into a watershed. Point out the high areas, low areas, and the boundary lines.

Key Questions:

- *Where is the highest area in the picture?*
- *Where is the lowest area in the picture?*
- *How does rainwater moves on the surface of the land?*

Teachers must prepare a local map which includes some elevation differences. In this module, we use topographical maps, such as *Figure 1.3*. Topographical maps consist of contour lines. These two-dimensional lines describe three-dimensional surfaces in the landscape. The word "topography" means the shapes and forms of the land in a particular region. The topography of a region includes mountains, valleys, plains, lakes, rivers, and other features. Topographical maps can be either very simple or very complicated.

Instructional Materials

For a overhead projector:

- *Water cycle drawing , Figure 1.1*
- *Three-dimensional Model of a Small Watershed, Figure 1.2*
- *Topographical Map of a Watershed, Figure 1.3*
- *Hand-land sample drawing, Figure 1.4*
- *Hand-Land Watersheds sample drawing , Figure 1.5*
- *Relief Map of North America, Figure 1.6*

See more information:

- *Appendix 1A: The Water Cycle,*
- *Appendix 1B: Topographic Map*

Key Words

boundary

concentric

condensation

contour line

evaporation

gradation

hypothesis*

investigation*

precipitation

primary colors

topography

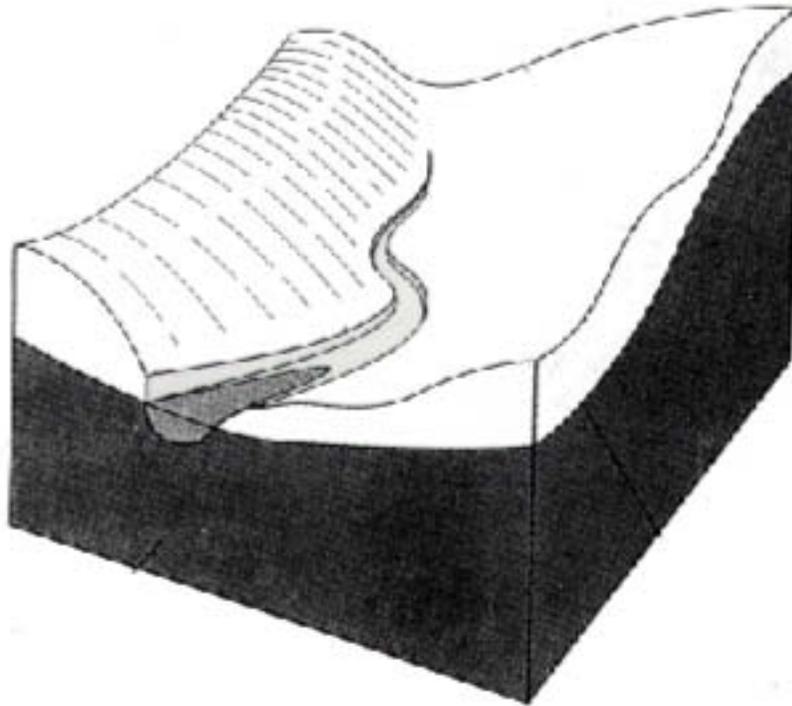
transpiration

watershed

*See *Inquiry teaching and learning process and vocabulary words* in the *Glossary 1*.



(Figure 1.1)



(Figure 1.2)

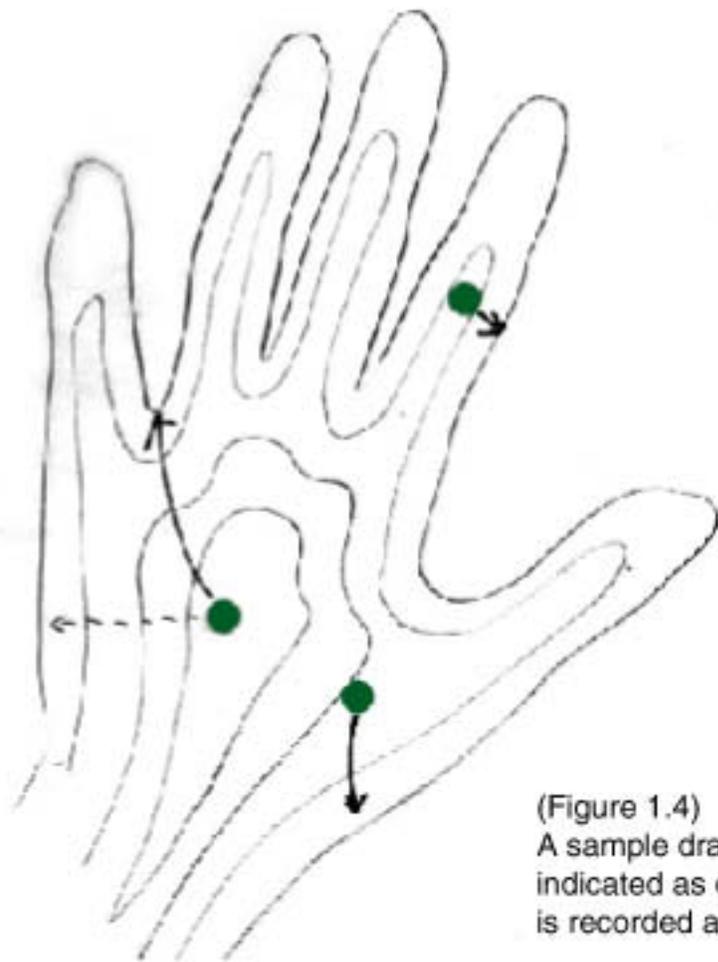
(Figure 1.3)
 Topographic map of Nine Mile Run Watershed



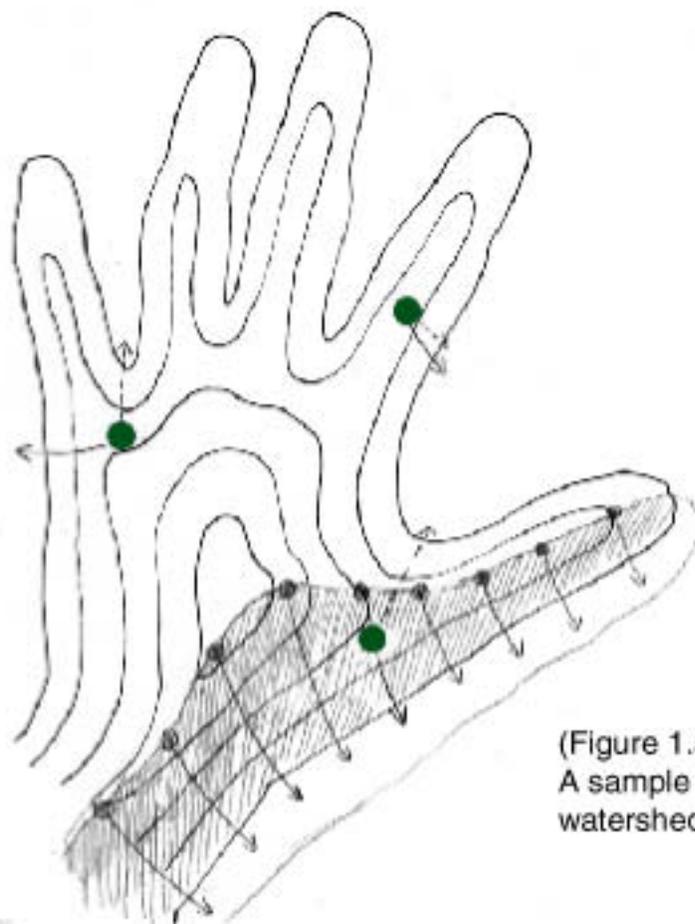
ROAD CLASSIFICATION

Primary highway, hard surface		Light-duty road, hard or improved surface	
Secondary highway, hard surface		Unimproved road	
	Interstate Route		U. S. Route
			State Route

Pittsburgh East, PA
 40079-08-TF-024



(Figure 1.4)
A sample drawing: prediction is indicated as dotted lines. Observation is recorded as solid lines.



(Figure 1.5)
A sample drawing: finding a watershed and its boundary

Activities

Activity 1: Understanding the Hand Land Model Creating a topographical map of your hand

Key Question:

- *What do the students know about watersheds?*
- *What would they like to know?*

Review the linear features of the topographical map of a watershed. Use *Appendix 1B: Topographical Map* for background information. Point out the boundary lines and ask where the high areas and low areas are. Compare it with similar features on one's hand. For example: the boundaries of the watershed are the high areas (ridges or divides) created by the bones of their hand. The low areas of the watershed are the areas between their fingers and along the and outside of their hand.

To make a topographical map, trace the outside contour of your hand on the white paper. Draw a series of concentric lines that imitate the outside shape, approximately 1/4" within the contour drawing, allowing the lines to diminish as one nears the center, *Figure 1.4*.

Activity 2: Making a hypothesis

Key Question:

- *Rain falls in Hand-Land. Where will the water go?*

Discuss with your students how water flows down hill. How will the water move when it falls onto the surface of their hand? Students place three color dot labels at strategic places on their real hand. Mark the same places with three color dot labels on their topographical drawing, *Figure 1.4*.

Ask students should be asked to predict which direction the water would flow if it hits directly on the color dots on their real hand. They will mark the topographical drawing with a dotted line and arrow to indicate the direction (their hypothesis). Students must note the reason for their hypothesis on their drawing.

Activity 3: Investigate! Discovering the movement of water in a watershed

Key Question:

- *What is the actual movement of the water?*

Students will use an eyedropper to drip water, drop by drop, onto one strategic dot at a time on their *Hand-Land*. They will continue to add drops until the water flows and they can observe which direction the water moves. They need to trace the *actual* movement of the water by drawing a solid arrow from each dot on their topographical map to indicate the direction.

They should be encouraged to experiment with other areas of their hand/watershed. They should record both the prediction and findings relative to their hypothesis on their drawing.

Activity 4: Further observation, finding a Watershed Boundary

Key Question:

- *What topographical features determined the movement?*

Ask students questions which will topographical features help them discover the role of the highest points and ridges, and their role as dividing lines between watershed boundaries. Have them identify a single watershed by outlining it with a specific color crayon. Challenge students to discover as many watersheds (and sub-watersheds) as possible within *Hand-land* and mark the boundaries on the topographical map, *Figure 1.5*.

Students should be asked to number and name the watersheds after identifying their boundaries. They should be directed to write a description (3-4 sentences) of their observations in their notebook, referring to specific watersheds on the Hand-land topographical map.

Activity 5: Finding and Evaluation

Key Questions:

- *Does Hand-Land represent a single watershed or a group of sub-watersheds?*

Show the relief map of North America, *Figure 1.6*. Ask students to find the major watersheds on the east coast and west coast. Have them try to explain the concept of a sub-watershed and its relationship to a larger watershed. They should be able to list the following characteristics of a major watershed: it drains to a major river, it has a large landmass, it has a diverse landscape (forests, fields, wetlands, houses, cities, industry). Characteristics of a sub-watershed would include; it drains to a creek or stream feeding a major river, it has a relatively small landmass, and it is likely to have a less diverse landscape.

Presentation of their *actual* versus *predicted* water movements on topographical maps. Students should be asked questions that help them state the reasons for their predictions and what they learned from the actual movement of the water on their hands. (This could be done in small groups of 4 to save time)

How is the student's Hand land topographical map like the topographical map of North America? What characteristics of topography determine watershed boundaries? How is the topography of their hand different than a natural topography? What characteristics do they share? What characteristics do they not share?

Recommended Web site: Allegheny Watershed Atlas, click "Explore the Watershed. You will see the Allegheny River Watershed and it's major sub-watersheds.
<http://www.watershedatlas.com/>

Note: *Keep the Hand Land drawing and writing as portfolio entries.*



(Figure 1.6)

A relief map of the united States

*Department of the Interior, Geological Survey

Module 1.2: *Watershed*

What is in our watershed?

Overview

After students experience the general characteristics of all watersheds, their local watershed is introduced. Have them study a *local watershed map like that of Figure 1.7* (also see *lesson plan/instructional materials*). Ask students to identify the different human impacts and natural resources within their environment.

Objectives

Students will:

- recognize and use the symbolic key on a map to locate important features/resources
- identify elements of natural resources and human impact
- identify how humans use the land
- identify natural resources and features of the land

PA Educational Standards

Related PA Proposed Science and Technology Standards: Earth Sciences

- Identify significant earth resources in Pennsylvania utilizing mapping techniques
- Identify various earth structures(e.g., mountains, faults, drainage basins) through the application of models

Concepts

The general principles of map use are an essential tool in both known and unknown localities. Recognizing the symbolic features of maps will help a student to understand both the natural resources and human-made features of one's environment.

(Figure 1.7)



The Nine Mile Run watershed, showing impervious streets and buildings, topography, and the charrette case study sites. For municipal boundaries, see the map on page 26. CIS map by STUDD for Creative Inquiry.

Preparation

Student Materials

- Watercolor markers or color pencils
- Photocopy of a local map per student
- One sheet of unlined paper

Set Up

Teams of students are equipped with the above materials.

Estimated Duration

45 minutes

Lesson Plan

Class Setting

Teacher works from the front of the classroom and students are primarily seated. Discussion and guided practice are necessary to fully understand the concepts.

Set up the classroom for students activities. Here is the check list:

1. Students have enough room on the table for activities and note taking.
2. Students can share the materials easily.
3. Students can work in pairs or small groups.
4. Materials should be easily accessible.
5. There should be some shelves or boxes to store the on going projects. Materials that need to be stored include portfolios, journals, activity records, etc.

Instructional Materials

- USGS map, *figure 1.7*, which includes watershed boundary line, topographical information, streets and municipalities
- AUSGS map for your local area, which includes watershed boundary line, topographical information, streets, and municipalities, also available on the internet, <http://www.usgs.org> or http://edcwww.cr.usgs.gov/Webglis/glisbin/finder_main.pl?dataset_name=MAPS_LARGE
- Overhead Projector

Other sources of interesting topographic maps:

The library --Check out the reference section, or perhaps your library has a map room.

Local government agencies--The Parks Department will have maps of all the parks in the community. The Public Works Department will have maps of the drainage systems.

Federal government agencies--Any federal agency that manages land will have maps or photographs of the land under its management.

Map stores--In Pittsburgh, you can buy many different kinds of maps at JR Weldin Company, 413 Wood Street, downtown Pittsburgh.

Key Words

cartographer

direction

land use

natural resources

symbolic key

Activities

Activity 1: Identifying the mapmakers' symbols

Key Question:

- *What could this map tell you even if you were not familiar with this watershed?*
Have students view the USGS map, *Figure 1.7* and explain the map's symbolic key. (Students can recreate the symbolic key for their map.) Direct students to locate four symbols on *Figure 1.7*. In pairs, have students discuss the symbol, its identity, and location.

Activity 2: Identifying familiar landmarks

Key Question:

- *What do you recognize in your own watershed?*
Students should view the local map and review its symbolic key. They should identify three to four familiar landmarks in their watershed. Ask students to identify the landmarks that they are familiar with. Ask them to mark the familiar landmarks with a symbol to identify it on their maps.

Students are to identify at least five areas on the map, including schools, homes, parks, freeways, railroads, playgrounds, shopping areas, streams, rivers, lakes, etc..

Activity 3: Evaluation and findings

Key Questions:

- *What is in the Watershed?*
- *How big is the watershed? Identify the boundaries by locating the divides.*
- *How many towns do you recognize in the watershed?*
- *Is the area mostly homes, factories, business, farms, or forest?*
- *How do you describe the physical characteristics of this watershed?*
- *What larger watershed does your sub-watershed fit into?*
- *Where does the rainwater drain in your watershed?*

Extensions

Students should be told to:

- Create their own symbolic key for a make-believe watershed. Draw its topography based on any shape. Label the important features for their watershed.
- Ask students to find more about the local watershed through web sites. Teachers work with the school librarian to prepare the school computers. Some web sites should be book marked, and the librarian can help students find the information about their local water watershed. Some web sites to start with include:
 - <http://www.dep.state.pa.us/>
 - <http://www.epa.gov/surf/>
 - <http://www.watershedatlas.com>
- Present students with a map from a rural town, a place they may have never been. For homework, ask them to try to identify three to four familiar landmarks from the map.

Discussion

Cities are made up of many different kinds of places that we can recognize on a map. Mapmakers, or cartographers, use certain symbols on all maps, so anyone can recognize the important features.

Module 1.3: Watershed

Hand Land Painting

Overview

Hand Land Painting focuses on topographical representation of a watershed through artistic means. In keeping with the nature of this module, a water-based medium is used to express the subtleties of the topography. In order to represent the high and low areas of a watershed accurately, the student must first practice graduating tones of watercolor to achieve the illusion of three-dimensions.

It is best to restrict the novice to the selection of two of the primary colors: one to represent the highest areas, one to represent the lowest areas, and the resultant color blending of the two for those areas between. The Kozo paper, when wet with water, will cause colors to bleed into one another, creating very suitable effects for an accurate depiction of the movement of water. Dark colored areas most saturated with color will represent the lowest areas, lighter colored areas more saturated with water will represent the highest areas.

Objectives

Students will:

- Use artmaking processes to represent a scientific concept
- Create subtle distinctions between the hue, value, and intensity of the primary colors
- Graduate hues from most saturated with pigment to most saturated with water to create an illusion of depth within the painting
- Vary the effects of watercolor to create a painting of the topographical map of their Hand Land

Concepts

Water is a traditional theme in art across cultures and history. Regardless of style media, or place, the representation of water has attracted artists from ancient to contemporary times. In this module, students are asked to create the illusion of land by manipulating the movement of water and pigment. Land forms influence water flow, water in turn erodes and degrades landscapes, depositing sediments in places which help to build new landscapes and refresh the soils of floodplains. In truth, one does not exist in its present state without the influence of the other. The interaction of water and land is a dynamic and ever-changing system.

PA Educational Standards

Related PA Proposed Academic Standards for Arts and Humanities

- Analyze artist's reasons for producing works in the arts in relation to other subjects
- Demonstrate the ability to define objects, illustrate an action or relate an experience through the creation of an artwork



Gradation painting



Hand Land painting

Preparation

Student Materials

- Kozo or Sumi-e paper (a good watercolor paper from an art supply or craft store)
- 2 of the 3 *Primary colors* in water color paints (yellow, turquoise, magenta)
- Watercolor Brush
- Water
- Palette (Substitute materials: paper plate, meat tray, plastic lid)

Set Up

Each student has the above materials in front of him or her. Experiment with the pigments on dry paper as well as wet paper in order to determine the effects of each technique.

Estimated Duration

Two class periods

Lesson Plan

Class Setting:

Each student is supplied with paper, two of the three primary colors, a brush and water. The teacher outlines the processes, then provides guided practice. Results will and should vary for each student! Allow for discovery and exploration of the medium.

Discussion

Show *Figures 1.8* and *1.9*. The artworks represent two different cultures and time periods. Both artists used water-based media to represent nature. Point out areas of graduated color, value, and intensity within the artworks.

Key Question:

- *How do the artists manipulate the pigment to create varying effects of lightness and darkness?*
- *How many colors were used for each of the paintings?*

Instructional Materials

- Slides or overheads of watercolor paintings
- *Pine Grove* (detail), Tohaku Hasegawa, 16th c., Japan, *Figure 1.8*
- *Wavery Oaks*, Winslow Homer, 1864, *Figure 1.9*
- *The Portage*, Winslow Homer, 1880, *Figure 1.9*



(Figure 1.8)
Pine Grove (detail) by Tohaku Hasegawa,
End of 16th century. Momoyama period
panes / Screen Sumi Ink on paper, 62"x138"

Masterpieces of Japanese Screen Printing:
The Momoyama Period
(late 16th century), Jon Etta Hastings Covell
plate #13
New York: Crown Publishers, 1962
Hunt Call #: 759.952 C87M (folios-4)



(Figure 1.9)
Waverly Oaks, Winslow Homer
1864, Oil on paper. 33.6x25.4cm
Private Collection, Thyssen-Bornemisza

The Life Works of Winslow Homer,
Gordon Hendricks p.60
New York: H.N. Abrams, 1979
ISBN: 0810910632
Hunt Call #: 751 G65 (stacks)



(Figure 1.9)
The Portage, Winslow Homer
1897, watercolor, 34.9x52.1cm
Yale University Art Gallery, New Haven
Bequest of Doris M. Brixey

Winslow Homer Watercolors, Helen A. Cooper
p.197
Washington: National Gallery of Art; New
Haven: Yale University Press, 1986
ISBN: 0894680870
Hunt Call #: 759.13 H76CIK (oversized)

Key Words

gradation

hue

intensity

pigment

Primary colors

value

Note: *This activity is enhanced by collaboration with an art teacher. It does not require an art teacher. These are relatively simple, easily learned skills with plenty of room for experimentation, variation and creative expression!*

1.8

Activities

Activity 1: Getting familiar with materials and obtaining skills

Creating a graduated effect with watercolor, *Figure 1.10*.

Pigment moves differently on a wet surface than a dry surface. By controlling what is wet and what is dry, what is more wet and less wet, as well as controlling the color and intensity of (or amount of) pigment on the brush, we can achieve a number of affects. These affects refer and react to the same physical laws that control the movement of water and other liquids in the landscape

- Wet a small spot on the Kozo or Sumi-e paper with a brush and water.
- Place one drop of a primary color onto the wet area.
- Observe the flow of the watercolor into the wet area of the paper.
- Wet approximately a one-inch strip along the length of the Kozo or Sumi-e paper.
- Saturate your brush with one color of paint.
- Start at one end of the strip and slowly pull the saturated brush across the wet paper.
- As the color lessens, dip the brush into water, and continue the process. Notice how the color becomes lighter as it loses pigment. Practice graduating the tones of one color from its most saturated in pigment (paint) to its least saturated. Regulate the amount of water and pigment to control the gradation.
- Wet another strip along the length of the Kozo or Sumi-e paper.
- Place one color at one end and a different color at the other end.

- Gradually pull the two colors together to create a third new color, while keeping some of the original colors visible.
- Practice varying the intensity of those colors by adding more or less pigment.

Activity 2: Discovery with watercolor

Painting the illusion of land, Figure 1.11

- Review the Hand Land drawing made with concentric patterns within its outline.
- Create a *new* contour drawing of your hand on Kozo or Sumi-e paper.
- Locate the highest areas and the lowest areas of the topography within the drawing.
- Wet only the highest areas of the topography with a brush and water.
- Observe its saturation and flow pattern.
- Paint that area with a different color.
- Wet only the next highest areas of the topography following a concentric pattern.
- Paint that area with one color, allow some blending to occur between the colors. Repeat this process until the entire drawing represents one or several "watersheds" with varying topographies.

Activity 3: Evaluation and Findings

Key Questions:

- *Describe the way the pigment moved across the wet paper.*
- *What relationship does this movement have to the way water moves over land?*

Compare the Hand-Land Drawing with the Hand-Land Painting.

- *Are there any similarities?*
- *What is the relationship between the two artworks?*
- *Which of the two tells us more about watersheds? Why?*

Appendix 1A: *The Water Cycle*

To understand water, one must think in circles. Water moves through the environment in a circular path we call the water cycle. As with a circle, the water cycle has no beginning and no ending. It is an infinite cycle of evaporation, transpiration, condensation, and precipitation.

Water is essential for not only human beings but for all living things. To get an idea of how much water we are made of, draw a line horizontally just below your chest: everything from that line to the ground represents the amount of your body that is made of water. Hold your hand to your mouth or nose and breathe for a minute; your hand will become damp. This is because water from your breath is condensing on your hand. You are transpiring. The water vapor condenses because it is cooler outside your body than within it. If you are sitting in a car on a cold night with all the windows rolled up, sooner or later they will fog over as the water vapor you are transpiring condenses on the surface of the window and perhaps even the ceiling. With enough condensation, the water will form a drop and you may see some precipitation.

All plants, trees, and animals transpire. We are all part of the cycle in which water is returned to the atmosphere. When the water in the atmosphere becomes precipitation [rain and snow, for instance] it is again available for us to use. Plants and animals accept water in its most naturally occurring forms.

