Mine Over Matter

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Understanding the Past to Shape the Future of Prince William Forest Park

Bridging the Watershed

An outreach program of the Alice Ferguson Foundation in partnership with the National Park Service and area schools

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Teacher's Guide

Student Booklet

Resource Booklet

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September 15, 2009

Dear Educator:

We at the Alice Ferguson Foundation and the National Park Service invite you and your students to join in the effort to preserve our nation's parks. The goal is to ensure that these treasured sites will continue to be available for generations to come. In the *Bridging the Watershed* program, we offer you a "real-world" setting in which to teach science and other disciplines' concepts such as those included in your Scope and Sequence and/or benchmark expectations.

Bridging the Watershed offers hands-on opportunities for students to examine our local watershed and study the impact humans have on it. In national parks, students will apply what they learn in the classroom to studies of trash, invasive plants, water quality, runoff, and/or macroinvertebrates. More importantly, the program will help them develop a greater sense of ownership for their environment and understand the impact of personal choices.

Field study is an excellent vehicle for concepts in context. Unfortunately, this vehicle is not always available in urban or suburban settings, leaving a gap between learning and application. Bridging the Watershed can help bridge that gap. Though national parks have been somewhat protected, what occurs in society does impact the parks. Students will collect and analyze authentic data to better understand this impact.

It is our hope that student experiences in the parks will foster a heightened sense of ownership and responsibility that will last a lifetime. Let us join together as partners in teaching our young people stewardship of their watershed.

Sincerely,

Peggy O'Dell
NPS Regional Director,
National Capital Region

Tracy Bowen
Executive Director,
Alice Ferguson Foundation

BRIDGING THE WATERSHED

Bridging the Watershed is an outreach program of the Alice Ferguson Foundation, in partnership with the National Park Service and area schools, that offers secondary school students opportunities to study real-world science in national parks. Its purpose is to promote student academic achievement, personal connections with the natural world, lifelong civic engagement, and environmental stewardship through hands-on, curriculum-based, outdoor studies in national parks and public lands.

Many thanks go to the Alice Ferguson Foundation, National Park Service, and Prince George's County Public Schools, who have provided in-kind and financial support to foster the development and sustainability of the BTW program. The BTW administrative office is based at the Alice Ferguson Foundation, a 330-acre environmental center on the Potomac within Piscataway Park—10 miles downstream from Washington, D.C.

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NATIONAL PARK SERVICE

"NATIONAL PARK LABS:" *BRIDGING THE WATERSHED*

The *Bridging the Watershed* (BTW) partners wish to thank Toyota USA Foundation for its generous donation that made "National Park Labs" (NPL) possible at National Capital Region and four other national parks across the country. The other NPL sites are Carlsbad Caverns National Park (NM)/Guadalupe Mountains National Park (TX), Lowell National Historical Park (MA), Santa Monica Mountains National Recreation Area (CA), and Golden Gate National Recreation Area (CA). The partners also wish to acknowledge the important role played by the National Park Foundation in working with Toyota USA Foundation to establish and guide this generous grant.

"National Park Labs" is a program of the National Park Service, the National Park Foundation, and Toyota USA Foundation. These model programs, the first of their kind, provide high school students with opportunities to study real-world science in the national parks and foster stewardship of park resources.

Thanks to a growing list of partners and sponsors, *Bridging the Watershed* has grown throughout the Potomac Watershed since its inception as a National Park Labs program.

Founding Partners

Alice Ferguson Foundation
C&O Canal National Historical Park
Chesapeake Bay Foundation
District of Columbia Public Schools
George Washington Memorial Parkway
Howard University
National Mall and Memorial Parks
National Capital Parks-East
President's Park
Prince George's County Public Schools
Rock Creek Park
Student Conservation Association
U.S. Fish and Wildlife Service Chesapeake Bay Field Office

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Prince William County Schools
Prince William Forest Park
National Oceanic and Atmospheric Administration
Maryland Park Service

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without whose vision this program would not have been possible.

An Overview of the *Bridging the Watershed* Program

Bridging the Watershed is an environmental education program for secondary school students designed to promote understanding and stewardship of the Potomac watershed. The program, the product of a partnership among twelve national parks within the National Capital Region, two school districts in the Potomac River basin, and countless schools throughout the region, uses national parks as outdoor learning laboratories. Part of every module