The earth's surface is covered with plants and trees, which have roots reaching down into the soil toward the ground water. There are millions of creatures living in and around those plants and trees. Every single one of these living things would perish without water. Rivers, lakes, streams, puddles, and even drops of dew collecting on a leaf, are sources of water for animals. Most plants get their water from the ground, although there are some species, which can draw water from the air. Plants like the willows and bullrush have shallow, widely spreading root systems to seek out water near the surface. Plants such as these can often be found growing on the banks of rivers and streams. Other plants, like the oak trees, have long taproots that reach deep into the earth to find ground water sources not visible on the surface. Animals in the wild drink water from rivers and ponds. They also get some water in the food they eat. This is true of humans as well. We get water through both drinking, and eating.

The water we use is closely tied to the natural cycle. It is also carefully organized and controlled by federal, state, and local governments. These control systems create another, parallel water cycle based on human consumption. Water is collected, treated, and distributed for use. Once used, it is again collected, purified, and tested to government standards before being released back into the environment to rejoin the natural cycle of evaporation, condensation and precipitation.

Appendix 1B: *Topographical Maps*

There are many kinds of maps and each map is made for a different purpose. Discuss in the classroom what types of maps students might know and how they are used. Examples include highway maps, local maps, topographical maps, world maps, maps of the solar system, etc..Originally the word *Topo* came from Greek, meaning "place". Topography means the shape and forms of the land in a particular region. It includes mountains, valleys, plains, lakes, rivers, and other features.

The earth's surface is very different throughout the world. In some places it is characterized by valleys and rolling hills. Exploring the different kinds of land areas on earth can be done with the aid of pictures and maps. The size of a hill, its elevation, for example, can be shown by color using the different shades color on a relief map. Another way would be to show it in a line form with topographic contours.

It is important to understand that topographical maps are made for describing three-dimensional earth surfaces using two-dimensional materials and techniques. Relief maps with gradations of color are useful to those who more interested in the general topography of an area--it's overall appearance and shape and where certain features such as mountains are located--than in the exact ground elevations. A shaded relief map gives the illusion of a solid, three-dimensional land surface.

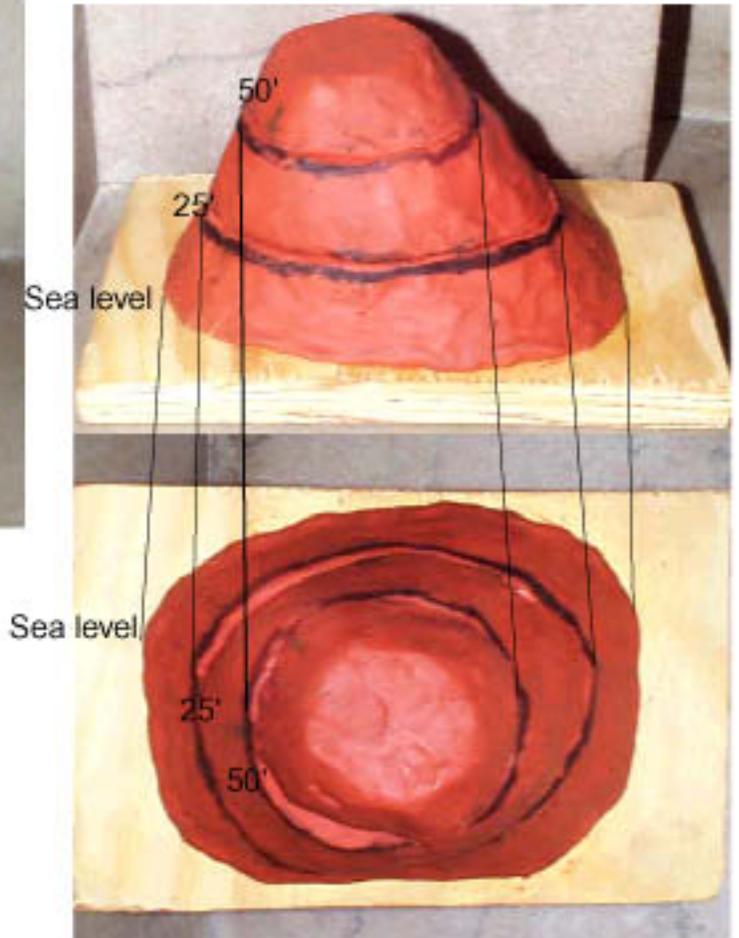
On topographic maps, contour lines are an effective way to show vertical dimension on flat paper. Elevations on a topographic map are shown by means of contour lines. Contour lines are like slices of the earth, *Figure A1B-1*. The position of each slice is shown by a line. Each line is exactly the same, as if the land flooded and, as the water went down, it left a mark every ten feet or so, like the rings in a bathtub. Little numbers on the contour lines tell you the elevation--just how high above sea level each line is. The more steep a slope, the closer the contour lines appear to one another.

Practice and imagination are needed to visualize hills and valley from the contour lines of topographic maps. Look carefully at the aerial photo, *Figure A1b-2* and a topographical map, *Figure A1b-3*. Comparing them can help us to understand how the topographic map is made. In the aerial photographs, you can see where the houses, buildings, and roads are located. The topographical map shows that the flatness or steepness of the land is represented by contour lines; the vertical difference between any two contours is the contour interval, which is 25 feet on this map. When the exact elevation of a hilltop is known, it is shown on the map. Any point between two contour lines is higher than a previous contour line, but lower than the next contour line. The closer the contour lines appear on the map, the steeper the landscape. Where contour lines converge, we have a vertical cliff.

Contour maps can show landforms, such as level land, hilltops, ridges, and cliffs. This information is useful to map users who are concerned with the exact elevation of the ground, such as civil engineers, planners, builders, hikers, and backpackers.

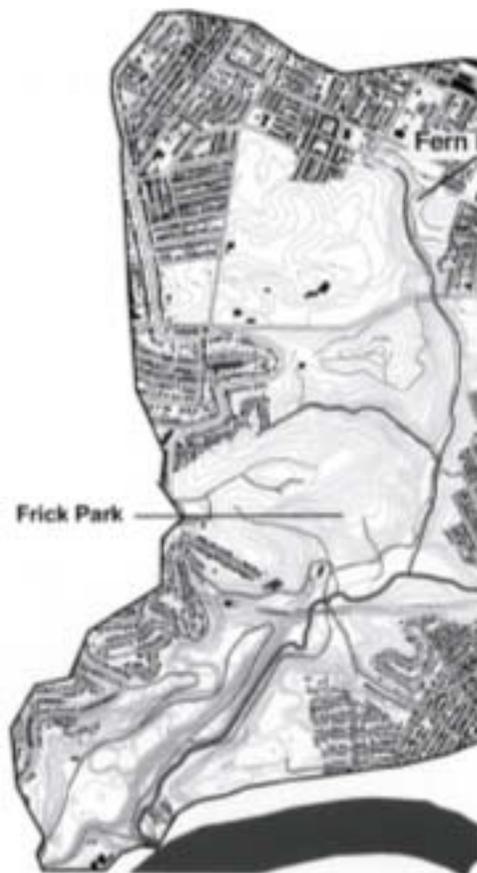


(Figure A1B-1)

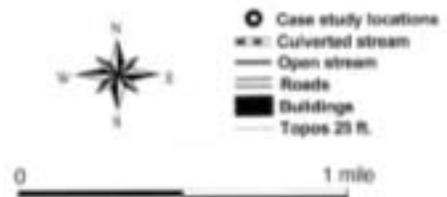




(Figure A1B-2)



(Figure A1B-3)



Glossary1 : *Watershed*

Atmosphere: The earth is surrounded by layers of gasses, extending nearly 100,000 miles into space. These layers make up the *atmosphere*, and are primarily made up of nitrogen, oxygen, carbon dioxide, and hydrogen along with traces of many other gaseous elements. The layer of atmosphere closest to the earth, called the *troposphere*, is about ten miles thick. Water vapor is trapped in the troposphere. When the air temperature, pressure, and humidity are just right, this water vapor condenses into fog or clouds, leading to forms of precipitation such as rain, snow, sleet, or hail.

Cartographer: A mapmaker.

Condensation: When water changes from vapor to a liquid. Clouds, fog, and dew are examples of naturally condensed water.

Concentric: An expanding set of circles sharing the same center. Concentric circles form as a raindrop falls into a puddle.

Contour line: A line joining points of equal elevation on a surface.

Contour interval: The space between contour lines indicating verticality or slope.

Divide: A ridge of land separating two areas that are drained by different rivers.

Evaporation: When water is placed in a shallow pan it disappears, changing from a liquid to vapor. Higher temperatures cause water to evaporate more quickly.

Gradation: Shading with a pencil or changes in paint-pigment intensity which can simulate the effect of light and shadow on a three-dimensional form.

Hue: A color or a shade of a color.

Intensity: The strength or sharpness of a color.

Land use: In urban areas, we might find roads, houses, apartments, downtown city areas; in suburban areas, we might find highways, houses, shopping malls, beyond that, we might find farms, forests, and parks. These are all examples of they way humans use the land.

Precipitation: Condensed water that falls through the atmosphere to the surface of the earth in the form of rain or snow.

Primary colors: Pigment primary colors are yellow, magenta, and turquoise

Symbolic Key: A map's symbolic key or legend is the symbolic dictionary which allows us to read the map. It is usually located in the lower right-or left-hand corner.

Transpiration: When we breathe, some of the water within us rejoins the atmosphere through exhaled vapor. This is a form of evaporation called *transpiration*. Plants also transpire by excreting water vapor through stomata --small holes or pores -- on the underside of leaves. Plants release their water vapor as they breathe. Unlike humans, they take in carbon dioxide and release or exhale oxygen.

Topography: The shapes and forms of the land in a particular region: valleys, plains, lakes, rivers.

Value: Degree of lightness or darkness in a color.

Inquiry teaching and learning process and vocabulary words

The definitions by: Doris Ash, Foundations / Inquiry, p.53, Directorate for Education and Human Resources, National Science Foundation, Arlington, VA,1999.

1. Observation
2. Forming questions
3. Forming a hypothesis
4. Forming a prediction
5. Investigation
6. Forming an evaluation
7. Present the process and result

Observing: Watching carefully, taking notes, comparing and contrasting.

Questioning: Asking questions about observations; asking questions that can lead to investigations.

Hypothesizing: Providing explanations consistent with available observations.

Predicting: Suggesting an event in the future, based on observations.

Investigating: Planning, conducting, measuring, gathering data, controlling variables.

Evaluating/ Interpreting: Synthesizing, drawing conclusions, and seeing patterns.

Communicating / sharing: Informing others through various means: oral, written, presentational.

Module 2.1: *Water Cycle and Watershed Interaction*

Sand Land

Refers to Surface Water and Ground Water

Overview

This module presents the student with a challenging inquiry-based learning opportunity to think about the movement of rainwater on the surface of the earth and through the soils underneath it. With the help of a physical model (a "sandbox"), students will simulate and observe rain falling upon and moving across and through a soil slope.

Students will inject food coloring into the soil. This will simulate the movement of a chemical contaminant in groundwater and surface waters. This demonstration helps students discover the invisible underground part of the water cycle, and can serve as a starting point for discussions about the impact of human activities on watersheds.

Background

In the last module, students learned how water moves across an impervious surface. In this module, they will learn how water moves through soils and other pervious materials. They will create a physical model which allows them to develop ideas about what might happen, then test those ideas by running water over the model.

Module 2, Sand Land, is a model of a natural soil system. Students will use a tray, sand, toothpicks, and other materials to represent land. Students will predict what might happen when water hits a pervious surface. Students will learn about the relationships between the movement of water and the forms created on land by erosion. Students can consider the placement of homes, streets, and other human constructions along natural systems. Students will also observe the change that occurs when a soil is dry, wet and saturated. In a colorful finale to the project, the concept of underground migration of pollutants through the soil into water can be investigated.

Objectives

Students will:

- Predict the effects of water falling on a soil slope
- Observe the movement of water on and through soil
- Record and analyze observation, and then compare them with predictions
- Discover answers to their own questions
- Expand their conceptual understanding of ecological and environmental contamination as it moves through soils and groundwater



Sand Land setting

Concepts

The following experiments simulate the movements of water and its effects on and through the soil. By using a sandbox that simulates a soil slope, students will explore aspects of real phenomena through the use of simple physical models.

It takes time for phenomena to evolve in nature. Human activities can go on for quite some time before we notice their impact on the environment (e.g. air pollution, groundwater contamination, global warming).

PA Educational Standards

Related PA Proposed Environment and Ecology Standards: Watersheds

- Understand the role of the watershed (Watersheds and Wetlands)
- Identify and explain what determines the boundaries of a watershed
- Explain how water enters a watershed
- Explain factors that affect water quality and flow through a watershed
- Explain the role of the water cycle within a watershed
- Explain the water cycle
- Explain the water cycle as it relates to a watershed

Related PA Proposed Science and Technology Standards: Earth Sciences

- Soil erosion
- Discern earth features and processes
- Groundwater flow and contaminant transport
- Explain the earth's water properties, behavior, and use

Preparation

Student Materials *per group of 4 or 5*

- 1 sandbox pan*
Drill a 3/8" drainage hole into the edge of the pan between the bottom and back walls
- Sand mix** 16 parts "Play Sand" to 1 part diatomaceous earth
- 1 pitcher
- 1 one-gallon (plastic milk) container filled with water
- 1 five-gallon bucket as a catch basin
- 1 scraper to pack sand
- 1 ruler as a drip container support
- 1 pint (drip) container, 4.5" diameter x 5.5" high with a 1/8" hole drilled into the center of the bottom
- 1 (drip) container with a 3/16" hole drip (*optional*)
- 1-2 blocks of wood to raise one end of the sandbox pan (1-2 inches high)
- Duck tape or masking tape to secure the ruler
- Food coloring
- Eye dropper
- Toothpicks
- 1 Watch with a second hand

**Sandbox pans*: Good plastic pans (18" x 15" x 4" deep), called "Tray Toes" are available from NASCO Scientific (Tel: 800-558-9595) for about \$6.00 (item # in NASCO catalog: #WO5175M). Also a large kitty litter pan or cement-mixing pan will do.

***Sand mix*: Use a mix of 16 parts "*Play Sand*" to one part diatomaceous earth. The mix could be used indefinitely if food coloring is not introduced. The reason for using the diatomaceous earth is to observe some soil erosion at the downstream side of the sandbox. Play sand alone works fine without the diatomaceous earth. Play sand is a generic name for multi-uses and is typically screened to consist of three different particle sizes for sandboxes and the like. It is available from most hardware stores for about \$5.00 for a 50-pound bag. Diatomaceous earth is available at most swimming pool supply stores for \$5.00 per pound. It is used in pool filters because of its fineness.

Set Up

Setting the system up properly before the class begins is key to a successful project. Encourage students to volunteer for the preparation. Add water to the sand mix until the mix can stand at a near vertical slope (don't add too much water; it may help to use a spray). Spread the moist mix to cover 2/3 of the pan to a thickness of 1-1.5 inch to simulate a "top soil". Tape the ruler at a distance of about 2" from the uphill rim of the pan. Balance the drip container on the pan's rim and the ruler and mark the position of the container bottom on the ruler. Set pan at an angle using the blocks to simulate a slope condition, *Figure 2.1*.

Note: *The sandbox was adapted from the "Stream Table" Landform Module developed at the Lawrence Hall of Science, University of California, Berkeley, CA.*

Estimated Duration

It takes 1 1/2 hours to complete the two activities described in this module. A modification, described below, allows the instructor to complete the lesson in 1 hour.

Lesson Plan

Class Setting

The students are divided into groups of four to five. The instructor and classroom helpers have prepared one sandbox for every group. The teacher will use a sandbox at the front of the room to explain the process.

Discussion

Review:

- The relationship of watersheds to topography, as introduced in Module 1: Hand Land.

- The movement of water over land, beginning with precipitation over watershed boundaries, its overland flow, and at ground water level is visible in *Watershed as a Macrocosm, Figure 2.1*.
- The movement of water through the land, and its potential underground flow is diagrammed in *Watershed as a Microcosm, Figure 2.2*.
- The Sand Land module is used to predict and observe the infiltration of precipitation into the soil, determining underground flow pattern, and runoff as described in *Schematic Representation of the Hydrologic Cycle, Figure 2.3*.

Key Questions:

- *Where does rainwater come from?*
- *Where does rainwater go?*
- *Are you related to the water cycle? If so, how?*
- *Are trees and lawns related to the water cycle? If so, how?*

Instructional Materials

- *Watershed as a Macrocosm, Figure 2.1*
- *Watershed as a Microcosm, Figure 2.2*
- *Schematic Representation of the Hydrologic Cycle, Figure 2.3*
- *It Rains In the Watershed, Activity Card 2.1*
- *Storm-Water Sources and Solutions Appendix 2A*

Keywords

atmosphere

condensation

contamination

evaporation

groundwater

Infiltration

precipitation

springs

transpiration

watercycle

wells

Activities

Activity 1: Understanding the Process

Explain the Sand Land model concept and materials to the students using the following directions:

Carefully secure the container on the ruler, which spans the back of sandbox's rim. Fill the drip container with water to about 4.5 inches, covering the 1/8" hole with a finger. Let water drip for 1.5 minutes. Water will flow over and through the soil (forming stream-like erosion patterns), and eventually through the hole of the pan into the collection bucket. After 1.5 minutes, a) cover the hole at the base of the stream table with your finger, b) mark the height of the water left in the container, and c) remove the drip container.

Notes: *The higher the water level in the drip container, the faster the water will flow. It is a good idea to make separate measurements of how quickly water flows out of the drip container with a 1/8" hole. This will be used as a means of comparison. Fill the drip container to the brim with water and mark the water level at 1 and 1.5 minutes. By repeating the experiment with the 3/16" hole drip container, students can observe different flow rates and the flows effect on erosion patterns.*

Activity 2: Developing a Hypothesis

Key Questions:

- *Where is the water going to go?*
- *What is the water going to do to the sand?*

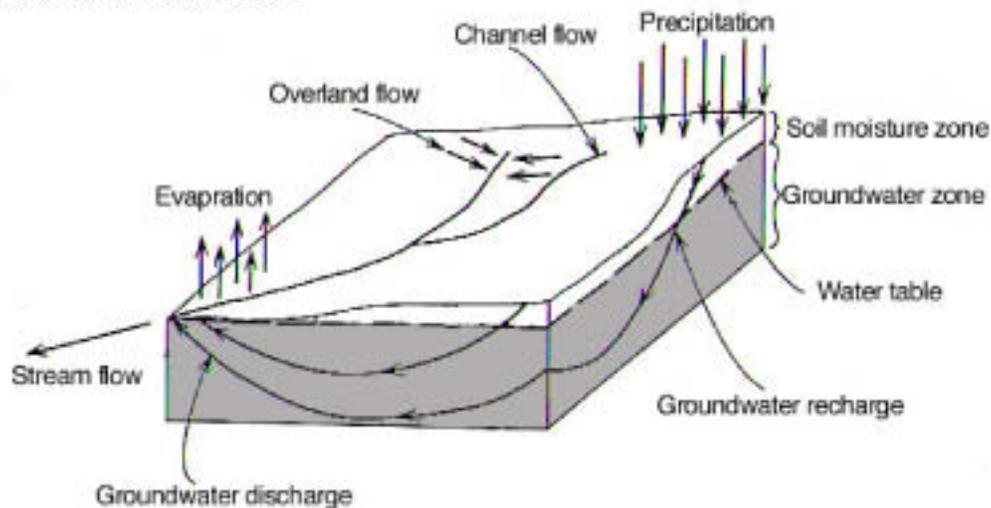
Think about the soil-water relationships that exist in our model. Each student will predict what will happen when rain starts falling on our sandbox model. Indicate the predicted movement of water by drawing dotted blue lines with arrows on the *It Rains In the Watershed Activity Card 2.1*.

Activity 3: Investigation, Running and Observing the Model

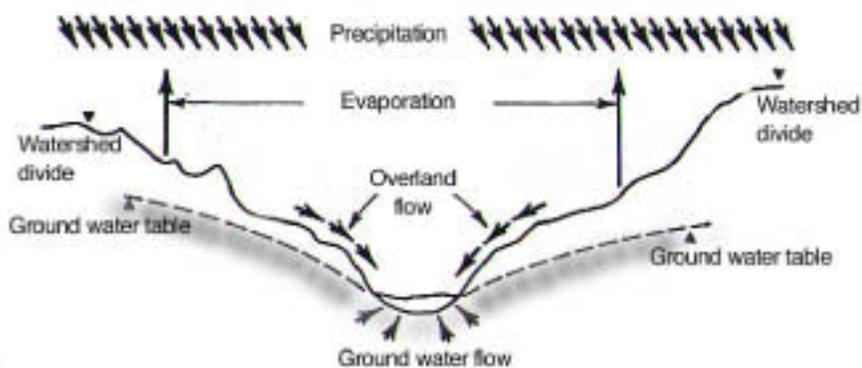
In order to simulate rain assign specific roles to team members: a "cloud", a timer, and two or three observers. They should follow the steps below.

1. Students will model "rain" by letting water drip from a container onto the soil slope in the sandbox. Each team of students sets the pan at an angle using the blocks to simulate a slope condition.
2. The "cloud" rains for 1.5 minutes (place the filled drip container on the ruler and removes finger from the hole), until the "timer" tells the cloud to cover the hole. In the mean time, the observers are paying attention to what is happening with the soil and the flowing water.

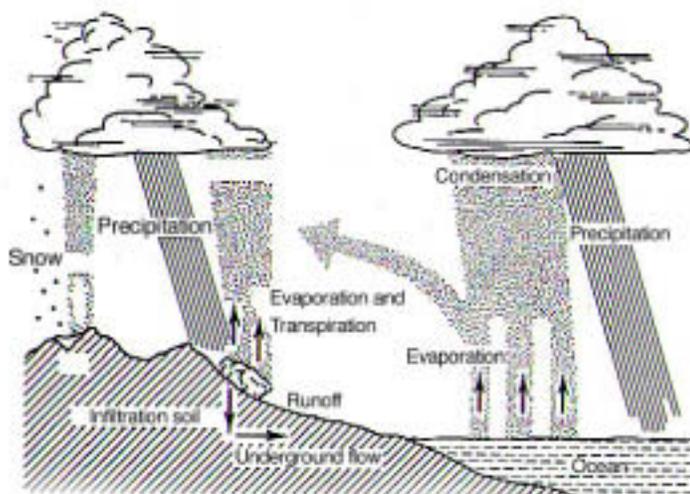
(Figure 2.1)
Watershed as a Macrocosm



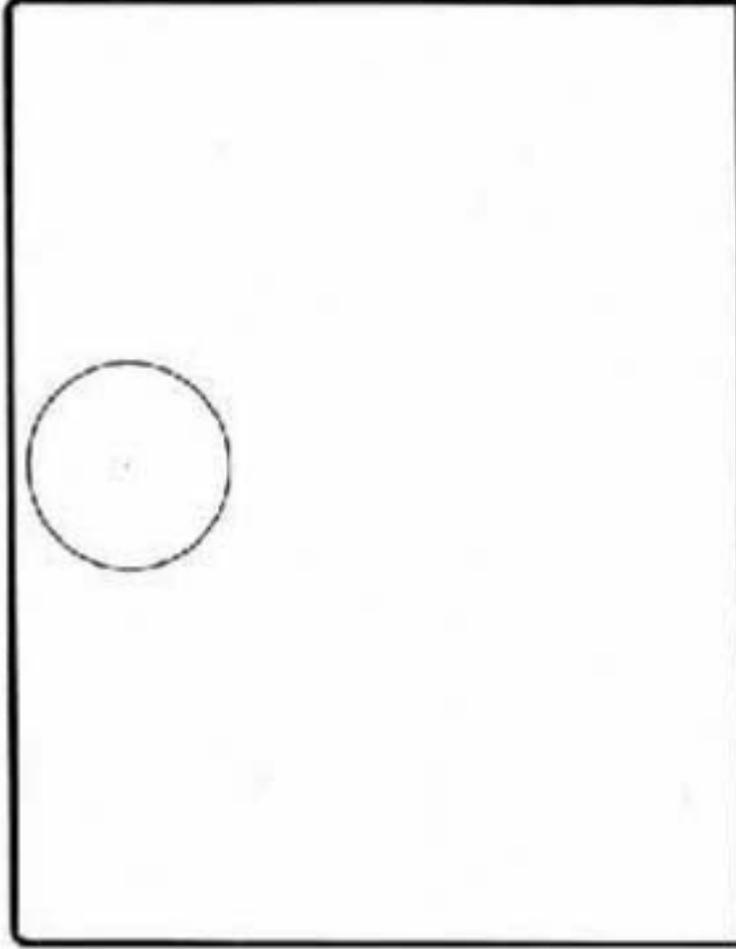
(Figure 2.2)
Watershed as a Microcosm



(Figure 2.3)
Hydrologic Cycle



Activity Card 2.1: *It Rains in the Watershed*

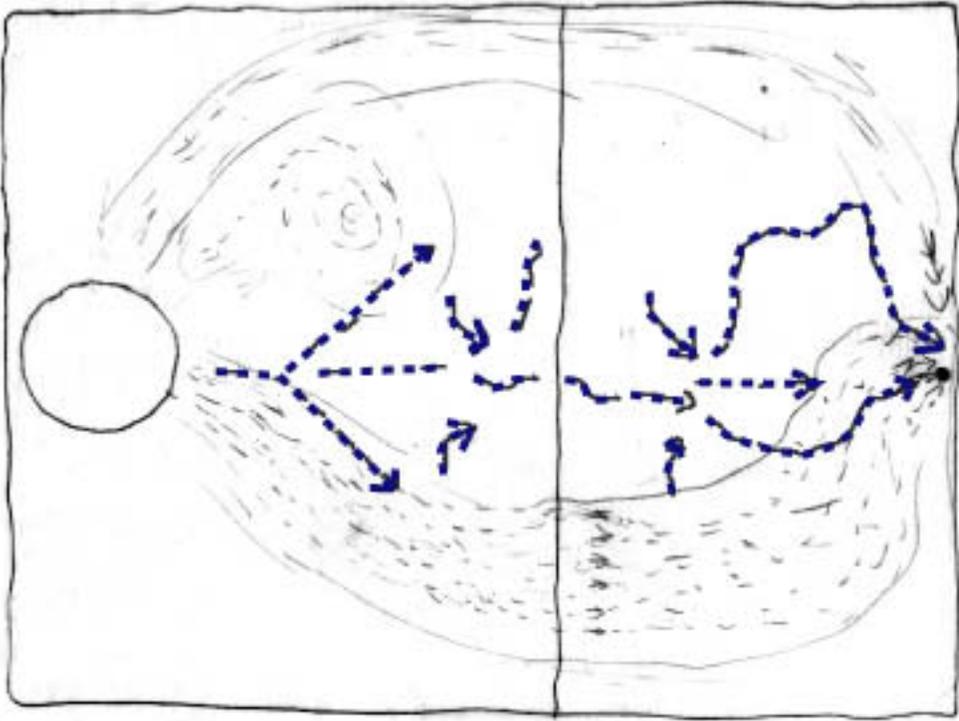
	
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1. We will use the sand box to model "rain".
2. Make a prediction drawing of what will happen when the rain" starts. Use this activity card.
3. The cloud rain for 1.5 minutes until timer tells the clouds to stop.
4. Observe and record what is happening. Draw a picture of what actually happened.

Name _____

Your Partner _____

Date _____



Sand-Land drawing by a student. The dotted lines represent her prediction, other lines are documentation of her observation about the actual water and sand movement.

3. The "timer" continues to keep time until no more water drips from the container or when the drops slow down significantly (until two consecutive drops are separated by two minutes).
4. The observers mark the boundaries of the existing stream channel that was cut into the sand by the water with five to six toothpicks.

Note: *The 1/8" hole simulates a smaller rainstorm than the 3/16" hole. Ask each group to balance the drip container on the pan's rim and the ruler, being careful to center it on the marks made previously on the ruler. Repeat the above procedure.*

Activity 4: Evaluating our Hypothesis and Investigation.

Place the sheet of tracing paper on top of previous sketch on *the Watershed Activity Card, Figure 2.4*. Draw solid blue lines to indicate the actual movement of the water. Draw any changes to the topography on the tracing paper. Write a brief description of observations in their notebooks. Teams can share their observations during class discussion and walk around to view each other's drawings and explanations.

Key Questions:

- *How did the water move?*
- *Did it move any differently than you predicted?*
- *What happen to the sand?*
- *How is our Sand Land model different than the real world? How is it the same?*

Extension

Students could extend their own inquiry experiences. For example:

- Use different particle sizes of sand and gravel.
- Make different land forms; simulate human development on the land. Use tooth picks, oil clay, small pieces of wood to simulate buildings, houses, and trees.

Module 2.2: *Water Cycle and Watershed Interaction*

Leak! An Underground Leak!

Overview

Often in our environment, contaminants spill on or below the earth's surface and result in contaminated groundwater, which feeds wells and springs and may eventually show up in surface waters such as rivers and lakes. This extension of the Sand Land experiment enables students to predict and observe the movement of contaminants through a watershed.

Objectives

Students will:

- Observe the movement of a contaminant (food coloring) through soil
- Record the time for the contaminant to be detected in surface waters

Concepts

This sandbox demonstration helps students visualize the invisible-underground part of the water cycle. It can serve as a starting point for discussion on the impact of human activities on watersheds and the role of a reductionist model in scientific inquiry.

This model will reveal the cause and effect of water and pollutants through the soil. By injecting food color into the soil, students can simulate the movement and dispersal of a chemical contaminant in groundwater and see its affect on surface waters.

Preparation

Student Materials

- Same as Sand-Land
- Food Coloring



Experiment of the underground leak

Set Up

Keep the sandboxes in the same condition from the previous experiment for this investigation. Recreate the slope under the sandbox, and prepare the water and drip containers. Prepare one bottle of food coloring with an eyedropper per group.

Estimated Duration

One hour

Preparation

Student Materials

- Same as Sand-Land
- Food Coloring

Set Up

Keep the sandboxes in the same condition from the previous experiment for this investigation. Recreate the slope under the sandbox, and prepare the water and drip containers. Prepare one bottle of food coloring with an eyedropper per group.

Estimated Duration

One hour

Lesson Plan

Class Setting

Students work in groups of four to five per sandbox.

Each student will need one *EEK! An Underground Leak! Activity Card 2.2*.

Discussion

Give a short introduction on underground sources of contamination, such as leaking tanks that store chemicals. Explain that spills on or below the earth surface result in contaminated groundwater, which feeds wells and springs and may eventually show up in surface waters such as rivers and lakes. Refer to *The Water Cycle, Figure 2.3*, to discuss the movement of contaminants through soil.

Activity Card 2.2: *Underground Leak In the Watershed*

	
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1. Inject a little food coloring into the sand with an eye dropper.
2. Make a prediction drawing of what will happen about the food coloring when the "rain" starts. Use this activity card.
3. Observe and record what is happening. Draw a picture of what actually happened.

Name _____

Your Partner _____

Date _____

Instructional Materials

- *The Water Cycle, Figure 2.3*
- *Leak! An Underground Leak!, Activity Card 2.2*

Activities

Activity 1: Developing a Hypothesis

Key Question:

- *What happens when water and chemicals infiltrate into the soil?*
- *Where is the color going to go?*

Activity Card (Figure 2.6)

- *How does the color interact with the sand before it rains?*
- *How does the color interact with the sand once it rains?*
- *Think about the dynamic systems and their relationships in our model*

Think about the soil-water-contaminants relationships that exist in our model. Each student will predict what happens when rain starts falling on our contaminated sandbox model. Indicate the predicted movement of water by drawing dotted blue lines with arrows on the *Leak! An Underground Leak! Activity Card, Figure 2.6*.

Activity 2: Investigation, Running and Observing the Model

Reassign team members to be a cloud, a timer, one - two observers and a person who pollutes the groundwater.

Students will fill the eyedropper with liquid food coloring and stick it into the sand all the way to the bottom of the container, at a point halfway down the slope, and within 1/2-1" from the "stream" boundary (i.e., the stream formed by the water in the previous experiment). A student squeezes the eyedropper of food coloring out and contaminates the soil near the streambed. The student assigned to pollute the groundwater.

Students make it rain. They keep adding water in the drip container so that the water level remains between 3.5 and 4.5 minute mark (marked from previous use), for 5 to 10 minutes (or until they can observe food coloring running through the hole of the pan). They remove the drip container and continue to observe changes in the size, shape, and color changes of the contaminated soil.

Students repeat the above and this time they inject another color on the other side of the stream and farther away from the stream boundary to observe differences in the extent of the contaminated area and the time it takes for the contaminant to spread.

Modification: *If the lesson lasts only an hour, inject the dye closer to the stream boundary and use only one container of water. In this way the dye will show up faster in the water in the stream.*

Activity 3: Evaluating Our Hypothesis and Investigation.

Place the sheet of tracing paper on top of previous sketch on *EEK! An Underground Leak! Activity Card, Figure 2.6*. Draw solid red or green lines to indicate the actual movement or shape of the contaminant. Using the listed questions, and ask students to write a brief description of their observations in their notebooks. Teams share their observations and their own questions during class discussion.

Key Questions:

- *How did the contaminated area change with time?*
- *Where did they first see the color? How big was the area where it was visible?*
- *What was the final extent of the contaminated area?*
- *How much time did it take for the food coloring to be observed in the running water?*
- *How is the Sand Land model different from the real world?*
- *Are there differences found in the soil?*
- *Are there differences found in the way the water moves?*
- *Are there differences found in the way contaminants are introduced into the water table?*
- *What are some of the ways that pollution gets into the soil and ground water?*
- *Describe the water cycle?*
- *How can human activities impact the water in the environment?*
- *Prompt: If someone changes the oil of their car and pours the oil on the ground, what is going to happen to the ground? Where will the oil go?*

Appendix 2A: *Storm-water Sources and Solutions*

Sewer overflow and high stream flows begin with rain and storm-water runoff in urban watersheds. Urban watersheds are characteristically heavily covered - 40 percent or more - with impervious surfaces, those being pavements and roofs that cause rain water to run off the surface and prevent it from infiltrating the soil. Impervious surfaces deflect rainwater into surface channels, where it can concentrate into erosive down-stream floods. The runoff water carries with it oil from cars, parking lots, maintenance yards and storage areas, and heavy metals from old construction materials known as, non-point source pollutants. Storm-water gets into the sewers, often producing overflows of raw sewage into the stream flow.

If we think of our overflowing sewer system as a bucket that is spilling over, we have two options: 1) buy a larger bucket or, 2) reduce the amount and slow the flow of water going into the bucket. Investing in increased sewer conveyance and treatment capacity without carefully examining the many ways of removing water from the system may be unwise. Reducing storm-water flows into the sewers can cost less, and it can produce additional benefit to the environment and the quality of life of the residents.

Urban retrofit and development projects could disconnect storm-water drainage from combined (mixed sanitary and storm sewers) and separate sanitary sewers and reconnect it with vegetation and soil. A range of measures can use natural processes to reuse, infiltrate, treat, and detain rainwater within individual sites and neighborhoods.

Some of the soils in Pittsburgh's watersheds are porous and permeable (meaning water can pass through). This soil has the capacity to infiltrate most of the water that comes into contact with it, filter solid particles out of the infiltrating water, and build them into the soil matrix. There are microorganisms that decompose some pollutants, turning them into nutrients for the living systems. Storage in the soil and deeper ground water turns intermittent pulses of rainfall into the streams and wetlands where aquatic organisms survive over dry summers. Even after a soil has been churned and compacted by construction, nature tends to restore these kinds of processes where ever it is allowed to work freely. In order to prevent erosion, soil must be re-planted as soon as possible after any land construction. Recently, environmental economists have begun to refer to natural conditions and processes as "natural capital" and "environmental services," and have assigned dollar values to them.

Taking advantage of natural processes to store and treat storm-water brings additional benefits. Recharging the ground water supports riparian vegetation, provides wildlife habitats, and opportunities for human interaction with the natural world. Reductions in impervious surfaces and enhanced tree plantings help moderate urban temperatures, increasing human comfort and reducing building cooling loads. Porous



The outfall of the main Nine Mile Run culvert at low flow



After a rainstorm, when the runoff carries raw sewage and other urban pollutants with erosive power.

pavements can be designed to improve pedestrian access to desirable places.
Revegetation of landscapes beautifies neighborhoods.

The informed, creative retrofit and redevelopment of urban places could solve Pittsburgh's watershed problems at the source, while revitalizing older communities. Such redevelopment can reduce impervious cover, disconnect storm drains from sewers, build storage and treatment features into the fabric of urban places, educate the residents about where they live, and allow natural processes to operate again.

Much of greater Pittsburgh's buildings, streets, land uses and infrastructure has been in place for years. Their functions and performance were adequate for the standards of their time. But standards change over time. Today's generations are re-evaluating the obsolete technical systems they have inherited and counting the mounting costs of potential reconstruction. At the same time, people today value the human scale and comfort of old urban places, and are seeking ways to bring them to full health and vitality.

From: *Re-Evaluating Stormwater*
The Nine Mile Run Model for Restorative Redevelopment
Bruce Ferguson, Athrns
Richard Pinkham, Rocky Mountain Institute
Timothy Collins, STUDIO for Creative Inquiry, Carnegie Mellon University
Published by: Linda Spangler, EDAW, Inc., Daniel Sadowsky, Rocky Mountain
Institute
1999

***Suggested resources**

Video tapes for public education.

- *Combined Sewer overflow; Solving a Community Problem*
- *When It Rains... It Drains!*

Both tapes are distributed free. For more information call
ALCOSAN Wet Weather Program (413)734-8721

Small Booklet:

- *EPA WE ALL LIVE DOWNSREAM*,
EPA Region 3 Non-point Source Program at (215) 597-9911



Urban impervious cover (concrete / asphalt)

generates excessive runoff during storms, which is conventionally routed into pipes or concrete channels, robbing the soil of moisture and bypassing its absorptive capacity.

In contrast, rain infiltrates into vegetated soil, recharging groundwater and supporting plants.

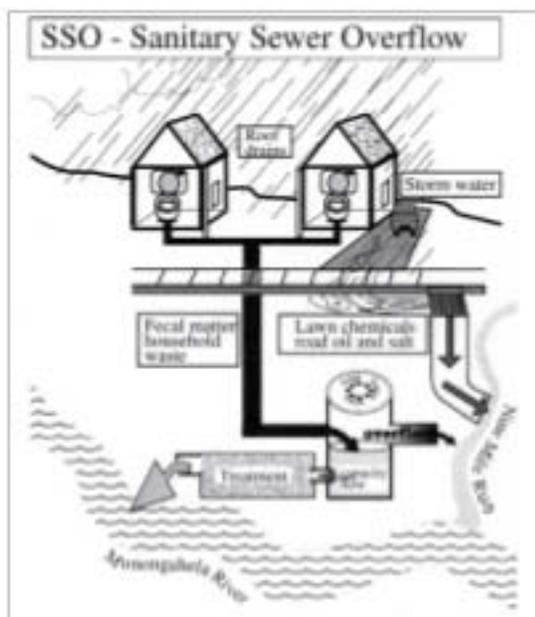
Drawing by Jen Uncapher, RMI.

SSO

In a separated sewer system, water from inside of the building flows into sanitary sewer lines. Street drains often discharge to storm sewers, but in older portions of Allegheny county they are often connected to sanitary sewers. Water may also enter sanitary sewers from cracked or disjointed pipes. Sanitary sewer overflows result when wet weather surcharges sanitary sewer line and contaminated water escapes at regulator structures (and sometimes at manholes and cracks in pipes).

CSO

In combined sewer systems, water from inside of buildings, roof drains, and street drains all join in combined sewer lines. Water may also enter the system through cracked or disjointed pipes. Combined sewer overflow occurs when wet weather surcharge the pipes and contaminated water escapes the system at regulator structures.



Glossary 2 : *Water Cycle and Watershed Interaction*

Surface water: precipitation pooling or flowing on unpaved or paved land towards streams, storm water pipes, and rivers. Part of this water evaporates, some infiltrates into the soil, another part flows into local streams, creeks, ponds, etc.

Groundwater: water below the surface of the earth, the source of spring and well water. Groundwater flows as surface water does, only much more slowly since it has to move through small openings between the soil grains.

Groundwater contaminant: any chemical compound harmful to human health and the environment that reaches groundwater and moves within it. Improper waste disposal, undetected chemical leaks in industrial plants, and accidental chemical spills typically result in groundwater contamination.

Notes

Module 3.1: *Stream Environment*

Not a Field Trip, a Stream Trip

An opportunity for observing nature

Overview

After the classroom experiences of Hand Land and Sand Land, it is time to see an actual stream environment. Instructors should select a stream that can be safely accessed by a number of students. A field trip to a stream will be organized around the key question: *What does stream or water quality mean?*

Upon arrival at the stream location, students become familiar with the area using the field book, *Appendix 3A*. Students collect stream environment artifacts for later classroom study, and learn to question water quality by visual observation and exploration of the stream its channel and streamside vegetation.

Once students have an understanding of the stream environment and conditions, they will begin an exploration into stream quality using two scientific techniques: a bio-indicator approach using benthic organisms, and a chemical approach using test kits.

Background

Water is rarely 100% clean or 100% dirty. Some very healthy streams can run turbid (muddy) at times. This is a natural part of the cycle. Normally healthy streams can be high polluted during rainfall; this is often true in cities. How do we know a stream is healthy? This module provides activities, information, and a field book that will help students understand the dynamic nature of streams. Students will learn to assess stream quality through careful observation and the strategic use of various tools. Students will learn about small aquatic creatures called benthic (bottom dwelling) organisms. They will also explore basic water chemistry and the various human impacts on stream environments. Each student will use a field book to record his/her observations.

Teachers are encouraged to give students an opportunity to compare and contrast different streams, or different parts of the same stream. They will look for changes in the banks, channel, and surrounding environment to acquire a full experience. Keep in mind that streams change over time, flowing water is always changing with rainfall, and that human activities and wildlife can affect stream flow and water quality! By using different tools, disciplines, and skills, students will discover that streams are not just moving water but complex and interesting living systems.

Objectives

Students will:

- Observe and analyze the stream and its environment
- Be exposed to the impact of human activities on water quality



Observing benthic organisms



A scene of the fieldtrip. Students are observing and recording.

- Observe, record, and collect some natural objects along the stream
- Engage in a full and personal inquiry experience
- Learn about what is around a stream and how that affects water quality

Concepts

Water quality effects the lives of many organisms in a watershed.

PA Educational Standards

Related PA Proposed Environment and Ecology Standards

Streams

- Explain the effects of water on the life of organisms in a watershed
- Explain how the physical components of aquatic systems influence the organisms that live there in term of size, shape, and physical adaptations

Environmental Health

- Identify environmental health issues

Ecosystem and their Interactions

- Explain the flows of energy and matter from organism to organism within an ecosystem
- Identify and explain the characteristics of biotic and abiotic
- Describe and explain the adaptations of plants and animals to their environment
- Demonstrate the dependency of living components in the ecosystem on the nonliving components

Humans and Environment

- Explain how human activities affect local, regional, and national environments
- Explain how a particular human activity has changed the local area over the years

Preparation

Materials

- Field Book, *Appendix 3A*
Assemble and review with students prior to the field trip
- Pencils or colored pencils
- A Magnetic compass
- Quart-sized, plastic zip-loc bags for collection (with students names on the bags)

Set Up

When you plan a field trip, it is ideal to choose a place in your local watershed. Visit the site and try your equipment *before* the field trip. You should have a good idea about what students will find and how impaired the body of water is. Contact your County Health Department or the State Department of Environmental Protection for more information. Carefully consider the safety issues and concerns of your students.

You will need to draw or acquire a simple map of the area you are studying to insert on page 4 of the field book. See example.

Estimated Duration

Three hours to all day

Lesson Plan

Class Setting

A field trip to a place in the local watershed. A park would be an ideal site. Take the normal precautions and preparations for any outdoor field trip. Prepare for wet feet. Students should wear layered clothing to allow for changes in temperature or wet conditions.

Note: *When you take students to a stream environment, have them observe the diverse elements of the watershed on the trip to the stream. Have them describe and record the places that are visible as they travel. Are there many houses, businesses, industries, parks, or forests? Once you get to the stream site, explain the goals of the field trip, safety issues, and rules. Review the **Reminder: How to be a Good Observer**, Field Book, Pg.5. It is vital to remember that this is an opportunity to observe and study living things in their environment.*

It is vital to help students understand that they need to be careful when working around streams with potentially suspicious water quality. They must wash well after working in the stream. They need to know that no food, candy, or gum should be

consumed while working with the stream, or until after they have cleaned their hands. Work with your school nurse to identify the best method of sanitizing their hands after their work. DO NOT POUR SANITIZING LIQUID INTO THE STREAM.

Activities

Activity 1: Getting Oriented and Becoming a Good Observer

Students should orient themselves by using a compass and the map, *Field Book*, p.4. Keep the students within visual contact. Spend fifteen minutes getting oriented to the site; note their positions on the map.

Activity 2: Observing the Stream Environment

The students are divided into small groups. Students are to use their *Field Book* to begin their inquiry into this particular stream environment. They should sketch their observations in the *Field Book*.

Activity 3: Collecting Stream Artifacts

Students should collect artifacts from around the stream environment, and place them in the plastic bags for use during the last module. Be careful not to crush any fragile artifacts.

Module 3.2: *Stream Environment*

Flip Rocks / Benthic Organisms

Overview

Benthic Macroinvertebrates: (benthic: creatures that live on the bottom of streams)
(macroinvertebrates: creatures with no backbone).

Benthic organisms are good biological indicators of water quality. By monitoring benthic organisms, we get an excellent picture of life in the stream over time. Benthic life in a stream provides a relative understanding of water quality which can be further explored by testing for specific chemicals.

Objectives

Students will:

- Identify, observe, record, and analyze different benthic organisms
- Use the presence of aquatic organisms to assess water quality
- Assess water quality with the presence or lack of aquatic organisms

Concepts

Introduce typical benthic organisms for local stream conditions, e.g. a typical urban PA spring fed stream will include planarians, gammarus, or scud, snails, and isopods. Discuss the implications of the presence of benthic organisms: diversity is a sign of a healthy environment, some organisms exist in comparatively clean waters (e.g., gammarus), while others are more tolerant of pollution (e.g., planarians). Learn about biological organisms which live on the bottom of streams, and what they can tell us about long term water quality.

Benthic organisms as indicators of water quality references:

Benthic Macroinvertebrates, Appendix 3C

The Issac Walton League and Save Our Streams Program are good sources of information. The University of Wisconsin Extension sells a Macroinvertebrate key. You can also find interactive keys on the web: <http://140.211.62.101/macroinverts/>

PA Educational Standards

Related PA Proposed Environment and Ecology Standards

Streams

- Describe the life cycle of organisms that depend on water
- Identify organisms that have aquatic stages of life and describe those stages
- Explain the effects of water on the life of organisms in a watershed

- Explain how the physical components of aquatic systems influence the organisms that live there in term of size, shape, and physical adaptations

Preparation

Materials

- A sampling pan for each group to look at benthic organisms
- A small plastic cup for each student to scoop benthic organisms and water
- two magnifying lenses and a pair of forceps for a pair of students
- Field book, clip-board, and pencil for each student
- Plastic gloves (teacher's preference)
- Antiseptic solution to wash hands after the sampling
Speak to the school nurse for recommendations.

Set Up

Prepare sampling materials as necessary for your students. Have the pans, cups, magnifying lenses, forceps, field books, clip boards, and pencils all prepared as single packages to be handed out to the groups.

Estimated Duration

The total field time: one to one and a half hours. Teachers might consider using a class period before the stream trip to prepare the students, and or a class period after to analyze the data and talk about the process and the results.

Lesson Plan

Class setting

Prepare to work in small groups in this outdoor workshop. Extra adults are necessary to help manage the class in the outdoor setting.

Discussion

Hand out the sampling pans and other materials to the students. Gather the students around the stream to pay close attention as you demonstrate a safe and sensitive manner of disturbing the benthic organisms home. ***Remember, if you pick up a rock put it back where you found it. Return all living creatures to the stream carefully, after your study.***

Instructional materials

- *Field Book*
- *Common Benthic Organisms in Nine Mile Run, Figure 3.1*
- *Background Information: classifying creatures, Appendix 3B*
- *Background Information: Benthic Macroinvertebrates, Appendix 3C*

Keywords

bacteria

benthic organisms

biological monitoring

habitat

kingdoms

phyla/phylum

Activities

Activity 1: Demonstration of How to Find Benthic Organisms

Key Question:

- *Where do you find a benthic organism?*

Tell students, “The easiest method with the least equipment is simply to choose some likely rocks in shallow moving water. Pick up a stone and look at the underside. “Wigglers” of all sorts are likely to be found and can be carefully nudged, picked up, and gently pushed into the collecting cups or directly into the sampling pan. Let me show you how.”

Students are to use the Field Book to observe and record what they discover about the benthic organisms and the environments they are found in. Ask them to write their descriptions of what they notice about the habitat. Students decide for themselves what to observe. They should record where different organisms are found and the conditions or characteristics of the place. Include information about where they are found:

- *Are they in a shady or sunny area?*
- *Is the bottom gravel, sand, or something else?*
- *Is the water shallow or deep?*
- *Is the water moving really fast or sort of slow?*
- *Are there trees or grass along the stream banks?*
- *Do you see any eroded bank? Where?*
- *Are there any manmade objects near by? What are they?*

Be specific about what is observed.

Activity 2: Observe the Benthic Organisms

Key Question:

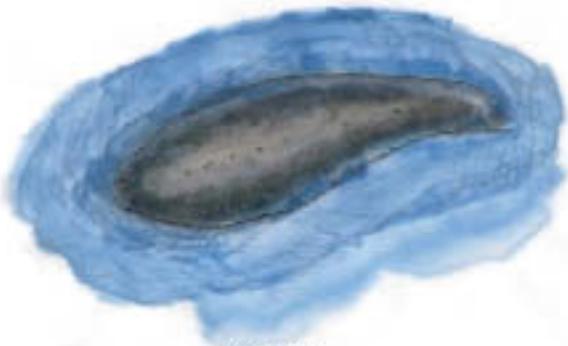
- What are its features?
- How many different benthic organisms can you find?

Observe the benthic organisms closely using a magnifying lens. Ask the students to record the body structure.

- *What features or characteristics does the organism have?*
- *How does it move?*
- *What color is it?*
- *Does it have a head? If so, describe it.*
- *Does it have legs?*
- *What do they look like and how many legs does it have?*

Common Bottom Organisms in Little Blue Run

(Figure 3.1)



Leech

(Leeches move in a flowing water-like motion)

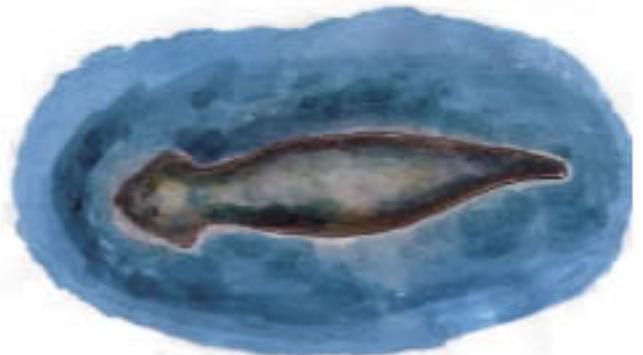


Snail



Gammarus or Scud

(Fast side swimmer - the scud indicates cleaner stream)



Planaria

(Planaria is usually found in cleaner streams)



Caddisfly
(larva stage)



Crayfish

(good indicator of water quality)

Carefully make detailed drawings of the benthic organisms, noting all of the observations listed above in the Field Book. Observe and record the different kinds of benthic organisms. How many different kinds have you found? Challenge yourself to find as many different types as possible. Identify, count, and describe the creatures in your Field Book. Would you classify them as "wiggler", "crawlers", "backstrokers" or "blobs"? Record all of your data in your Field Book.

Activity 3: Evaluation and Findings

Key Questions: (Assessment opportunity)

- *How many different kinds of benthic organisms did they record?*
- *How many creatures were they likely to find? Is there a lot of diversity in the stream?*
- *Is the environment producing more than one kind of benthic organism?*
- *What questions should one ask when bio-monitoring a stream for water quality?*
- *What might this answer tell us about the water quality or this ecosystem?*
- *Is our stream in good, fair, or poor shape?*
- *Why do you think this stream is in the shape it is in?*
- *What would make the stream and its banks better?*

Module 3.3: *Stream Environment*

Water Chemistry

Overview

If we rely only on our eyes and nose, we sometimes miss important indicators of water quality. Chemistry provides another way to inform our perception of water quality. By testing the water of a stream we get an immediate numeric indication of the chemical composition of the stream at that point in time. Each test tells us specific information. We will perform some basic water-chemistry analysis. This lesson should provide students with an opportunity to observe the temperature, pH, and dissolved oxygen in water. Free flowing stream water should be cooler than the air. It should have a neutral pH because there is a narrow band that supports life. It should have enough oxygen for creatures to breathe.

Teachers must use safe laboratory practices at all times. Some of the chemical solutions used in these tests are strong acids or bases, and some are toxic. Wash affected areas immediately if students spill any of the solutions on themselves. Ask students to report any spills immediately. Also ask students to report any broken glassware or problems with equipment or apparatus. In general, use common sense.

Specific instructions for each test are located on the test kits. Read the instructions before you begin the test. Follow the instructions carefully.

Note: *Good chemical analysis of water takes practice. Students have to be familiar with using the equipment in the lab or classroom before the field trip. Run the test with them discussing the concepts presented here.*

Objectives

Students will:

- Use chemical testing as a means of assessing water quality.
- Learn good sampling techniques and "in the field" testing techniques.
- Explore two testing techniques and compare them.
- Learn about specific chemistry tests for water quality.

Concepts

Provide a baseline understanding of water chemistry. Understand the importance of good "in the field" sampling techniques. Learn how our eyes and nose can fool us when we are beginning to think and learn about water quality. Explore two testing techniques, and their relative import to local water quality. Understand that there are specific chemistry tests that give us a very exact information about a single parameter of water quality. Understand how and why biological indicators denote water quality over time and chemical testing indicates water quality at the moment of the test.

PA Educational Standards

Related PA Proposed Environment and Ecology Standards

Environmental Health

- Identify various examples of long-term pollution and explain their effects on environmental health.
- Identify diseases that have been associated with poor environmental quality.

Ecosystem and their Interactions

- Explain how human activities affect local, regional and national environments.
- Describe what effect consumption and related generation of wastes have on the environment.

Humans and Environment

- Explain how human activities affect local, regional and national environments.
- Explain how a particular human activity has changed the local area over the years.

Preparation

Materials

- A sample bottle for collecting water for each station
- Testing kits, *Appendix 3C*
- Thermometer, pH meter, DO testing kit, *Appendix 5*
- Recording materials (clipboard, pencil, *Field Book pg.7*)
- Clean water to rinse the equipment
- Watch or stop watch
- Waste bottle or bucket with lid if many students participate
- Surgical gloves
- Eye protection
- Bucket for washing hands
- Boots to take samples
- Antiseptic solution to wash hands after the sampling
Speak to the school nurse for recommendations

Set Up

Scout and prepare testing stations. Look for safe access, interesting context, and a place to run the tests comfortably. Specific instruction for students to follow for each test should be located at the testing station. Review the instructions with your student before you begin the test. Instruct chaperones and students regarding issues of safety and use of the kits prior to the test. Follow the instructions carefully.

Estimated Duration

The field time: one to one and a half hours. To use the chemical testing equipment properly, students require a minimum of one class period to practice before the fieldtrip. Invite the chaperones to learn the techniques at the same time. Schedule class time after the field work to analyze and discuss the data collected.

Lesson Plan

Class setting

Prepare to work in small groups in this outdoor workshop. Before the fieldtrip teachers must explain the procedure for water chemical analysis, *Appendix 3C*, and demonstrate how to use the equipment. Students must rehearse using the chemical testing equipment, and learn of the importance of documenting the data and of working as a team.

Discussion

Almost everything on earth is soluble in water. Imagine that all the things that could dissolve into water when it rains on our watershed, consequently becoming part of it. Discuss the parameters for which we will be testing, and discuss how we compare different streams to determine health or quality. Brainstorm the human activities further up in the watershed that might have affected our results. Discuss how humans can protect water quality.

Key Words

alkalinity

chemical

chloride

dissolved oxygen

monitoring,

nitrate and phosphate

pathogenic monitoring

pH

Activities

Activity 1: Choosing a Site and Running Chemical Tests

Key Question:

- *How do you use the equipment to test for temperature, pH, and DO?*

Demonstration and Discussion

The teacher must review the procedure for water chemical analysis. Explain the safety issues related to working with chemicals. Indicate specific locations for students to test. Review temperature, pH and Dissolved Oxygen and ask students to explain what each indicates about water quality. Provide the activity sheet and equipment, *Field Book, Page 7*.

Each group must discuss water testing procedures and outcomes at the specific location. Observe students' conversation. Ask the chaperones and other participants to join this conversation. The basic activities are below.

- Collect water samples from at least two areas of the stream or two different streams.
- Test the water samples at the designated sites.
- Record all observable data in the Field Book.

Activity 2: Evaluation

Key Questions:

- *What do your results indicate?*
- *Discuss what might affect the analysis of stream quality.*
- *Discuss the relationship between benthic organisms and water chemical testing.*
- *Discuss the relationship between the concept of clean water and good scientific field work, team work, and documentation.*

Discuss what they have observed and what they have learned.

Chemical analysis gives us a momentary glimpse of water quality in time. Students should consider the time of day and weather, as well as how these factors could affect the results. Students should be able to explain all findings in their journal. Ask students to cite evidence for who/what uses the stream, when they use it, and what impact it has had on the stream environment.

- *What kinds of wild life use this stream?*
- *How do people use the stream?*
- *Can a street, a park or a group of nearby houses affect results?*
- *Does it change at different times, days of the week or seasons?*
- *Discuss how human impact is effecting the stream environment.*
- *Does it change at different times, days of the week or seasons?*

Clean up

Carefully place all used chemicals and wastewater in the waste bottles to take them back to the school for proper disposal. Wash hands with antiseptic.



pH testing

Appendix 3A

Field Book

Watershed _____

School _____

Name _____

Date _____

Notes and sketches are to be completed during the field trip.

Note: *After planning the field trip, select some activity sheets from this field book that you would like to use for your students. Add your local map. Copy and bind them to make your own field book for your students.*

How to Use This Booklet

Record what you see, think, and learn. Use this booklet to focus your observation. Your teacher will tell you which page you should be on for each activity. Spend your time carefully writing and drawing throughout the book. Everything you do in this booklet will be used in class. If you can not finish during the visit, finish as soon as you get home, before you forget!.

How to Use This Booklet	p.1
Schedule	p.1
Map (example)	p.2
Reminder	p.3
Why are we here?	p.4
Streams	p.5
Draw a picture of the stream and its environment.	P.8
Water testing	p.9
Colors in Nature	p.11
Draw Benthic Organisms	p.12
New Vocabulary Words	p.13
After The Field Trip	p.14

Example of Field Trip Schedule

9:30	Board the School Bus at school
10:00	Arrive at lower Park Parking Lot Hike to the _____ Creek
10:10 -11:00	Observe and study the stream and benthic organisms
11:00 - 11:30	Observe and study _____Creek
11:30 - 12:00	Hike through the wetland. Board bus at the Parking Lot Return to school

What to Bring: Bring this Field Book some pencils, and water as you wish. Wear long pants. Layers are best. Wear comfortable walking shoes or boots.

Caution: Prepare to clean and disinfect hands after urban stream studies and use of laboratory chemicals. No food, drinks, candy, gum, or other snacks should be consumed during field testing.

Map Example of a map (Frick Park)



Note: Add your local map. After students get off the bus, gather the students and use the map to introduce them to the study site. Talk about the map, mapping and icons.

Key Question: Direction

Where are you?

- *Where are you on the map? (each marks where they are on the map)*
- *Which direction is north on the map? (create an icon, mark on the map)*
- *What direction does the sun rise and sun set? (create an icon, mark on the map)*
- *What direction is your school? (create an icon, mark on the map)*

Where is the stream?

- *What direction is up-stream? (create an icon, mark on the map)*
- *What direction is down-stream? (create an icon, mark on the map)*
- *Where is the source and mouth of the stream? (create an icon, mark on the map)*

Reminder

The example was created for Homewood Montessori 6th grade students.

This field trip is an opportunity for you to observe and study living streams. Before jumping off the bus, let's review some rules and safety issues.

"To be a good observer"

- Think before asking questions. You must be quiet and observant. Look and listen, record your observations with drawings and writing.
- Leave only foot prints, take only memories!
- Treat all living creatures with patience and respect. Be quiet and sensitive when working with living things!
- You should not disturb the environment. You have to become part of the background. To become part of the background you have to sit really still.
- Concentrate and observe carefully. You can't draw from nature without observing it.
- Focus on details. Does it have a shape? Color? Do you see many or few? Does it move? Does it have legs? How does it move?

To be a good observer in both art and science means not disturbing or changing what you are studying. It means paying careful attention to detail. In art, you draw what you see. In science you write about what you see. Get every detail that you can on to the paper, in your writing, your drawing, or in your mind. Think about what you want to remember from this field trip. Think about new questions that you might have, and want answers to.

Note: Use next page "Why are we here?" and "Reminder" for the actual Field Notes.

Basic safety rules:

- Wash hands well after working with chemicals and in the stream. No food, drinks, candy, or gum should be consumed while working along the stream, or until after cleaning hands. Work with your school nurse to identify the best method of cleaning and sanitizing their hands after their work.
- Using chemical testing kits, wear gloves and goggles.
- Do not pour sanitizing liquid or chemicals into the stream.

"Why are we here?"

Write your comments and questions about this place.

Stream Study - Area 1

You are going to carefully observe two different stream conditions. They could be two different streams or different parts of a stream. One might be more effected by human impact than the other stream. One might be more shady and vegetated than the other one.

(Teachers can identify the study areas or they can let the students decide.)

Record your observations below.

Name of the Stream:

Describe Study area 1:

How wide is your study area? (Use a tape measure)

Study area 1:

How deep is your study area? (Use a stick to find out)

Study area 1:

Does your study area have a riffle (can you hear the water) or a (quiet) pool?

Study area 1:

Is the water in your study area muddy or clear?

Study area 1:

Is the study area shady or sunny?

Study area 1:

Do you see any algae? How much?

Study area 1:

Do you see any signs of human impact? Explain what might be happening.

Study area 1:

Are there any signs that animals are using the stream? If so, what kinds of animals?

Study area 1:

Are the banks eroded? How much?

Study area 1:

Stream Study - Area 2

You are now going to carefully observe the second of your two stream areas. You are going to ask yourself the same questions as before, so you can compare the results later.

Record your observations below.

Name of the Stream:

Describe Study area 2:

How wide is your study area? (Use a tape measure)

Study area 2:

How deep is your study area? (Use a stick to find out)

Study area 2:

Does your study area have a riffle (can you hear the water) or a (quiet) pool?
Study area 2:

Is the water in your study area muddy or clear?
Study area 2:

Is the study area shady or sunny?
Study area 2:

Do you see any algae? How much?
Study area 2:

Do you see any signs of human impact? Explain what might be happening.
Study area 2:

Are there any signs that animals are using the stream? If so, what kinds of
animals?
Study area 2:

Are the banks eroded? How much?
Study area 1:

Draw a picture of the stream and its environment.

Water Testing

Today you will test the stream in two different locations for three different factors: temperature, pH, and Dissolved Oxygen (D.O.). As you perform the various tests, record your information and any comments in the data fields below.

Study Area 1

Temperature: Use digital temperature instrument. Record the temperature of the water.

Study area 1:

pH: pH stands for the power of hydrogen. It is a measure of acidity and base.

Study area 1:

Dissolved oxygen: Dissolved oxygen is the amount of oxygen that is dissolved in the water. This determines what organisms can live in the stream.

Study area 1:

Your Comments

Study area 1:

Study Area 2

Temperature: Use digital temperature instrument. Record the temperature of the water.

Study area 2:

pH: pH stands for the power of hydrogen. It is a measure of acidity and base.

Study area 2:

Dissolved oxygen: Dissolved oxygen is the amount of oxygen that is dissolved in the water. This determines what organisms can live in the stream.

Study area 2:

Your Comments

Study area 2:

Note: *After the fieldtrip, students can graph the results and analyze their data.*

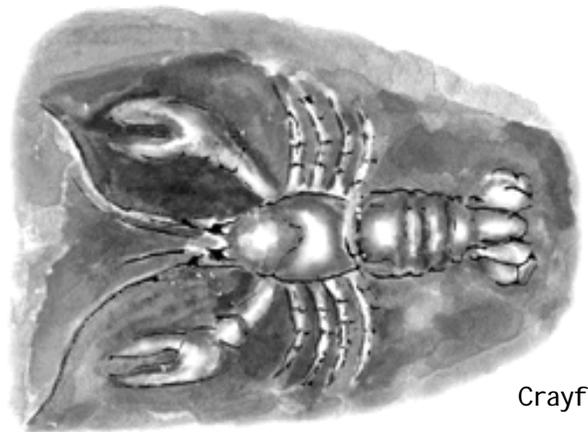
Colors in Nature

Pick up five to eight natural objects in and around the stream. Try to collect different colored ones. (Remember, we are visiting other creatures' homes! Do not pick any live plants or animals. Students can find all kinds of natural objects, including falling green leaves on the ground.)

Note: *This activity is explained in module 5.1: Colors in Nature.*

Draw Benthic Organisms

Draw a detailed record of the benthic organisms you observed from the stream. Use a magnifying glass to look at them carefully. Does it have legs? How many legs does it have? How does it move? Which colors does it have? Use drawing and writing to record information about the environment where you found them.



Crayfish

New Vocabulary Words

Define these vocabulary words:

Benthic Organisms

Culvert

Down-stream

Environment

Erosion

Human Impact

Mouth of river

Riffle

Tributary

Up-stream

Note: *If there is not enough time to finish, complete the Field Book as homework.*

After The Field Trip

What did you learn about benthic organisms?

What was the most interesting discovery during your stream visit?

What sign of human impact did you see in and around the stream?

How is this topic (streams) important to you?

What kind of changes might make the stream environment better for wildlife and humans? What is your vision about the future of the stream?

What else would you like to know?

Extension: Take the students to a rural, undisturbed stream for a comparison study.



Appendix 3B:

Scientific Classification of Aquatic Organisms

Dr. Mary Kostalos, Chatham College, Pittsburgh, PA

Aquatic organisms are incredibly diverse. The following information is designed to give you a brief overview of some of the major groups of organisms that you will find as you study various aquatic systems during this class. It is not inclusive and, for the most part, uses common names for these organisms.

All living things are divided into large groups called Kingdoms. You are probably familiar with the plant kingdom and animal kingdom, for example. Each kingdom is further divided into groups called phyla for animals (phylum is the singular) and divisions for plants. Phylum or division is further divided into class, order, family, genus, and species.

The major kingdoms in most systems of classification are the following:

A. **Monera**

These are simple, single-celled or colonial forms that do not have a membrane-bounded nucleus (prokaryotic). Important organisms in this group are the bacteria and the blue green bacteria (formerly known as the blue green algae).

B. **Protista**

Organisms in this kingdom are also single-celled or colonial but they have a distinct nucleus (Eukaryotic). Some of the organisms in this kingdom are plant-like (they carry out photosynthesis). We call these organisms algae. Diatoms are an example of an alga that is important in aquatic systems. Other organisms in this kingdom are more animal-like. We call these organisms protozoans. Different types of protozoans have different forms of locomotion. Some protozoans (ciliates) have cilia (small hair-like structures); others (flagellates) move by pseudopods -- the whole cell flows in the direction of movement.

C. **Fungi**

Fungi are unique organisms that are parasites or saprophytes (feed on dead organic matter). They may be single-celled or colonial, but most are multicellular (composed of many cells which have become specialized to carry out different functions within the organism). Most aquatic fungi are small and look like a mass of threads. Mushrooms are a type of fungus with which you are familiar.

D. **Plant**

Almost all plants are photosynthetic autotrophs (they are able to make their own food). Most plants are multicellular although a few algae are included within this

group, some of which are single-celled or colonial. The green algae are important in both fresh water and marine systems. The red algae and brown algae are large algae that are almost exclusively marine. Other plants that are found in aquatic situations are small plants like mosses and flowering plants such as water lilies and cattails.

E. **Animal**

This kingdom consists of multi-cellular organisms that cannot make their own food and depend directly or indirectly on plants. Most animals have fairly complex structure with specialized systems for movement, digestion, etc. Most also have nervous systems to help coordinate the organisms activities. Animals tend to be divided into two basic types--vertebrates (animals with backbones) and invertebrates (those without).

There are many phyla of invertebrates.

1. **Sponges** (Phylum porifera).

These are simple organism which consist of an outer layer of cells and an inner layer which surrounds a network of internal pores and canals. These organisms are sessile (attached to the substrate and do not move). Most are marine, although there are freshwater sponges in our local area. These sponges don't look like typical animals--most appear as a mass of cells attached to sticks or other structures in the water.

2. **Hydra, Jellyfish, and Sea Anemones** (Phylum cnidaria).

These are simple organisms that float in the water (jellyfish types) or move slowly along a substrate (hydras and sea anemones). Most capture small organisms with their tentacles, which surround their mouths. You will see hydras in the lab and possibly in the field. Corals are also members of this group.

3. **Planarians** (Phylum platyhelminthes).

Planarians are flatworms. They are common in streams in our area. They are small, usually dark brown or black, arrow-shaped organisms that glide along the undersurface of rocks by means of cilia on their lower surfaces. They have an esophagus and mouth on the middle of their undersides. They capture and consume small aquatic organisms.

4. **Segmented Worms and Leeches** (Phylum annelida).

You are familiar with earthworms. You may find earthworms near the edges of streams or ponds. There are also aquatic species, including many marine forms. They typically have a long worm-like body which is divided into segments (block-like sections). The marine forms often have broad paddle-like extensions on each segment to help them absorb oxygen. Leeches are annelid that are external parasites. They attach to fish or other organisms and bite through the outer layers of cells to absorb blood and fluids from the host organism.

5. **Snails, Clams, and Oysters** (Phylum mollusca).

Many of the organisms of this group have distinctive hard calcareous shells which cover and protect them. Some are sessile; others move slowly along surfaces or burrow into the

bottom substrate. Some mollusks such as slugs, octopus and squid do not have external shells. Note the different kinds of shells on the mollusks you observe on the field trips.

6. Insects and Crustaceans (Phylum arthropoda).

Organisms in this group have jointed legs and other appendages, and they have hard jointed outer skeletons called exoskeletons. In freshwater systems, two of the most common arthropods are insects and crustaceans. Insects typically have six legs although some of the larval forms don't have any legs. Think of the caterpillars (larvae of butterflies), for example. Many insects are aquatic in their juvenile stages (larvae or nymphs), but emerge to form winged adults that can fly. Some insects continue to live in water as adults. You should see many different kinds of insect larvae on your field trips. We have keys to help you identify these organisms.

Some crustaceans are quite small, almost microscopic. Common types include cladocerans like daphnia which have clear shells or coverings that are not segmented. You can see the internal organs through the exoskeleton. Another small crustacean is the copepod. These organisms generally have two antennae and segmented bodies that end in a forked tail. Ostracods are small crustaceans that are enclosed in a hinged shell (they look like tiny clams).

Larger crustaceans (easily seen without magnification) include amphipods such as Gammarus and isopods such as Asellus, which you should see in many streams. Crayfish, shrimp, and lobsters are other large crustaceans. Crustaceans usually have more than six legs. Insects are not common in marine environments but you will see lots of crustaceans.

7. Rotifers (Phylum rotifera).

This group of microscopic animals are about the size of the protozoans, but are multicellular. They vary in shape from worm-like to ovals that have a transparent cuticle or outer covering. Rotifers have a crown of cilia at the anterior end. When they feed, you can see one or more circles of cilia beating to create a current which collects small cells and particles on which the rotifer feeds. Rotifers usually have a small forked tail. Some are found at the bottoms of ponds and lakes, others swim or float in the water.

Appendix 3C: Benthic Macroinvertebrates

From Benthic Invertebrates and Water Quality of Nine Mile Run

Uma Jayant Mirani

General Description

Benthic organisms, or benthos, are characterized as bottom-dwelling organisms in an aquatic environment (Ingram, Mackenthun & Bartsch, 1966). The size of these organisms vary from species to species, and may also be slightly variable within species. Some groups may be seen with the naked eye, while others are microscopic. Those invertebrates that are visible to the naked eye are considered to be macroinvertebrates. (Klenm, Lewis, Fulk, & Lazorchak, 1990).

Macroinvertebrates may be found in a wide variety of substrates including mud, in riffles, under tocks, in pipes, and within aquatic vegetation (Klemm et al., 1990). Riffles refer to "the section of a stream in which the water is usually shallower and the current of greater velocity than in the connecting pool," (Ingram et al., 1966).

Freshwater macroinvertebrates are divided into various taxonomic groups including arthropods, annelids, mollusks, and platyhelminthes (Klemm et al., 1990). These organisms are also divided into three main functional feeding groups. The first group is composed of detritivores, including shredders, that break up and feed upon fine particulate organic materials (Trichoptera), crayfish, and crane fly (Tipulidae). The second group includes grazers, invertebrates that obtain food (of which algae is a primary source) by scraping it from the rocks on the streambed. Some species of grazers include mobile caddisfly larvae and beetle larvae. This group of macroinvertebrates are predators that feed on aquatic and terrestrial invertebrates. Stream salamanders and large stoneflies are among this predatory group of organisms (Smith, 1996; Welch, 1980).

Many benthic macroinvertebrates are subject to multi-stage life cycles. For some species, this occurs within a year. Others may take several years to complete one life cycle. The three stages for some hemimetabolic aquatic insects include the egg, nymph, and adult (e.g. mayflies, stoneflies). The four stages for some holometabolic insects include the egg, larvae, pupae, and adult (e.g. caddisflies, beetles) (Welch, 1980)

Taxonomic Groups

Phylum Arthropoda

Arthropods are a group of organisms that are ubiquitous in freshwater streams. Attributes of the organisms in this category include paired and joined appendages, and exoskeleton made of chitin, antennae, and external mouthparts. Crustaceans and aquatic insects are two of the subgroupings within this phylum (Thorp & Covich, 1991).

Crustaceans are a part of the Subphylum Crustacea. They are found in many diverse environments around the world. These scavengers feed upon other smaller

organisms living in the stream. In general, crustaceans tend to stay within their immediate habitats for the majority of their life cycle. As a result, they are sensitive to changes in their immediate environment and may be used in chronic pollution studies (Thorp & Covich, 1991).

Class Insecta includes aquatic insects, those insects that spend at least a portion of their life cycle in an aquatic environment. These insects are subject to either three-or four-stage life cycles. In several cases, the insects in their intermediate stages do not resemble the adults (Hilsenhoff, 1991).

Phylum Annelida

Annelids are segmented worms that are abundant in freshwater environments. They move through bottom sediments and aquatic food within this region. Microorganisms make up a large portion of their diet, in addition to algae and other plant materials (Pennak, 1989; Thorp & Covich, 1991).

Phylum Mollusca

Mollusks are a group of invertebrates found in both freshwater and marine environments. Approximately 110,000 species have been identified. Some distinguishing physical characteristics include a mantle, a shell composed of calcium, a head region, a muscular foot, and a soft, unsegmented body. Their diet is primarily composed of detrital material but may also include algae (Brown, 1991; Thorp & Covich, 1991).

Phylum Platyhelminthes

Platyhelminthes are a group of worms that have representatives in marine, terrestrial, and freshwater environments, e.g. planarians. Most species of this group are parasitic, with only a few species that are free-living. This group consists of organisms with long, narrow, and relatively flat bodies. They feed upon various types of organisms including nematodes, protozoans and small crustaceans (Pennak, 1989, Thorp & Covich, 1991).

Use in Biological Stream Monitoring

Benthic Macroinvertebrates have been used as biological indicators of pollution since the early 1900's. The original system that was developed to use invertebrates as indicator organisms originated from Europe. Two researchers, Kolkwitz and Marsson, designed this Saprobien system on the basis of "zones of pollution." Three main zones were designed, going from "extreme pollution" to "fairly clean" water. Organisms that were found in highly polluted waters were considered to be tolerant. Those that were found in reasonably polluted waters were determined to be facultative, with an array of tolerance. The third group of invertebrates were intolerant of even mildly polluted environment (Klemm et al., 1990, Sykora, 1996).

Several drawbacks exist with this method. Some tolerant species exist in diverse environments, not just in polluted waters. Finally, other physical factors such as the velocity of the water may also affect the residence of intolerant species in a particular environment. Due to these drawbacks in this design, further refinements were made to compensate for the subjective nature of this method (Klemm et al., 1990; Sykora, 1996).

Appendix 3D: *Basic Water Analysis*

Dr. Mary Kostalos

PERCEIVING STREAM QUALITY

We normally decide if a stream is clean or dirty based on visual clues like turbidity (muddiness) or sense of smell (good or bad). Water is rarely 100% clean or 100% dirty. We will provide you with some information and skills that will help you understand water quality.

Benthic Organisms (bottom dwelling species) give us a sense of the long term water quality. Finding a diversity of species indicates our stream is in very good shape. Finding less diversity may indicate either some very hardy benthic organisms or a stream that has potential but is in need of attention.

Chemistry can indicate immediate water quality. When we sample the water, we have an immediate understanding of the chemical "signature" of a particular section of the stream on the day at the minute the sample was taken.

Basic Water Analysis

We will be performing some basic water analysis tests. If we rely on our eyes and nose, we sometimes miss important indicators of water quality or pollution. Chemistry is another way of informing our perception of water quality.

Use good laboratory safety practices at all times. Some of the chemical solutions used in these tests are strong acids, bases, or are toxic. Wash affected areas immediately if you spill any of the solutions on yourself. Report any spills immediately. Also, report any broken glassware or problems with any of the equipment or apparatus. In general, use common sense.

Specific instructions for each test are located at the test station. Read the instructions before you begin the test. Follow the instructions carefully. If you are uncertain or have any questions, ask.

Chemistry of Freshwater

Major ions in freshwater include Sodium (Na^+), Potassium (K^+), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Sulfate (SO_4^{2-}), Chloride (Cl^-), and Bicarbonate (HCO_3^-). These ions are generally present in at least milligram/liter (parts per million) quantities. Other important ions such as Phosphate (PO_4^{3-}) and Nitrate (NO_3^-) are present in natural water in lower amounts (micrograms / liter to milligrams / liter) and are more variable in their concentrations (See attached sheet for some typical values for freshwater areas in their concentrations).

Below is a very brief description of the various substances for which you will be testing:

Dissolved Oxygen (DO) - Virtually all living organisms (with the exception of a few anaerobic bacteria, for example) need oxygen. Our atmosphere typically contains about 21% oxygen, so obtaining oxygen is usually not a problem for air-breathing organisms. However, oxygen can be limited in aquatic situations. The amount of oxygen in water is influenced by flow and turbulence, as well as by temperature and pressure. For example, cold water will hold more oxygen than warm water. For aquatic organisms, the percent saturation (the amount of oxygen in the water relative to the maximum it can contain at a given temperature and pressure) is more important than the actual amount. The percent of saturation determines how readily the oxygen will cross gill or other respiratory surfaces and, therefore, how available it is to aquatic organisms. Organisms vary tremendously in their requirements for oxygen. Some stream organisms that live in still water or wetlands may be adapted to much lower levels.

Hardness - Water hardness tends to measure calcium and magnesium ions in water. Hard water is often slightly basic (above pH 7) and, because it contains carbonate and bicarbonate ions, it is more likely to have a higher buffering capacity. It is more able to withstand inputs of acid without the pH dropping. Many organisms seem to be restricted to water within some range of hardness. Many invertebrate, for example, require calcium for their shells or exoskeletons.

Chloride - Chloride occurs naturally in low concentrations in natural water. It will tend to be higher in precipitation in areas near the ocean. Increased chloride levels may come from domestic sewage, food processing, road salt, or other activities.

Nitrate and Phosphate - These two nutrients are important for the growth of algae and other organisms. They are often limiting nutrients. The levels of these nutrients may be increased by domestic sewage, agricultural activity, and industrial processes. An increase in the concentration of these nutrients leads to eutrophication, rapid growth of algae or other plants, which can become harmful. When these plants die, their rapid decay can deplete the water of oxygen.

pH - pH is a measure of the hydrogen ions in water. All aquatic organisms have a range of pH within which they can exist. Changes in pH, for example, by acid precipitation can lead to the changes in the community structure of an aquatic system.

Alkalinity - Alkalinity is a measure of the carbonate and bicarbonate ions in water. It can be used to determine the amount of carbon potentially available for photosynthesis.

Bacteria - (Has to be done in lab) - Bacteria will be present in almost all natural waters. High levels of bacteria are associated with high nutrient levels or large amounts of organic compounds. High level of bacteria lead to high Biological Oxygen Demand (BOD) Activity of these bacteria can deplete water of oxygen. Coliform bacteria may

indicate sewage or other fecal contamination. Water containing high levels of coliforms is unsafe for recreational activity.

Temperature - Aquatic organisms may be found over a wide range of temperatures from hot springs where some bacteria exist in water that is close to the boiling point to water that is always ice covered. Different organisms are adapted to particular ranges of temperature. Increasing temperature by addition of hot water to natural systems may cause native species to be eliminated. Warm water contains less oxygen and the increased temperature will increase the metabolic activities of many of the organisms in this water.

- More information: <http://slaggarden.cfa.cmu.edu/research/stream.htm>

Water Analysis Kits

Temperature Pocket Pal Tester

Company: HATCH Company, Phone: 970-669-9032, E-mail: intl@hatch.com

Catalogue No.: 44450-00

Price: \$41.00

pH Pocket Pal Tester

Company: HATCH Company, Phone: 970-669-9032, E-mail: intl@hatch.com

Catalogue No.: 44350

Price: \$42.00

pH Paper

Company: HATCH Company, Phone: 970-669-9032, E-mail: intl@hatch.com

Catalogue No.: 376-33

Length of the paper ribbon: 15'

pH range: 4.5 - 7.5

Price: \$5.50

Dissolved Oxygen high range

Company: HATCH Company, Phone: 970-669-9032, E-mail: intl@hatch.com

Catalogue No.: 1469-00

Model: OX-2P

Range: 0.2-4, 1-20 sample size 60mL

Smallest Increment: 0.2, 1

Method/Chemistry: Drop count titration/Modified Winkler

Approximate Numbers of tests: 100

Glossary 3: *Stream Environment*

Benthic: organisms that live on the bottom.

Camouflage: A disguise or false appearance that is used to hide something by making it look like its surroundings.

Culvert: A pipe designed to bury a stream carrying stormwater underground to a downstream location.

Environment: The air, the water, the soil, other physical elements, abiotic (non-living), and all other that surround a person, animal, or plant.

Erosion: The wearing away of soil and stone through the movement of water or wind.

Flow: Movement in a stream; any continuous rate of flowing; the volume of fluid that flows through a passage of any given section in a unit of time.

Human Impact: An ecological or environmental effect created by human activities; human effects on natural systems.

Impervious Surface: Roofs and pavements where rain water flows as runoff over the surface, rather than soaking in.

Organisms: All living things, animal, plants, microorganisms, and bacteria.

Permeable: Surfaces that allow water to soak through and into the soil.

Pollution: Contamination of water or air by harmful chemicals and waste substance.

Pool: A slower and deeper area of a stream.

Primary Colors: One of the basic colors from which all other colors can be made. In mixing paint, magenta, yellow and cyan (turquoise blue) are the primary colors.

Riffle: A rapid and shallow area in a stream where oxygenation often occurs.

Runoff: Rain water that flows across the surface of the land, especially across impervious surfaces.

Tributary: A river or stream that flows into a large river / stream.

Module 4.1: *Brownfields to Greenfields*

Who Made This Rock?

Comparing natural processes to manmade processes

Overview

The industrial revolution has left us with many vacant and abandoned properties throughout our cities, suburbs, and urban watersheds; we call them brownfields.

In this module, 4.1 and 4.2, we focus on Nine Mile Run, a brownfield which consists of manmade rock called slag. This is just one example of how to approach a brownfield from an environmental perspective. Students and teacher will discuss the historical aspects of the industrial revolution, changes to land, as well as the challenges we now face as nature and man return to these places to restore, reclaim, re-vegetate, and heal these forgotten lands.

There are two topics in this module. In module 4.1, students will learn about slag a byproduct from steel making. Students are invited to think about the differences between natural (rock formations) and manmade (steel making) processes. They will conduct a physical inquiry of materials based on lectures about the similarities and differences between the natural and industrial process. Module 4.2 closes by addressing industrial soils as a growing medium.

The question being addressed is, can plants grow in industrial soils? This inquiry builds on the Sand Land module, extending the students' understanding of the relationship between soils, water, and plants. Students will be gently guided through a process of forming their own questions, creating physical tests, then analyzing their results for answers to the questions. The site of this case study is an urban slag heap. In other areas of Pennsylvania, bony-piles from coal mining, slate dumps, even a construction rubble field could provide the "medium" for this study. Each place has a different story to tell about the history of the site.

Background

In the previous modules, we explored the geographic and hydrological concept of a watershed. We discussed the form and function of a natural watershed system and its relationship to the water cycle. We also discussed the cause and effect of human habitation and use of the land in relationship to stream and water. In this module, we will move closer to a specific landscape for a better look. We are going to explore how Brownfields got their name. They are the opposite of greenfields, areas where developers usually prefer to build. Brownfields are often in the city, and greenfields are always in the country. Greenfields are farms or forests just beyond the suburban edge, while brownfields are old buildings and waste piles left behind by the industrial revolution.

Further information is provided in *Appendix 4A: Natural Processes and Industrial Processes*. Some basic understanding of the structure of the earth and familiarity with chemistry concepts such as elements, compounds, and reactions is required.



A brownfields site Nine Mile Run slag heap and valley

The slag had been dumped from steel mills between 1922 and 1962. The estimated amount of slag is 269,007,138 cubic feet, or 9.9 million cubic yards. This volume corresponds to a weight of 22,193,089 tons, based on average density of 165 pound per cubic foot.

(Ground Water Technology, 1996)

Objectives

Students will;

- Review basic information on rock formation and steel making processes.
- Be guided to find similarities between the two kinds of processes.
- Observe and describe rocks and metallurgy byproducts.
- Understand effects to the environment that result from manufacturing byproduct.

Concepts

We will learn through observation, hypothesis, testing, and analysis about the physical characteristics of rock samples and slag. We will compare different samples and discuss the differences between the processes that create rock and soils. We will also learn about natural by-products versus industrial by-products.

PA Educational Standards:

Proposed Academic Standards for Environment and Ecology

Renewable and Nonrenewable Resources

Examine the renewable aspects of resources.

- Identify renewable resources and describe their uses
- Identify nonrenewable resources and describe their uses

Describe the role of recycling and waste management.

- Identify materials that can be recycled in the community
- Describe methods that could be used to reuse materials for new products
- Evaluate the costs and benefits of disposable products
- Understand that raw materials come from natural resources

PA Proposed Science and Technology Standards

Earth Science

Discern earth features and processes

- Demonstrate an understanding of geologic structures and processes
- Describe processes that formed Pennsylvania geologic formations (e.g., coal, volcanic, folded mountains, glacial formations)
- Discern the earth resources and how they affect everyday life
- Compare human settlement as related to available resources

Preparation

Materials

Each rock sample* collection, *Figure 4.1*:

- 1 volcanic rock sample (e.g., pumice, granite, lava)
- 1 sedimentary rock sample (e.g., shale, sandstone, limestone)
- 1 metamorphic rock sample (e.g., marble, schist)
- 1 slag

Steel making raw materials and byproducts, *Figure 4.3*:

- 1 sample of iron ore
- 1 sample of coal
- 1 sample of coke
- 1 sample of limestone
- 1 magnifying glass
- 1 magnet
- 1 chunk of slag
- 1 small container with pulverized slag
- 1 Observation of Rocks Activity Card per student

**Rock samples*: Rock samples can be obtained from;

- Department of Energy (DOE) and National Institute of Occupational Safety & Health located on Bructon Rd., near South Park, PA.
- Natural Science Museums.

Alternatively, donations can be solicited from Geology Departments. It is recommended that the samples include local rock samples which the students can observe in situ during a field trip. Pumice can be purchased from drugstores. (Pumice is a good example of an igneous rock trapping gases as it solidifies.)

Four Different Types of Rocks

(Figure 4.1)



Igneous Rock
Pumice (left), volcanic rock (right)



Sedimentary Rock
Sandstone



Metamorphic Rock
Marble



Manmade Rock
Slag



Shale
Sedimentary Rock at Nine Mile Run
(Figure 4.2)

Set Up

You will need a sample collection for each group of four to five students. Every group has a paper plate to hold the samples distributed by the instructor. Each student will need one Activity Card.

Estimated Duration: One to one and a half hours

Lesson Plan

Class setting

The students are divided in groups of four to five. The instructor has prepared samples of rocks and steel making products and byproducts for every group. To develop the lesson fully, the instructor needs one and a half hours. With less detail on rock formation and steel making processes, the lesson can be taught in an hour.

Instructional Materials

- *Section 4.1 Activity Cards (on the following pages)*
- *Pictures of local slopes of sedimentary rocks/ shale, Figure 4.2*
- *Picture of the raw materials for steel making, Figure 4.3*
- *Blast Furnace drawing, Figure 4.4*
- *Appendix 4A: Natural Processes and Industrial Processes*
- *Appendix 4B: The History of Nine Mile Run*
- *Picture of local slopes of sedimentary rocks / shale, Figure 4.2*
- *Blast Furnace, Figure 4.4*

Homework

Copy Appendices 4a and 4b. Have students read these before the discussion.

Materials for Steel Making

(Figure 4.3)



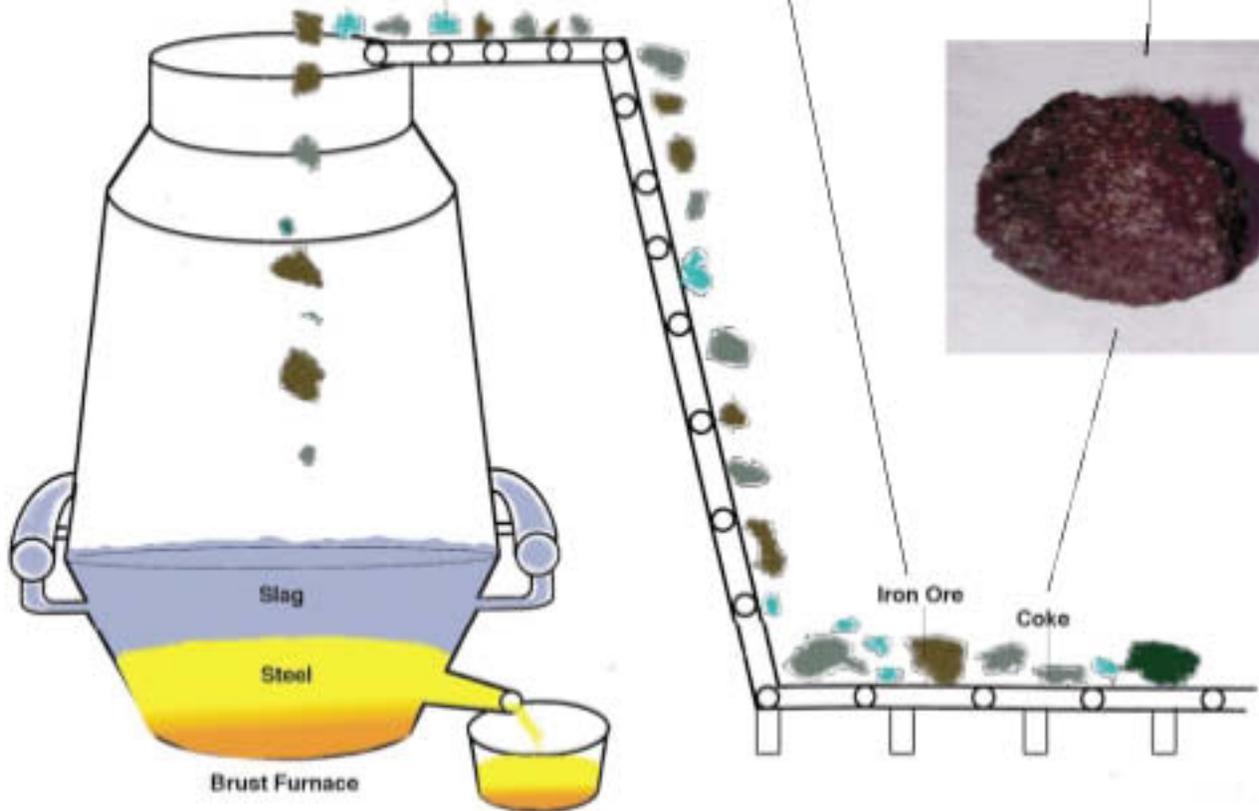
MAKING STEEL

LimeStone



Coal

Coke is made of Coal



Blast Furnace

(Figure 4.4)
Blast Furnace

Activity Card 4.1: Observation of Rocks

Your Name _____ Room Number _____

Carefully observe the different rocks

Key Questions:

How do you describe each rock?

Is it heavy or light? What is its texture (smooth, rough, fracture, or cleavage)?

Do you see any patterns? Does it look like something else? How was it formed?

Any other observation?

What are the differences and similarities between the natural and the "manmade" rocks?

Volcanic rock

Name of the rock _____

Texture _____

Colors and patterns _____

How was it formed? _____

Other observation _____

Drawing

Sedimentary rock

Name of the rock _____

Texture _____

Colors and patterns _____

How was it formed? _____

Other observation _____

Drawing

Activity Card 4.1: Observation of Rocks

Your Name _____ Room Number _____

Carefully observe the different rocks

Key Questions:

How do you describe each rock?

Is it heavy or light? What is its texture (smooth, rough, fracture, or cleavage)?

Do you see any patterns? Does it look like something else? How was it formed?

Any other observation?

What are the differences and similarities between the natural and the "manmade" rocks?

Metamorphic rock

Name of the rock _____

Texture _____

Colors and patterns _____

How was it formed? _____

Other observation _____

Drawing

Manmade rock

Name of the rock _____

Texture _____

Colors and patterns _____

How was it formed? _____

Other observation _____

Drawing

Natural Processes

Discussion

Give information on the processes of rock formation. We find rocks and soil on the earth's surface. Soil consists of decomposed rock, plant detritus, and organisms. Rocks are eroded by wind, water and ice, and broken into particles that form soil, beginning the rock cycle formation all over again. This earth contains a certain amount of materials that are constantly combining and breaking apart.

We define three categories of rocks, depending on the way they are formed: Sedimentary, Igneous, and Metamorphic rocks.

Key Question:

- *What do you know about different rocks? How are they formed?*

Sedimentary Rocks

Some soils are deposited as particles in the bottom of lakes and oceans. As more and more layers are piled on top, soil gets transformed in rock with all of this additional weight. This is called compaction of sedimentary rocks, also formed through cementation. These are the sedimentary rocks - they are often easy to distinguish by their layered structure. Some students may not be able to imagine what they look like; show pictures of local slopes of sedimentary rocks, *Figure 4.2*.

Key Question:

- *Where do you see slopes of sedimentary rocks in your neighborhood, in the world?*

Igneous Rocks

Igneous rocks are formed by the cooling and solidification of magma (magma is hot, 600-1300°C, molten rock either in the earth's interior or on its surface). Show photographs of volcanic eruptions and slag being poured from a crucible, *Figure 4.1*

Metamorphic Rocks

There is a third category of rocks that were initially igneous or sedimentary and got transformed by temperature and/or pressure. These are called metamorphic rocks. Show a picture of natural marble or granite, show a picture of a work of art created from marble or granite.

Activity

Activity 1: Observation of Rock Samples*

Give students a sample of a sedimentary rock (a shale), an igneous rock (pumice, volcanic rock, or lava), and a metamorphic rock (marble). Students are to describe the samples and compare them. Observe and record the following characteristics such as: texture (smooth, grainy, or made of aggregates), color, density, and patterns, such as layers and irregularities on the *Observation of Rocks Activity Card 4*.

Note: *This activity could be combined with an art activity, Colors in Nature, Module 5.*

Manmade Processes

Discussion

We talked about nature's way of combining materials. Humans have developed additional processes for combining materials. Steel making is one of them. Ask students to define the vocabulary words recycling, renewable, and non-renewable resources found in *Glossary: Brownfields to Greenfields*.

Key Questions:

- *What kinds of things are made of steel?*
- *What do you know about how steel is made?*

Steel Making

During steel making, we melt iron ore at high temperatures (1600°C). In Pittsburgh, they made steel in a two-step process. During the first step, they mixed iron ore, limestone, and coke in the blast furnace in order to separate the iron, Figure 4.4. This step produced molten iron (pig iron), which remained at the bottom of the furnace. Everything else formed slag, which was removed and disposed of as waste. This slag had little iron in it, so it was lightweight.

During the second step, the pig iron was mixed with lime in an open heart furnace to remove the impurities, *Figure 4.4*. This step produced steel and slag. The slag produced at this step was heavy, because a considerable amount of iron was lost in the process, and it often had traces of lime in it, Appendix 4A.



Images of a volcanic eruption (photo left) and steel making (photo right)
What are the similarities of both processes? What are the differences?

Comparison of Natural and Manmade Processes

We discussed today how the earth "recycles" rocks: rocks melt in the earth's hot interior, they then rise to the surface and solidify, and the process starts all over again. Steel and slag are formed in a similar process; the difference is that we do not use all the materials as nature (earth) does: we keep the "manmade rocks" we want (steel), and we throw away those we don't want (slag).

Key Questions:

- *What are similarities and differences between volcanic eruptions and steel making process?*
- *What are the similarities and differences between natural cycle of rock and man made cycle of steel?*

Activity 2: Observation of Steel Making Raw Materials and Byproduct (slag)

Have students examine samples from *Steel Making Raw Materials and Byproducts Process* (See Preparation). Have them record their observations, guided by the same questions used for the natural rocks on the *Observation of Rocks, Activity Card 4*.

Have students examine samples of pulverized slag with a magnet, to confirm that the slag contains iron. Record their findings, *Figure 4.5*. Talk to them about the history of the slag disposal at Nine Mile Run, *Appendix 4B*, or any other similar brownfield site.

Key Questions:

- *What kind of materials are recyclable?*
- *Is slag recyclable? How would you use it?*
- *Can places be recycled? Restored?*

Research opportunity:

Ask students to do a project about the steel industry and the people who made steel. Students might ask their families, use the library, or use the internet. Prepare some resource materials (books, web site, video) for this research with the school librarian.

Ask students to write about:

- *If there were no slag at Nine Mile Run, how would the place be different? (Or if there were no _____ in your hometown, how would that place be different?)*
- *You have just taken ownership of Nine Mile Run (or your local brownfield), what will you do with this place to make it better?*

Keywords

brownfield

greenfield

igneous rock

industrial revolution

infrastructure

manmade rocks

metamorphic rock

ore

recycling

renewable resources

non-renewable resources

sedimentary rock

slag

steel

suburb



(Figure 4.5)
Experimenting on slag with a magnet



Homestead and up the Monongahela River



A student's response to how steel is made

Module 4.2: *Brownfields to Greenfields*

Restoring Land

Overview

This module will introduce the concept of ecological restoration of slag soils. Slag is a material that is new to this planet. It had not occurred before the industrial revolution and as a result, it has no "native" vegetation. Students and teacher discuss the historical aspects of the industrial revolution and changes to land, as well as the challenges we now face as nature and man return to these places to restore, reclaim, re-vegetate and heal these forgotten lands. Students will observe the differences between slag and soil. Students will make a hypothesis about how and why plants might grow differently in each of these soils. They will test their hypothesis by observing a plant's germination and growth.

Background

The concept of a brownfield and the case study site at Nine Mile Run slag heap were introduced in module 4.1. Students began to think about a place as a non-renewable resource. The question we address in this section is how do we restore a place like Nine Mile Run? This module (4.2) focuses on succession, soil, remediation, and revegetation at our model brownfield site. Many of these concepts can be applied to bony piles, strip mines, etc.

Objectives

Students will:

- Review basic information about brownfields and plants.
- Understand the concept and limitations of succession theory.
- Observe differences between slag and soil.
- Make a hypothesis about plant growth in different soils.
- Observe germination and growth.
- Evaluate the results.

PA Educational Standards:

Proposed Academic Standards for Environment and Ecology

Renewable and Nonrenewable Resources

Examine the renewability of resources.

- Identify renewable resources and describe their uses
- Identify nonrenewable resources and describe their uses



(Figure 4.6)

Non-vegetated slag and vegetated slag in Nine Mile Run

PA Proposed Science and Technology Standards

Biological Sciences

Explain basic concepts of natural selection

- Identify adaptations that allow organisms to survive in their environment
- Illustrate environmental changes that can affect the survival of organisms and entire species

Inquiry

Explain basic systematic elements of scientific research

- Generate questions that can be studied in science
- Design an investigation with limited variables to investigate a question
- Conduct a two part experiment
- Judge the significance of experimental information in answering the question

Science, Technology, and Human Endeavors

- Identify and describe the resources necessary to solve a selected problem in a community

Concepts

The previous module is briefly discussed. Key points include the source of slag, and the similarities between slag and natural metamorphic rocks and soils. Students are asked to consider the difference between soils, which occur naturally, and materials like slag, which are created by man.

The question that we are seeking to answer is *What do plants need to grow?* Planting grass seeds in a mixture of slag and soil will give students an opportunity to hypothesize about the revegetation (restoration) of post-industrial waste sites and the renewability of brownfields.

Preparation

Activity 1 Materials

- two to three thermometers
- *Activity Card 4.2* for each student

Activity 2 &3 Materials for Each Pair of Students

- Slag in a plastic bottle (*put 3-5 holes in the bottom for drainage*)
- Soil in plastic bottle (*put 3-5 holes in the bottom for drainage*)
- two cups of water
- two funnels
- one drainage basin
- *Activity Card 4.2* for each student
- A scale (one for whole class...optional)

Activity 4 Materials for Each Pair of Students

- A tray
- two medium sized (12 oz) plastic cups
- two small sized (6 oz) plastic cups
- Old silver ware spoons or plastic spoons
- A water spray bottle
- A plastic potting tray with four 2" x 2" x 3" deep cells
- Orchard grass seed* (6 seeds per cell)
- four plastic plant tags
- Fine slag
- Potting soil
- Permanent Markers
- *Activity Card 4.3 & 4.4* for each student

Set Up

The above materials are prepared for distribution to each team. The instructor has prepared the demonstration materials listed above.

Estimated Duration

One and a half to two hours preparation, weeks of growth, then analysis.

Grasses and Legumes, selected for Steel Mill Slag.

Note: Orchard grass is one of the selected seeds from the research on vegetation growth on slag by the Nine Mile Run Greenway Project in 1999. The soil scientists selected 21 species for the experiment. Ten species are introduced species and others are native to Pennsylvania. For students, we recommend using the fast growing and hardy plants *.

Scientific Name	Common Name	Endemicity
GRASSES:		
<i>Agropyron intermedium</i>	Intermediate wheatgrass	I
* <i>Agrostis alba</i>	Redtop	I
* <i>Alopecurus arundinacea</i>	Creeping foxtail	I
* <i>Andropogon gerardii</i>	Big blustem	N
* <i>Anthoxanthum odoratum</i>	Sweet vernal grass	I
* <i>Bromus inermis</i>	Smooth brome grass	I
<i>Bouteloua curtipendula</i>	Side-oats grama	N
* <i>Dactylis glomerata</i>	Orchardgrass	I
<i>Dichanthelium clandestinum</i>	Deertongue grass	N
<i>Elymus canadensis</i>	Canada wild rye	N
* <i>Festuca arundinacea</i>	Tall fescue	I
* <i>Festuca ovina</i>	Sheep fescue	I
<i>Panicum amarum</i>	Costal panicgrass	N
<i>Panicum virgatum</i>	Switchgrass	N
<i>Schizachrium scoparium</i>	Little bluestem	N
<i>Sorghastrum nutans</i>	Indiangrass	N
LEGUMES:		
* <i>Desmodium canadense</i>	Showy tick-trefoil	N
<i>Lupinus perennis</i>	Wild blue lupine	N
<i>Lotus corniculatus</i>	Birdfoot trefoil	I
<i>Robinia psuedoacacea</i>	Black locust	N
<i>Robinia hispida var. fertilis</i>	Bristly locust	I
Endemicity - N = native, I = introduced		

Obtaining the seeds: Order 1 oz of seed.

ERNST Conservation Seed, 9006 Mercer Pike, Meadville, PA 16335

Phone: 814-336-2404

Lesson Plan

Class Setting

The students are paired into working teams.

Instructional Materials

- *Appendix 4C: Slag Soil Remediation*
- *Appendix 4D: Succession*
- *Restoration Activity Card 4.2 & 4.3*

Homework

Copy *Appendices 4C and 4D*. Have the students read these before the discussion.

Discussion

Teachers and students should be familiar with the general concepts. The discussion is to clarify misconception and integrate the abstract concepts into probable applications and potential classroom experiments.

Key questions:

(Ask, but do not force an answer. We can come back to them after the experiment.)

- *What do plants need to survive?*
- *What is soil? How is soil is made?*
- *What are the shared characteristics of slag and soil?*
- *What are the differences between slag and soil?*
- *Do we need plants? Why?*

Note: *Ideally students come up with these questions.*

Key Words

soil

succession



(Figure 4.7)
An experiment with soil and slag

To prove slag
doesn't hold water.
They is a bottle full of
soil, and another full of slag.
they both have two holes in the bottom. They pour water in
each, then hold them up. Water poured out of the slag, but
not the soil.

An observation and recording by a student

Activity Card 4.2

Your Name _____ Room Number _____ Date _____

Grass
Asphalt
Soil
Other Observation

Weight of soil and slag
Water through soil and slag
Other Observation

Activity Card 4.3

Your Name _____ Your Partner's Name _____

Species of Seeds Planted: _____ Date of Planting: _____

Treatment 1	100% soil	0% slag	# seed 6
Treatment 2	0% soil	100% slag	# seed 6
Treatment 3	% soil	% slag	# seed 6
Treatment 4	% soil	% slag	# seed 6

Activity Card 4.4

(Make 5 copies for 5 weeks observation of plant growth)

Your Name _____ Your Partner's Name _____

Species of Seeds Planted: _____ Date of Planting: _____

of Plants Germinating Measurement of Highest Plant

Treatment 1 1 2 3 4 5 6

Treatment 2 1 2 3 4 5 6

Treatment 3 1 2 3 4 5 6

Treatment 4 1 2 3 4 5 6

Day Count Total # of Plants Germinated Measurement of highest Plant

Activity

Activity 1: What Would the World Be Like Without Plants? ? (This question and activity refer to *figure 4.8* and the key question "Do we need plants? Why?")

Send students out into the school yard and ask them to observe different surfaces such as a grass yard, bare soil, and asphalt. Guide them to use their sense of touch (feel) instead of vision. Then students use a thermometer to find and record the temperature of each area (simply lay household thermometer down on the surface to be tested). Use the *Activity Card 4.2*.

Activity 2: Slag vs. Soil

Have students prepare two same sized plastic soda bottles. Have them make 3-5 small holes on the bottom with small nails, mark each bottle, 3" from the top. Ask them to use a funnel to fill one with soil up to the mark. The other one should be filled with slag the same way. Have the students brainstorm and test comparisons. Record all the differences and similarities they observe.

Key Questions (which could emerge from students):

- Which bottle is heavier?
- Do they look different?
- Do they sound different?

Activity 3: How Water Moves Differently Through Slag and Soil

Ask the students to hypothesize which soil will drain faster. Will one drain much faster? Will they drain at about the same speed?

Have students place each bottle over a drainage basin. Ask one student with a watch to keep time for another with a bottle, *Figure 4.7*. Ask students to pour the same six inches above the drainage basin in order to observe the movement of water. Record what they observed on *Activity Card 4.2*.

Activity 4: Mixing Soil and Slag

There are two options for preparing soil treatments using the plastic potting trays with four cells:

Option 1

One pair of students prepares four different soil treatments:

Treatment 1...100% soil

Treatment 2...100% slag

Treatment 3...Mixture of slag and soil (50%)

Treatment 4...50% slag is on the bottom and 50% of soil is on the top.

Record your treatments on the *Restoration Activity Card 4.3*.

Option 2

Have each student use a tray and silverware to mix slag and soil, creating a slag-soil treatment, which they believe is likely to grow plants.

Key Questions:

- *How will you analyze your experimental treatment of the slag-soil?*
- *What do you have to remember about each experiment if you want to replicate it or do it again?*

Keep track of how many spoons of soil and how many spoons of slag in each treatment experiment. (Example: 2/3 = two scoops of slag + three scoops of soil) Record your slag-soil ration on the *Restoration Activity Card 4.3*. After you have placed all the treatments into individual cells, wet the soil treatments with the water spray bottle.

Key question:

- *Do you still need an all slag or all soil tray? Why? or Why Not?*

Activity 5: Plant Seeds

Students will need toothpicks and an *Activity Card 4.3*. Have students organize their seeds. They must place six seeds on the top of the soil. Have them spread the seeds carefully and evenly with a tooth pick, repeating the process for each cell. Tell them what kinds of seed they are planting. (Make sure they do not cover the seeds with the soil, we are attempting to replicate the processes that occur in nature.)

Using a permanent marker, and label each cell with the date, the number of seeds, their names, and ratio of slag of slag-soil on the plastic plant tags, *Figure 4.8*. Make sure they record the number and species of seeds, on their activity card. Plants are living things and will require care: have students water with spray bottle each day. Keep the experiments damp, but not wet. Cover the cells over the weekends with a wet paper towel.

Activity 6: Observation and Taking Care of the Plants

- Replace the pots near a window or under a grow light (sodium halide light).
- Pots will be watered from the top once daily (3cc / day).
- Cover the cells over the weekends with a wet paper towel.
- Observe the plant germination and growth weekly.
- Record the observation on the *Restoration Activity Card*.
- Keep records of their observations daily. Data collection of the study shall run for a period of five weeks (thirty-five days) from the first watering. The following data will be collected:
- Fourteen day counts will be made for the number of plants per cell that have germinated.
- Measure the highest plant from each cell.
- Repeat counting and measuring at twenty-one, twenty-eight, and thirty-five days from the planting date.

Evaluation

Five weeks from the planting ask students to organize the data from the Activity cards 4.4 and 5, then present the results. Then discuss the plant growth in different soil treatment. (Optional: The class could graph and analyze all data.)



Mixing slag and soil



(Figure 4.8)

Labeling the plants and different soil treatment

Key Questions:

- *When did the seeds start germinating?*
- *How many plants survived in each cell?*
Treatment 1-100% soil _____
Treatment 2-100% slag _____
Treatment 3 _____
Treatment 4 _____
- *The highest plant:*
Treatment _____
Inches _____
- *Any other observations?*

Teacher writes all the data above on a large sheet of paper or black board. Ask students what this means. What does the experiment tell?

Key Questions:

- *What do your results tell you about restoration of brownfield sites?*
- *What kinds of plants could grow in slag at the case study site? (Appendix 4D)*
- *Why is it important to do this type of inquiry?*
- *What effects may it have on your quality of life?*
- *What kinds of wildlife might be attracted to this vegetation?*
- *What did you learn from this study?*

Appendix 4A: ***Natural Process and Industrial Processes***

Natural Processes - Rocks

Murck, Skinner and Porter, 1996, Environmental Geology, John Wiley & Sons, Inc., NY.

On the surface of the earth, we see rock (soil is primarily decomposed rock). The interior of the earth, we know is hot and moving (imagine a boiling thick tomato paste turning over as it bubbles in a pan.) This movement results in material from the surface of the earth moving slowly to the interior of the earth and back. This movement also causes the exterior rocky layer to break occasionally, as happens during earthquakes. So earthquakes remind us that the interior of the earth is moving. Volcanoes remind us that it is hot. Rocks can exist in liquid form in the interior of the earth.

We define three categories of rock, depending on the way they are formed. ***Igneous*** rocks are formed by the cooling and consolidation of magma, which is hot (600-1300°C) molten or partially molten rock from the earth's interior. Igneous rocks formed from cooling and solidification of magma below the earth's surface are called plutonic rocks. Unlike plutonic rocks which cool fast, volcanic rocks are formed from magma erupted at the earth's surface and solidified quickly. Rocks at the earth's surface are eroded by air, water, and ice. Loose particles transported by wind, water or ice are called sediments. Under pressure and/or cementation they form ***sedimentary*** rocks. The third category is ***metamorphic*** rocks. These are rocks, originally formed by high temperatures. The earth's crust is 95% igneous rocks or metamorphic rocks resulting from igneous rocks. The earth's surface, however, is 75% sedimentary rocks. The most abundant elements in earth include silicon, oxygen, iron, and magnesium.

Industrial Processes - Steel Making and Slag

The New Encyclopedia Britannica, volume 21, p.369, Encyclopedia Britannica Inc.

Steel is an alloy of iron and carbon (the content of carbon ranges up to 2%). Steel making is a melting, purifying and alloying (mixing of metals) process carried out at approximately 1,600°C in molten conditions. The major raw material is iron in different forms. The ***basic oxygen process*** is a steel making method in which pure oxygen is blown into a bath of molten blast-furnace iron and scrap. The oxygen initiates a series of intensely exothermic (i.e., heat-releasing) reactions, including the oxidation of impurities, such as carbon, silicon, manganese, and phosphorous. Unfortunately, some iron is also lost as it reacts with oxygen. The products of the above reactions (i.e., the silica, manganese, phosphate, and ferrous oxides) together with burnt lime (calcium oxide), added as flux (flux refers to a substance used to refine metals by combining with impurities to form a molten mixture that can readily be removed, say something like a froth), form the slag. The ratio of CaO to SiO₂ (calcium oxide to silica oxide, the basic

component to the acidic component) expresses the basicity of the slag (usually around 3.5). The slag floats on the surface of the molten metal from where it is removed.

Note: *In general, "slag" refers to any by-product formed in smelting, welding, and other metallurgical and combustion processes from impurities in the metals or ores being treated.*

Steel Making At the Time When the Nine Mile Run Slag Disposal Facility Was Active

(Reference: *Henry Prellwitz Ph.D., personal communication*)

The iron ore used in the steel mills of Pittsburgh was brought from Minnesota and was primarily Hematite (Fe_2O_3) and Quartz (SiO_2). Steel was produced in two steps, first in a blast furnace and then in an open hearth furnace.

The purpose of the first step was to remove the quartz from the iron ore by adding limestone (CaCO_3). The raw materials were iron ore, limestone, and coke (made by heating soft coal to drive off most of its volatile material). Hot air was introduced into the blast furnace. In the furnace, CaCO_3 was broken down to CaO and CO_2 . CaO reacted with SiO_2 and was removed as slag. The slag produced from the blast furnace had very little iron (Fe) in it, so it was lightweight. The products of this first step are molten iron (pig iron) and light-weight slag. The pig iron was transferred to the open hearth furnace where lime (Ca(OH)_2) was added in order to raise pH and remove impurities. Different alloys were also added at this step to produce steel of desired properties. The products of this second step are steel and heavy-weight slag (with lime chunks in it).

Appendix 4B: *The History of Nine Mile Run* ***By Joel A. Tarr Ph.D., Carnegie Mellon University***

The history of Nine Mile Run stream and valley provides a classic example of a clash between those who held values of utilitarianism and those who focused on the preservation of areas of natural beauty for use as urban recreational facilities. Nine Mile Run and its watershed area forms a natural drainage basin of the Monongahela River. The watershed has a land area of approximately 250 acres. During the 19th century, portions of the valley had been used variously for farming, as a salt works, as the location for several natural gas wells, and as a golf course. While the lower valley was relatively undeveloped as of 1910, areas of Pittsburgh, as well as the boroughs of Swissvale, Edgewood and Wilkinsburg had shaped the upper valley for residential purposes and had placed portions of Nine Mile Run into culverts to accommodate development.

During the early part of the 20th century, Pittsburgh underwent a period of civic reform. As part of this process, in 1910 Frederic Law Olmsted, Jr., son of the famous landscape designer, prepared a report for the Pittsburgh Civic Commission making a number of suggestions for urban betterment. In his report, Olmsted identified Nine Mile Run as the “most striking opportunity...for a large park”, but no action was taken on his proposal. In 1923, the Citizens’ Committee on Civic Plan, another elite group attempting to improve the Pittsburgh environment, issued a report on parks. In this report, the committee proposed the development of Nine Mile Run as a waterfront park with a range of recreational facilities. Like Olmsted’s recommendation, however, this one was never implemented. In fact, in 1922 the Duquesne Slag Company, which had purchased 94 acres in the valley in that year, began filling it with slag from neighboring steel mills.

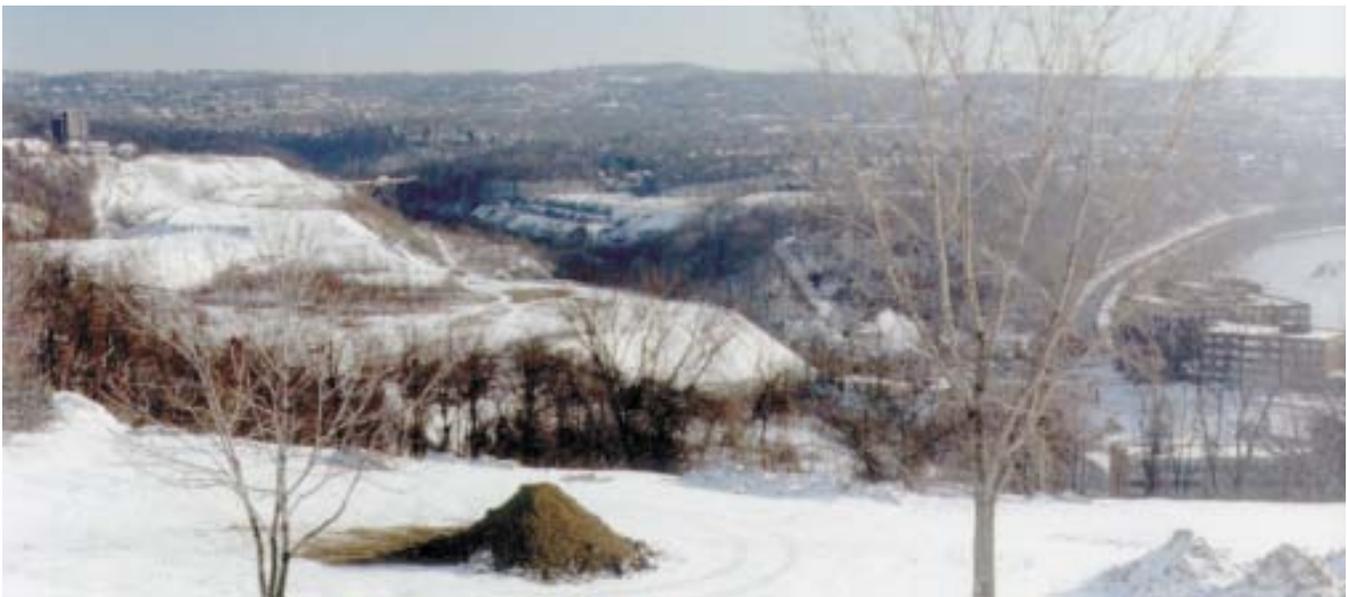
Duquesne Slag’s land purchase occurred just before passage of the Pittsburgh Zoning ordinance. While all 238 acres of Nine Mile Run valley were zoned residential, the 94 acre land purchase and Duquesne Slag’s use of it for slag dumping “grandfathered” the firm’s activities in the valley. Between 1922 and 1962, Duquesne Slag purchased further acreage in the valley, filling it with million of tons of slag even though the valley was zoned “residential.” Duquesne Slag acted on the justification that it had owned property in the valley prior to the creation of zoning and that its slag dumping was a "non-conforming use." Protests over the years about the firm's dumping activity, primarily by the Swisshelm Park Civic Association, had little effect in reducing its dumping or controlling nuisances. By 1972, when slag dumping ceased, approximately 17 millions cubic yards of slag filled the valley.

Because Nine Mile Run is the largest area of undeveloped land within the Pittsburgh city boundaries, several attempts have been made in recent decades to develop it. In 1982, for instance, the City Planning Department explored the possibilities for residential and light industrial development but could not attract a developer. In 1987, J.J. Gumberg,

a shopping center developer, obtained the option to buy the site and proposed to build a shopping and office center on it. Citizens from nearby residential areas, however, objected to highway construction related to the Gumberg plan and were able to block development. Finally, in October of 1995, the City of Pittsburgh purchased the 238 acres site for \$3.8 million and selected a development team to begin the transformation of Nine Mile Run into a residential complex and an associated greenway.



Nine Mile Run Valley early 1900s



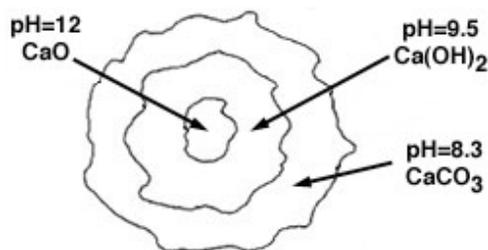
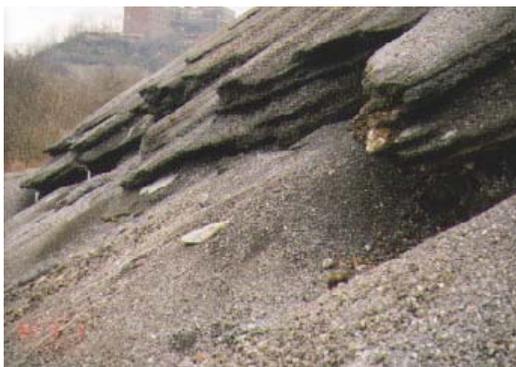
NINE MILE RUN 1998
(Photography by Robert Bingham)

Appendix 4C: *Slag and Soil Remediation*

By John Buck, Civil and Environmental Consultant

What is Slag?

In producing steel, iron ore is introduced into a blast furnace along with limestone and coke. The limestone decomposes and melts into a slag that removes phosphorus and sulfur impurities from the liquid iron. Slag is highly alkaline (pH 9.5-11) and does not retain enough water for plants to germinate.



The Composition of slag at Nine Mile Run

Element	Average Amount	Element	Average Amount
Carbon	1.70%	Nitrogen	0.03%
Phosphorus	0.12%	Sulfur	0.10%
Potassium	0.02%	Calcium	4.35%
Magnesium	1.34%	Zinc	0.03%
Copper	0.01%	Aluminum	0.27%
Manganese	0.85%	Iron	6.18%
Molybdenum	0.00%	Cadmium	30.69 ppm
Chromium	671.4 ppm	Lead	167.1 ppm
Mercury	0.02 ppm	Nickel	88.53 ppm
Arsenic	6.1 ppm	Selenium	0.52 ppm

Chart from Nine Mile Run: A Study of the Reclamation and Sustainable Redevelopment of a Brownfield Site by the Department of Engineering and Public Policy, H. John Heinz School of Public Policy and Management, and Department of Social Decision Sciences of Carnegie Mellon University.

What Do Plants Need to Survive?

- Adequate water storage to avoid drought (soil that retains water).
- Aeration (free exchange of soil gasses with the atmosphere).
- Absence of intolerable physical stress (e.g., landslides).
- Absence of intolerable chemical stress (phytotoxicity or plant toxicity).
- Adequate nutrient availability.
- Anchorage (a soil that is penetrable by roots to provide stable support).

Every soil (and alternative growing medium) has assets and deficits with regard to the above plant-support criteria. In response to the range of soil conditions, particular plant species have evolved adaptations to less-than-ideal soil conditions. Adapted plant communities with both native and non-native species have sprung up on the Nine Mile Run slag.

So What Kinds of Plants Grow on Slag?

Characteristics of Native Tree Species Growing on Slag

				Longevity
Boxelder	<i>Acer negundo</i>	(6.5-7.5)	Deep laterals	Short
Sycamore	<i>Planatus occidentalis</i>	(6.6-8)	Shallow	Long
Bigtooth Aspen	<i>Populus grandidenta</i>	(5.1-6.3)	Shallow	Short
Smooth Sumac	<i>Rhus glabra</i>	(6.1-7.0)	Shallow	Short
Staghorn Sumac	<i>Rhus typhina</i>	(6.1-7.0)	Shallow	Short
Black Locust	<i>Robina pseduacacia</i>	(5.1-7.7)	Shallow	Short
Slippery Elm	<i>Ulmus rubra</i>	(6.6-8.0)	Shallow to Deep Lateral	Medium

Chart from Nine Mile Run: A Study of the Reclamation and Sustainable Redevelopment of a Brownfield Site by the Department of Engineering and Public Policy, H. John Heinz School of Public Policy and Management, and Department of Social Decision Sciences of Carnegie Mellon University.

What Has to Be Done If We Are to Grow Plants in Slag?

Successful vegetation establishment requires a combination of the following:

- Introduction of species adapted to soil conditions.
- Modification of soils to allow a wider range of species to become established.

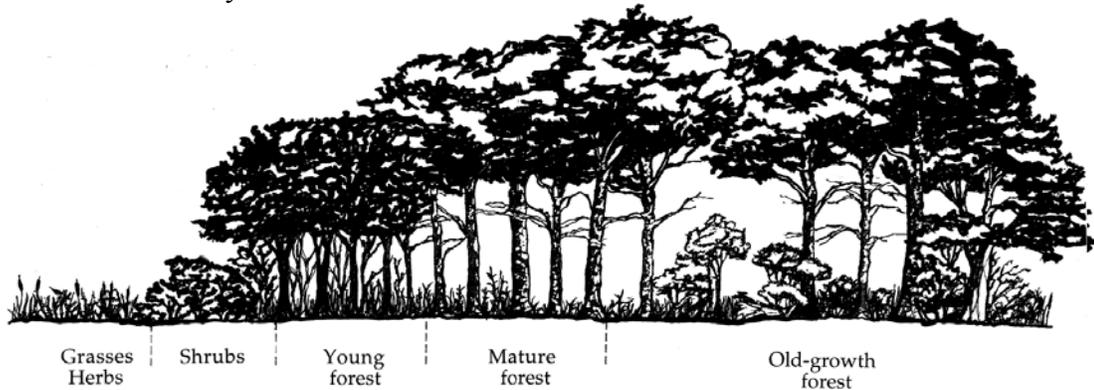
To that end, the soil treatment options include the following:

- Regrading slag to reduce slag/soil creep.
- Breaking up fused slag to increase root penetration (e.g., "ripping" with a bulldozer).
- Mixing materials into the slag to improve water retention. Water retention amendment systems could be temporary, lasting long enough to establish plants with deep root systems, or permanent, widening the range of species.
- Adding fertilizers, chemical additives, and/or organic nutrient sources. This would include, introducing nitrogen-fixing plants (legumes to naturally maintain nitrogen fertility). Examples include clovers, birdsfoot trefoil, black locust, bristly locust).
- Covering or "capping" the slag with topsoil or the use of slag/soil mixtures as growing media.
- Heavy mulching to minimize erosion, shelter seeds and seedlings, and reduce moisture losses.
- Use of adapted plant species and a succession process (starting with fast growing plants and transitioning over time to more desirable species).

Appendix 4D: *Succession*

By John Buck, Civil and Environmental Consultant

Succession [L. Succedere, to follow after] is the orderly change in species composition in an area after a disturbance (often natural but sometimes human-caused as in the case of Nine Mile Run) which results in a more or less constant group of species that constitutes the climax community.



1. Changes that Occur During Succession:

- a. Soil building.
- b. Changes in the physical environment (light, moisture).
- c. New species of plants displace existing plants because their seedlings are more able to become established in the changed environment than the seedlings of existing species.
- d. Eventually a climax community that is more or less stable will become established and have the ability to reproduce itself.
- e. Disturbances will start the process of succession again.

2. Rate and "Success" of Succession

A. Presence of soil (an issue on slag):

- a. Primary succession starts with little or no soil present.
- b. Secondary succession starts after a disturbance of a previously vegetated area where the soil is left intact (or with the addition of soil amendments).

B. Ability to retain water (an issue on slag):

- a. Depends on disturbed soil quantities.
- b. Increases with buildup of decaying vegetative matter.
- c. Can be amended with super-absorbents and organic.

C. Mineral availability (an issue on slag):

- a. Depends on disturbed soil qualities.
- b. Can be amended with minerals and organic.

D. Suitability of plants for the soil and environment:

- a. From existing underground plant roots.
- b. Existing seeds left in the soil and seeds of nearby plants.

Existing Succession of Shrubs and Young Forest on Slag Slope on Nine Mile Run

Trees

Box-elder	<i>Acer negundo</i>	native
Tree-of-heaven	<i>Ailanthus altissima</i>	introduced
Catalpa	<i>Catalpa sp.</i>	introduced
Ash	<i>Fraxinus sp.</i>	native
White Mulberry	<i>Morus alba</i>	introduced and invasive
Red Mulberry	<i>Morus rubra</i>	native
Large-toothed aspen	<i>Populus grandidentata</i>	native
Quaking aspen	<i>Populus tremuloides</i>	native
Balm-of-Gilead	<i>Populus balsamifera</i>	introduced
Sycamore	<i>Platanus occidentalis</i>	native
Staghorn Sumac	<i>Rhus typhina</i>	native
Black Locust	<i>Robinia pseudoacacia</i>	native
Elms	<i>Ulmus sp.</i>	native

Shrubs

Butterfly Bush	<i>Buddleia</i>	introduced
Forsythia	<i>Forsythia</i>	introduced
Wild Hydrangea	<i>Hydrangea arborescens</i>	native
Privet	<i>Ligustrum vulgare</i>	introduced and invasive
Honeysuckle family	<i>Lonicera sp.</i>	mostly introduced
European Buckthorn	<i>Rhamnus cathartica</i>	introduced.
Bristly Locust	<i>Robinia hispida</i>	introduced

Annuals and Perennials

Boneset	<i>Eupatorium sp.</i>	native
Foxtail Barley	<i>Hordeum jubatum</i>	native
Butter-and-Eggs	<i>Linaria vulgaris</i>	introduced
Sweet Clover	<i>Melilotus sp.)</i>	introduced
Japanese Knotweed	<i>Polygonum cuspidatum</i>	
Bouncing Bet	<i>Saponaria officinalis</i>	introduced
Goldenrod	<i>Solidago sp.</i>	native
Poison Ivy	<i>Toxicodendron radicans</i>	native
Common Mullein	<i>Verbascum thapsus</i>	introduced

Vines

Japanese Honeysuckle	<i>Lonicera japonica</i>	introduced and invasive
Virginia Creeper	<i>Parthenocissus quinquefolia</i>	native
Multiflora Rose	<i>Rosa multiflora</i>	introduced and invasive
Blackberry	<i>Rubus allegheniensis</i>	native
Raspberry	<i>Rubus occidentalis</i>	native
Grapes	<i>Vitis sp.</i>	some native but invasive

Succession plants on slag slope



Foxtail Barley (*Hordeum jubatum*)



Common Millein (*Verbascum thapsus*)
Teasel (*Dipsacus sylvestris*)
Queen Ann's Lace (*Daucus carota*)



Black Locust (*Robinia pseudoacacia*)



Staghorn Sumack (*Rhus typhina*)

Glossary 4: *Brownfields to Greenfields*

Abiotic: A nonliving factor or element (e.g., light, water, heat, rock, energy, mineral).

Biotic:: An environmental factor related to or produced by living organism.

Brownfield: An abandoned industrial site.

Igneous Rocks: Rocks formed by solidification of molten rock material.

Manmade Rock: Rock-like byproducts of manufacturing processes .

Metamorphic Rocks: Rocks formed within the earth when previously existing rocks are subjected to temperatures and pressures different from those under which they first formed.

Nonrenewable Resources: Substances (e.g., oil, gas, coal, copper, gold) that, once used, cannot be replaced in this geological age.

Ore: Metal-bearing mineral or rock.

Recycling: Collecting and reprocessing a resource or product to make into new product.

Renewable Resources: A naturally occurring raw material or form of energy that will be replenished through natural ecological cycles or sound management practices (e.g., the sun, wind, water, trees).

Sedimentary Rocks: Rocks formed at the earth's surface by deposition and gradual hardening of particles eroded from previously existing rocks and other materials, such as remains of plants and animals.

Slag: A byproduct of the steel industry. In producing steel, iron ore is introduced into a blast furnace along with limestone and coke. The limestone separates liquid iron from impure metals.

Soil: A combination of eroded material from rocks and decomposing organic matter.

Succession: The orderly change in species composition in an area after a disturbance which results in a more or less constant group of species that constitutes the climax community.

Module 5: *Artifacts of a Watershed*

5.1: *Colors in Nature*

5.2: *Memories of a Watershed*

5.3: *A Model of a Watershed*

Overview

Throughout the preceding modules, students made a series of observations drawings, and paintings from a variety of sources in the watershed. Paint and form were integrated as tools of observation, inquiry, and analysis to record the movement of water over land. In turn, technology and science were used to expand and extend their understanding of the physical traits of the watershed. Students' topographical drawings from Hand Land along with prediction drawings and sand beds from Sand Land revealed patterns of water flow in nature. During the *Stream trip*, natural and man-made artifacts such as leaves, bark, stones, pop cap lids, and feathers were collected, while benthic organisms were recorded through drawings .

In this module, (informed by their inquiry and learning in the preceding modules), students will explore multiple ways to create visual interpretations of the stream environment. They will select resources from their watershed portfolio of drawings, paintings, statements, collections, and notes in the preceding modules to use as media in the construction of two and /or three-dimensional artworks about the watershed.

Background

This module provides the student with the opportunity to represent the aesthetic and ecological issues they have encountered. The integration of art, science and ecology is intended to broaden the students' intellectual base, finding that art is conceptual as well as representative in nature. The function and purpose of this art-making opportunity is to give students both personal and shared responsibilities in the creation of a work that provides contextual as well as interpretive information about the watershed. The unspoken question underlying this module is how can the artifacts be integrated into the artworks in such a way that it provides a meaningful narrative for each child? Students should be encouraged to share their perspectives for each of the artworks created; artist's statements should accompany an exhibition of the completed work, providing insight into the nature of each child's process of inquiry and conceptual development.

Objectives

Students will:

- Practice observation skills and art-technical skills, necessary for imitating nature
- Select or create images that represent important concepts about the watershed
- Create artwork(s) that reflect the student's aesthetic and intellectual response to the watershed



- Reflect on the significance of their choices and how they may influence others through their artwork
- Associate their artwork with the concepts represented by other environmental artists

Concepts

Three separate art-making opportunities are presented. The first, called *Colors in Nature*, encourages students to carefully imitate the colors of the objects from the stream environment. It requires careful observation and an exploration of media before some technical prowess is achieved.

In the second, *Memories of a Watershed*, a "collection box" is designed to house the students' selection of leaves, rocks, and other artifacts from the stream visit. The design and concept of collection box require planning and encourages each student to present his or her collective memories and objects in a *personal* way—each should be different.

The third activity, *A Model of a Watershed*, is collaborative in nature and may take the form of a three-dimensional model or a two-dimensional artwork. Either of these requires the ability to work collaboratively, respecting each individual's contributions and finding a way to use them in an appropriate manner in keeping with the overall idea for the final artwork. A written artist's statement should articulate the goal of the model as intended by the group. For teachers with the time and resources to do both, they may allow students to volunteer for either the 2-D or 3-D piece.

PA Educational Standards

Aesthetic response to the arts and humanities

- Identify uses of expressive symbols that show philosophical meanings of works in the arts
- Justify an informed individual opinion about the meaning of works of art to others.
- Art can communicate experiences, stories, or emotions.
- Explain choices made by artists regarding media, techniques, form, subject matter, and themes to generate their ideas to make works in the arts.

Module 5.1: *Artifacts of a Watershed*

Colors in Nature

Overview

In this module, students will carefully observe all parts of the natural objects they collected from the stream environment to develop a visual and tactile sensitivity to the colors, patterns, and textures. The goal of this exercise is to familiarize students with the subtle nuances of nature, enabling them to see those subtleties as an artist or scientist, eventually making distinctions between color variations, shades, and surface. Students will explore watercolor painting before trying to imitate the stream *artifacts*.

Background

In Hand Land, students explored watercolor painting to create graduated effects of color from darkest to lightest, to represent the various heights of the topography of their hands. In *Colors in Nature*, students will use the same watercolor paints to imitate the observable shapes, colors, and textures of the artifacts from their stream collection.

Students should be encouraged to experiment with the watercolor media before being expected to replicate or interpret a rock, twig, or leaf. It is important to understand the possibilities of watercolors before expecting students to explore without guidance. This may be an opportunity to collaborate with the visual art teacher.

Important: Students should keep all attempts from this exercise in their Watershed portfolio, even those that they may not feel successful. They may be useful in the remaining module.

Objectives

Students will:

- Recognize and describe colors found in nature by studying natural objects from the stream environment.
- Explain the concept of camouflage and its relationship in nature.
- Imitate colors, patterns, and textures with watercolors.



(Figure 5.1)
A chrysalis of Anise Swallowtail butterfly



A student work



Colors in nature activity for observing rocks

Preparation

Materials

- Natural objects: leaves, flowers, twigs, rocks, feathers, etc.
- Watercolor or tempera paints (primary colors: yellow, turquoise, and magenta)
- A paper plate or palette for a pair of students
- #6, #12 watercolor paint brushes
- 8.5" x 11" heavy weight drawing paper or watercolor paper
- Water
- Texturing tools-dry sponge , stiff bristle brushes
- Tape

Set Up

The instructor has prepared the above materials for each team. Allow students to best set themselves up with artifacts, paint, water, and tape. Two students share watercolor paints. Each student should have his/her own paper plate or palette.

Estimated Duration:

45 minutes to 1 hour-practice/discovery

45 minutes to 1 hour-application of knowledge and skills

Lesson Plan

Class Setting

Ask students to clean their tables. Ideally the room is flooded with natural light. Alternatively it should be brightly with a mixture of light bulbs and as much natural light as possible. Light has a strong affect on color. Teachers might want to experiment with the difference between natural day-light and flourescent-light when looking at objects and coloration. While the students are painting, help them keep their water as clean as possible. Prepare an empty bucket and a water pitcher to facilitate changing the water at their desks.

Discussion

Key Question: Why does the phenomenon of camouflage happen in nature?

Students will use the artifacts collected at the stream. They should carefully observe the colors, patterns and textures of the artifacts. They should describe how they think plants and animals camouflage to adapt to their environment. Discuss figure-

ground relationships and the way camouflage disrupts this relationship. Explain the characteristics of biotic (living) and abiotic (non-living), and then allow students to explore these concepts with the artifacts and materials that have been gathered. Before working on a color, exercise with them.

Instructional Materials

- *Images of Camouflage in Nature, Figure 5.1*
- *Activity Card 5: Colors in Nature*

Key Words

artifacts

camouflage,

figure-ground

Activity

Activity 1: Observing the Colors, Patterns, and Textures in Nature

Ask students to identify the artifacts they collected on *Activity Card 5*. Indicate if the artifact is biotic or abiotic. Name and describe each color they observe by listing them in the space next to the artifacts name. Note any unusual characteristics of features that distinguish this artifact from the others they have collected. Turn the artifacts carefully over, making sure to document the description of front, back, sides, or overall appearance. Describe the shape and texture(s) of the artifact in the space provided.

Activity 2: Interpreting or Imitating the Color of Nature

Note: *Students should be given the opportunity to discover the following concepts through an exploration of and use of materials and artifacts. As the students are painting, the teacher discuss their discoveries, and affirms the techniques and concepts which will be most productive. Students can then apply what they know to this module.*

Colors

If any areas are to remain white, draw the shape of that area and leave it without paint. Watercolors can be thought of as a layering of paint with under-painting and over-painting of layers. Encourage students to work from the lightest to the darkest colors, one can easily paint layers over dried paint to achieve a richer effect, but it is difficult to remove pigment once applied. One may also paint over wet paint, called wet-on-wet technique, so the colors will blend together.

It is very important to provide practice sessions when the students begin using the media. Encourage students to keep all practices in their Watershed Portfolios. They may be useful in this module.

Explain that primary colors can be mixed together in various combinations to create the colors of the spectrum. Students should practice mixing combinations of primary colors together on their palette to match those in the objects. Varying the ratio of one color to another they will increase the different varieties of colors. Varying the amount of water on the brush *before you pick up paint* will determine the area the paint may take up on the paper. The following chart or a color wheel may be helpful:

Turquoise + Yellow = Greens
Turquoise + Magenta = Violets
Yellow + Magenta = Oranges
Yellow + Magenta + Turquoise = Browns or grays

Activity 3: Refining the Shape of the Artifact Painting.

Shapes

Shapes occur both inside and around of the artifact. Some artists begin by looking at the outside shape; some begin by looking from within and work toward the outside. Teachers should encourage students to practice either method, each is effective in the end. A light pencil sketch of the shape is very useful to help guide some students painting efforts; others will find the outline cumbersome and too difficult to paint into. Allow the colors to form the shape as the painting evolves.

Demonstrate how to use watercolor and brush to vary the line width:

- To achieve fine lines, pull up on the brush.
- To achieve wide lines push, slightly down on the brush.
- A dry brush dipped in paint will achieve a textured effect.
- Dry sponges, paper towels, plastic bags or found objects can be pressed into wet paint and printed onto painted surfaces to achieve texture.
- Colored pencils can be used on top of a dry painting to achieve more details.

Activity 4: Evaluate Your Painting

Students should use the *Activity Card 5* to assess their paintings. To do this effectively, students should place the completed paintings next to the artifacts. Remember, the objective was to see how well the students worked the colors and shapes of the artifacts. Colors and shapes did not have to be exact, and may be painterly (showing a level of control and experimentation which is about color and paint, rather than a photographic replication of the object). Some students may have better colors than shapes, so both are scored equally. Look at the overall effort.

Activity Card 5: Colors in Nature

List your stream artifacts	How I matched colors	How well I matched shapes

Use the following key to self-assess your work:

- 4 = Advanced Accomplishment of Objective
- 3 = Very Good Accomplishment of Objective
- 2 = Limited Accomplishment of Objective
- 1 = Little or No Accomplishment of Objective

Reflection Questions:

- Which look most like the shape of the artifact?
- Which look most like the colors of the artifact?
- Which best matches the texture or pattern of the artifact?
- Overall, which looks most like the natural artifact? How did you achieve the effects?
- Overall, which do you like even though it may not look like the artifact?
- What did you think about as you were painting?
- What would you tell others who were trying this process?

Module 5.2: *Artifacts of a Watershed*

Memories of a Watershed

Overview

This module gives an individual the opportunity to make a personal artistic statement about the ideas and information gathered from the study of the watershed. Students should have access to their watershed portfolio to help them make decisions about what they would like to represent through the collection box.

Artists create meaning in various contexts and with an endless variety of media. This module gives the students an opportunity to express what memories are important to them about the watershed. The following poem may serve as an introduction to this module. You might ask your students, "What memories does Wendell Berry call to mind about the river?" What memories will the students express visually through the design of their collection box?

Background

January, Nineteen Seventy-Five

Wendell Berry

*Another rainy winter / the third one in a row. Cattle stand in mud.
Fog rise in rain. The old river / maker of the hills / runs muddy, / swollen / day after day.
All here is shaped by search / we often finding this way.*

The valley keeps the shape of the escape of water. Moving water carved it in violence so long and slow it was gentle. It hollowed the long main stem of the valley / drew its fingers down tributaries and coves, / and did it all in little displacements of stone/ little shifts and slips/ nudgings / wedgings of frozen soil / meltings. And all the while the forests stood unmoved of the slopes / canebrake grew to the water's edge/ speckled bass soared in pools clear as the sky.

Millions of years it worked at this great work / missing nothing / meticulous and patient as a colony of ants. It worked like a mind / a goodly fathering and mothering mind / teaching its creature how to grow.

In flood it bore the humus of the forest floor / and left it on the bottomlands downstream, / richness to make myth behind us / so great it was, so soon destroyed.

It was old light the currents bore / old time itself / the past more vital and complete than myth or memory / laid down to bless the fields. And then we cut the trees / opened the mountainsides for coal / cast the mountain down into the valleys / and so destroyed the ancient light or ground / time gone into the power to come again. That history is the

*undoing of light / days turned against days. The river has become the gut of greed.
Human evil moves in its currents now / each rise a kind of weapon / the old clarity gone.*

Wendell Berry

Copyright 1975 by Wendell Berry, This keeps ask broadside celebrates a quarter century of Larkspur Press on an evening of rending by authors and friends The King Library Press. 300 copies were printed by Larkspur Press in Monterey, Kentucky.

Wendell Berry's poem serves as an explicit reminder. His descriptive writing offers students an opportunity to discuss other's experiences and to compare these with their own, This poem may help students to focus on the issues they wish to represent in their collection box.

Objectives

- Use art to express personal meaning discovered through inquiry in other disciplines.
- Construct an *assemblage* of selected artifacts to represent those meanings.
- Collage the surface of the box using artwork or writing from their Watershed Portfolio.
- Articulate the meaning of the collection box in an artist statement; title the work.

Concept

There are many ways to express knowledge, experiences, or emotions about nature and human impact on nature.

Preparation

Materials

Per student

- One sturdy wooden or cardboard box with lid, not to exceed 3" x 3" x 9"
- Stream Environment Artifacts *such as leaves, rocks, feathers, etc.*
- Paintings and drawings from the preceding modules
- Various origami papers, transparent papers, colors
- Transparent and permanent markers
- White glue, scissors
- Some tape or hot glue gun for attaching the natural objects to the paper

Set Up

Each student has one box, a collection of stream artifacts and their collection of paintings and drawings from the preceding modules. The above materials are available to all students.

Memories of a Watershed



Estimated duration

One hour to one and one-half hours plus homework, or two class periods

Lesson Plan

Class setting

The above materials are readily available to students. The instructor has similar materials prepared to model the concept of assemblage and / or collage for the students. It is important to remind students to arrange several compositions first before they decide on the final arrangement. If they glue something important down first without considering what the background elements may be, they will have a difficult time rearranging the materials.

Discussion

The teacher should distribute copies of Wendell Berry's poem to the students and ask student volunteers to read it aloud to the class. Discuss the poem, asking students to identify descriptive evidence of the environment and evidence of Berry's interpretation of it. Discuss the content of the poem as it relates to evidence of the river's nature as opposed to human nature. Have students relate this poem to the stream environment or watershed that they visited. Also have them relate to the land based issues of brownfields.

Another example of this is Dr. Seuss's *The Lorax*, which also represents the theme of man vs. nature.

Further Discussion

Introduce the art forms of *Collage*, *Assemblage* and *Mixed Media* (*Appendix 5A*). This is an opportunity to collaborate with an art teacher. Find some example of work which are comfortable for you and your collaborator (teachers) to use. Show and discuss with students what items the artist(s) selected, note the titles of the works, and ask students to interpret the reasons for the selection of media. *Interpretation does not require a correct answer*. Chose two different artworks and compare how each is different from the other.

Ask students to speculate how the assemblage or collage was put together: What was constructed first, next, after that? What is the purpose of ordering one's artifacts / drawings before gluing the parts together?

Instructional Materials

- *Appendix 5A: Collage, Assemblage and Mixed media*
- *January Nineteen Seventy-five* by Wendell Berry, (*see Background*)
The Lorax by Dr. Seuss (*available in public libraries*)

Activities:

Activity 1: Demonstrating Techniques

The teacher should develop his/her own watershed box prior to teaching the module to share their Memories of a Watershed box with his/her students. Ask students to interpret the artwork and determine what parts you glue down first, then next, until you achieved your final composition. Be certain to share some of your reasons for the selection of some parts of your work.

The teacher should model cutting a shape from a least favorite painting from their own portfolio to show its possible usefulness, even in the background. Also, model arranging and rearranging different parts from the portfolio on and in the box so students feel comfortable with the consideration of different interior and exterior arrangements before selecting a final one.

Remind students that glue should be placed on the back of the cutout piece, not on the surface of the box, when the final arrangement is decided upon. Although elements may be similar, each student's watershed box may look different.

Activity 2: Selecting and Composing the Materials

Students should preview their Watershed Portfolio and assemble the collection of materials from the preceding modules. Encourage students reflect on ideas they would like to represent. This is a very personal selection and may even consist of newly constructed items. The box should be designed on the interior as well as the exterior. Consider all drawings, paintings, photocopies of watershed maps, scanned images of rocks, and stream collection item (leaves, rocks, colors in nature) as possible compositional elements. Even paintings that are not favorites may have a use as background elements.

Preparing the surface. All gluing of parts should be done after several compositions are drafted. It may be necessary to glue paper to the box for the background, before gluing on the selected materials. Cut out the painting and drawings to be collaged onto the surface of the box.

Consider the display of fragile or large items within the interior of the box, or place them on the box lid, to emphasize the contents. Create any additional support imagery by cutting shapes from origami papers. Include poetry, phrases, newspaper articles about the environment, or related words to support images.

Glue the final composition. Title the work. Sign and display the work with an artist's statement or poem about the artwork. The length and content of the artists' statement should be determined by the artist.

Reflection Questions:

- *What watershed symbols or themes did you include in your box? Why?*
- *Before you glued everything together, you were asked to try different arrangements of the elements. How did the different arrangements of those elements change the meaning or emphasis of the box?*
- *As you planned your box, did you think about camouflaging it, or revealing the objects by using opposite or complimentary colors?*
- *As you put the parts together for your box, describe any memories or experiences that came to mind.*

Imagine that a friend of your family visits your home, and sees your Watershed Box displayed on a shelf. They are curious about the box and want to know what it is about.

Module 5.3: *Artifacts of a Watershed*

A Model of a Watershed

Overview

In this module, students will collaborate to create a model of a watershed; it may be three-dimensional or two-dimensional, or include both two and three-dimensional elements. All models require the students to demonstrate the ability to work collaboratively, respecting each individual's contributions, incorporating ideas that may be represented in the watershed:

- Animals and their habitat within the watershed
- Water Flow within the watershed
- Human impact on the watershed or stream
- The future of the stream

Background

See Appendix 5.B: Ecosystem Restoration Art, Discursive Democracy

Objectives

- To work collaboratively through art to represent the collective issues of students about watersheds

To construct an informative 2-D or 3-D model using good *craftsmanship*

Preparation

Materials:

- Cardboard, foam board, Masonic
- Remaining paintings from previous modules
- Watershed artifacts such as leaves, rocks, feathers, acorns, etc.
- Various origami papers
- Transparent and permanent markers
- White glue, Tacky Glue, hot glue gun (optional)
- Scissors
- Plasticene clay in various colors

- Various origami papers
- Transparent and permanent markers
- White glue, tacky glue, hot glue gun (optional)
- Scissors
- Plastic Clay in various colors



A view of the classroom during the activity "Creation of Watersheds"



Working in progress of a collage piece

Set Up

Each student has determined their area of collaboration-either 2-D or 3-D. The remaining collection of stream artifacts and their collection of paintings and drawings from the preceding modules are available. The above materials are available to all students.

Estimated duration

Two class periods

Lesson Plan

Class setting

The above materials are readily available to students. Divide students into groups for either 2-D or 3-D, in this way a variety of final projects will be presented at once.

Discussion

Introduce some examples of 3-dimensional models. Students should speculate as to the purpose of these examples. Explain the ideas behind each example. (*Appendix 5B: Ecosystem Restoration, Restoration Art, Discursive Democracy*)

Key Questions:

- *What issues will this watershed model represent?*
- *What does your group intend to do?*
- *What kinds of elements are in the piece?*
- *Who is going to do what in the class time?*
- *Which part is the "still unknown" part of the piece?*
- *Is there any disagreement over how to make the piece?*

Instruction Material

Appendix 5B: Ecosystem Restoration, Restoration Art, Discursive Democracy

Activities:

Activity 1: Discussing the Model

Key Question:

- *What issues will this watershed model represent?*

Teachers must direct his/her students to brainstorm ideas or topics that they would like to represent three-dimensionally. Students should list all ideas, then sketch ways the ideas can be represented. Students or groups of students should present their concept (idea) sketches to the group for discussion and revision. Once ideas are clear, students should determine who will make what, and make a list of responsibilities that can be seen by all. Be sure to include every member of the class.

The size of the base and time constraints will determine the number of students who can work comfortably. Before you choose a size, you may consider first where it will be displayed and the ease of its movement or storage. It may be advisable to create the model in sections that can easily be placed together for display.

Activity 2: Constructing the Model

Key Question:

- *What technical problems do our ideas present? How to solve them?*

Forming Issues: Teachers should demonstrate how to use Plasticene clay to form small animals; colors can be mixed to create patterns. *Note: Plasticene clay can be painted with tempera paint.* Plasticene clay can be spread over cardboard to create a low-relief, which can be carved with pencils or Popsicle sticks, or built up for a high relief.

Elevating surfaces: It may be necessary to elevate some parts of the surface by creating a wire armature in the shape of the needed part. Styrofoam, cardboard, and fabric can be layered and glued in concentrically smaller elevations to create an interesting topography.

- Cut out relevant images from preceding modules and arrange them within the three-dimensional format.
- Select background and base coverings for the collage.
- Create any additional support imagery by cutting shapes from origami papers or by painting surfaces.
- Use artifacts from the stream collection as three-dimensional props within the scene.
- Arrange several compositions of background and base elements.
- Form animals, plants, and humans with Plasticene clay within the stream environment, and show the potential of their impact on the environment (positive or negative impact).

- Glue and place all parts of the final composition.
- Title, sign and display work.

Reflection Questions:

- *What watershed concept does your model depict?*
 - *Why is this concept important for others to see?*
 - *Describe the kinds of collaboration that occurred as your team created the artwork.*
- Create a collaborative artist's statement to display with the model.

Appendix 5A :

Collage, Assemblage and Mixed media

Collage:

An artistic composition of fragments (as in printed materials) pasted on a surface. Originally created by the Cubists Picasso and Braque with the intention to replace the need for painting the likeness of an object, who cut and glued bits of newspaper and scraps onto the many surface planes of their paintings. (*Robert Atkins, Art Speak, p.66, Abbeville Press Publishers, New York, 1990*)

Assemblage:

The three-dimensional counterpart of collage, assemblage similarly traces its origin to Pablo Picasso. In collaboration with George Braque, he created the first assemblage in 1913 with his Sheet-metal Guitar, two years before the DADA artist Marcel Duchamp attached a bicycle wheel to a stool and called it a READYMADE. Previously known simply as "objects", assemblages were named by Peter Selz and William Switz, curators at the Museum of Modern Art, for the exhibition, The Art of Assemblage in 1961.

Assemblage involves the transformation of non-art objects and materials into sculpture through combining or constructing techniques such as gluing or welding. This radically new way of making sculpture turned its back on the traditional practices of carving stone or modeling a cast that would then be translated into bronze. (*Robert Atkins, Art Speak, p.55, Abbeville Press Publishers, New York, 1990*)

Mixed Media:

Art of the 20th century which combines different types of physical material. Art which draws on several disciplines, for example music, movement and environmental sculpture. In this sense, synonymous with Intermedia and Multimedia. (*Thames and Hudson, Edward Lucie - Smith, p.122, Thames and Hudson, 1988*)

Assemblage Box by Joseph Cornell 1903 - 1972, America

Cornell's association with the Surrealists* in the 1930s and '40s enacted him to adopt a free attitude toward the object. He celebrated collage and assemblage as true poetic forms.

Cornell created many assemblage boxes. Each box has singular feeling for childhood's game and toys; it also has sanctification of the small object -- a marble or a block which he treats as if it were a treasure. Cornell used mirrors and glass often in his boxes, creating a marvelous illusion of space and depth within a small space.

*The Surrealism, movement that dominated the arts and literature during the second quarter of the twentieth century. Salvador Dali, Max Ernst, Frida Kuhlo, Rene Magritte, and Giorgio de Chirico are well known as the Surrealism artists. They were greatly influenced by the theory of Sigmund Freud, who had shown that when our wakening thoughts are numbered, the child and the savage in us takes over. (Figure A5A-1)

A Blizzard of Released and Agitated Materials on Flux

Mierle Laderman Ukeles

This permanent environmental installation was commissioned by the Research Institute for Contemporary Art and the Taejon Expo Organizing Committee for the Recycling Through Art museum in Taelon, Korea. It celebrates the 1993 opening of the Taejon Expo, the first University Expo in a developing country.

I wanted to create a place to begin a new kind of journey, a place where one could pass through a blizzard of released and agitated materials in a state of flux. These surprisingly rich and abundant materials have all been thrown out. The desire that made people work to make them, and to purchase them, has passed. The materials have now been densified, and are in the first stages of reprocessing. They are not yet formed again. Visitors enter the place and see them, held for a moment in flux.

This passage, 20 feet long by 16.5 feet high by 15 feet wide, includes 14,000 hand-pulled "blobs" of extruded polystyrene, 6,000 washed and smashed steel and aluminum cans, and 1,721 bundles of spiraling metal filings -- all bound onto 572 binding wires.

(Figure A5A-2) Mierle Laderman Ukeles, *Sculpting with the Environment*, edited by Baile Oaks, Van Nostrand Reinhold, 1995, p.188-189

Casting a Green Net: Can it Be We Are Seeing a Dragon?

Helen Mayer Harrison and Newton Harrison

In 1998, Helen Mayer Harrison and Newton Harrison were given the opportunity of casting a "magic green net" over the land between the estuaries of the rivers Mersey near Liverpool and Humber near Hull, bordered in the north and in the south by the old Roman roads and the contours of the Pennine Mountains. "Can it Be We Are Seeing a Dragon?" they asked on the map, and they started to discover the dragon and to develop the vision for a green net. This net was meant to make connections between ecological islands which would finally develop further and higher all by themselves.

The documentation on the show narrates the story of their conversations with foresters, farmers, planners, politicians, and scientists, and it describes what landscape will look like if things are continued in the same way as they are now. But it also tells us "what if..." certain things were changed, the disintegration of landscape and mono-culture could be averted: in a functioning system into a source of energy and food for another species. Only in a natural net, the further development of nature and its continual adaptation to environmental changes is secured. From these principles, the Harrisons deduct suggestions for bringing about "small changes in the heads of many", in order to spread out a green net from Liverpool to Hull.

(Figure A5A-3) Catalog text from the Exhibition, *Natural Reality* at the Ludwig Forum for International Art, Aachen Germany, Curated by Heike Strelow, published by Daco Verlag, Stuttgart, 1999, p.188

Appendix 5B: Ecosystem Restoration, Restoration Art, Discursive Democracy

Nine Mile Run Greenway Project

By Tim Collins

Introduction

The Nine Mile Run Greenway Project is the first of a series of urban ecological-art interventions by an interdisciplinary team. Directed by three artists Bob Bingham, Tim Collins, Reiko Goto and an attorney, John Stephen. The work occurs within the context of academic-art research facility. The project has the support of partners in Pittsburgh City Planning and various academic-art research facility. The project has a support of partners in Pittsburgh City Planning and various academic and non-profit institutions. We approach the project as an interconnected system of opportunities often constrained by outdated policies and practices. Our work is a systems intervention targeting research, communication and public education. We take specific action targeting the points which seem the most constrained or have the most potential for long term change. Our goal is to effect the decision making process.

I. Nine Mile Run (NMR) Issues of a Post-Industrial Valley and Stream

Nine Mile Run is a small creek connected to the Monongahela river. It is about nine miles from the Point. Next to the creek there is a 240 acres slag heap. Nine Mile Run creek is a watershed which consists of a wooded park and five municipalities. In 1993, Pittsburgh City Planning produced a conceptual plan for the development of houses and open space on the 240 acre steel industry-slag dump at Nine Mile Run. Pittsburgh City Planning and a team of developers outlined a plan called "Somerset at Frick Park." Summerset, would extend the developable land by 20%, enclosing the NMR stream in a steel pipe and burying it under 150 feet of slag. Essentially obliterating the stream and the valley, an outrage, even the steel industry couldn't accomplish. During this time the Nine Mile Run Greenway Project team of three artists and a lawyer had begun to conduct hiking tours of the slag valley and urban stream with a multi-disciplinary mix of specialists and various community members.

We were seeking a deeper understanding of the human and ecological systems that had evolved in and around Nine Mile Run. Four issues became clear.

- The slag filled valley connects a large urban forest and the Monongahela river water front, a brownfield sandwiched between two good sources of bio-diversity.
- The stream was in very bad shape. Plagued by municipal sewage problems and erosion.

- The perception of the place as a dump, reinforced the developers argument for radical change in landform.
- There was enormous potential for academic-art research in the issues of post-industrial public space and urban eco-aesthetics. During public tours, it became clear to us that onsite experience and informed discussion allows the casual viewer to perceive value, opportunity and by extension potential for change. The argument that “any-change” is for the better, begins to hold less weight when a place retains an intrinsic value.

Working through Carnegie Mellon University (CMU) academic contacts, the team arranged a meeting with the assistant director of Pittsburgh City Planning. From this meeting we clarified our potential involvement;

- Our input on issues of public space were valuable to the city.
- Our input on the issues of the private development were not.
- Our approach must remain open to compromise.
- We must find our own funding.

II. Community Inquiry, the art and Process of the NMR Team.

Our inquiry is based on a four step process; observation, hypothesis, investigation and evaluation. We utilize this process to explore local knowledge, infrastructure and ecological phenomenon as well as intellectual constraint. Our long term goal is to develop a program that is transcendent yet culturally embedded, formative, yet open to discussion, discovery and ultimately revision.

1. Observation and Hypothesis

In 1997 we began Ample Opportunity the Community Dialogue. This was a series of issue publications, site tours and public discussion pertaining to the development of postindustrial public space at Nine Mile Run. From this series of meetings we clarified a number of issues which were previously lost to a development discourse which had been focused on the new community's effect on private property, local and homeowners notion of neighborhood integrity.

1. Investigation (conceptualization)

In 1998 we outlined a two year project plan, Ample Opportunity the Brownfield Intervention. This began with a year of ecosystem and infrastructure assessment leading to and interdisciplinary conceptual planning process. The NMR team developed an onsite resource trailer, site experiments, infrastructure and ecosystem intervention, website and innovative uses for a computer mapping system.

2. Evaluation

In 1999 we presented the conceptual plan alternatives (2 for each site) with a program of new community dialogues intended to elicit specific approaches for the open space. This culminated in an interactive public exhibition at the Miller Gallery Carnegie Mellon University, and finally a long term business/ stewardship plan.

We are learning how group of different people can become passionately informed and work collectively to make important social choices, and how such decision making process can be source of aesthetic, health and resilience in a system. The art of the NMR Greenway Project is found in the intent to address these issues while applying the ideas of re-constructive post modern theory, state of the art urban restoration strategy and the evolution of thinking about the form and function of the liberal public realm.

III. Thoughts for artists involved in the restoration of post-Industrial Public Space:

The theoretical, physical and design analysis of urban open spaces are the traditional realm of urban planners. Each of these disciplines are shackled to the private realm of commercial development by vested interests. Municipal design professionals – the traditional guardians of the public realm are equally affected by vested interests and-or conflicted politics of municipal government. It is our hypothesis, the public realm is in need of interventionist care. The visual arts with a history of value based creative-cultural inquiry are best equipped to take on this role. any role in an arena complicated by capital and politics must be met with a sustained autonomy through careful funding. We must enable an advocacy that is free to raise questions, paid to voice alternatives and at times embrace conflict as a tool in the support of the goals of an expanded public realm. This calls for an independent, citizen-professional – a generalist with training in the techniques and concept of creative inquiry, social-systems intervention and discursive democracy. The long term goal, is to develop a culture discourse which will;

- Expand the social and aesthetic interest in public space to the entire citizen body.
- Re-awaken the skills and belief in empirical analysis and critical dialogue.
(versus professional analysis and pronouncement)
- Teach and disseminate the notion that everyone is...an artist, thereby undermining the interim “profession” which we must create to intervene and uncover the form and function of a post-industrial public realm.

The question we must ask in a thousand cities is, “how do we reclaim our brownfield sites to restore the ecological function to our cities? How do we “build in” a sustainability that will allow these natural interventions in the urban landscape to endure the changes in politics, economics, and adjacent environments? How do we create land stewardship in communities that were weaned on the extraction of resources? How do we learn to ‘recognize the interdependence of humanity and nature, to treat nature as a model and mentor, rather than an inconvenience to be uses, evaded or controlled?’ These questions begin to circumscribe our challenge and the evolving meaning of nature in a post-industrial urban setting.



Homewood Montessori School
Valerie Lucas and her students 1997

Assemblage Boxes by Joseph Cornell

(Figure A5-1)

Joseph Cornell, Edited by Kynaston McShine,
The Museum of Modern Art, New York, 1980



Untitled (Paul and Virginia),
1946 - 48, 9" x 4", Collection Mr. and
Mrs. E.A. Bergman, Chicago



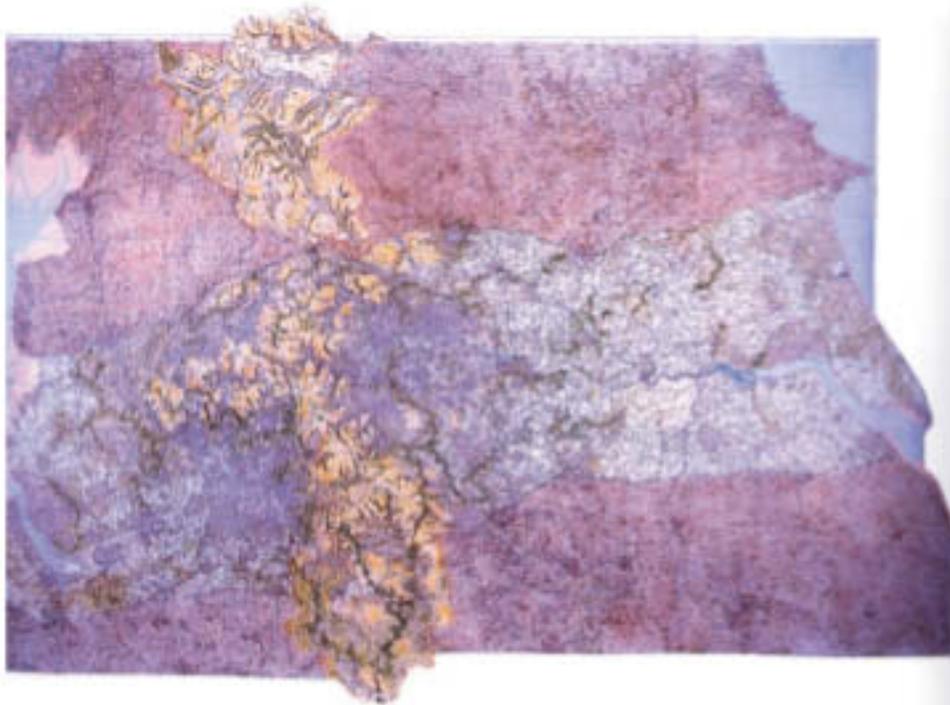
Untitled (Pharmacy), 1943
Construction, 15" x 12" x 3", Collection
Mrs. Marcel Duchamp, Davis, Mr. and
Mrs. Gerald Murphy Fund



Object (Roses des vents), 1942 - 53
Construction, 2" x 2" x 10", The Museum
of Modern Art , New York



(Figure A5A-2)
A Blizzard of Released and Agitated Materials on Flux
Mierle Laderman Ukeles, 1993



(Figure A5A-3)

Casting a Green Net: Can It Be We Are Seeing A Dragon?

Helen Mayer Harrison and Newton Harrison, 1993

The entire piece consists of large maps. One map shows the existing ecosystems in the dragon shaped area. There are hundreds of meadows and miniature wildlife drawings on the map. From a distance, these drawings look like scales of the dragon. Other maps show different ideas on how to make the place environmentally healthier. This map is one which suggests strengthening the net by evolving an eco-urban edge where wildness co-mingles with expanding urban forms. There is also a map that evokes the question of what if nobody does anything. The dragon's veins and scales were painted in black which appeals to the audience that the dragon is dying.

Glossary 5 : *Artifacts of a Watershed*

Artifacts: A man-made object

Figure-ground: In painting, the way in which an object or shape is related to the background against which we see it. Human perception normally operates in such a way that the 'figure' seems to advance, and lie in front of the background. Sometimes, however, especially with ABSTRACT ART, where the 'figure' and the 'background' occupy approximately becomes confused, so that the background assumes equal importance to the subject of the work. (*Thames and Hudson, Art Terms*)

Craftsmanship: a workman who practices a skill or dexterity especially in the manual arts.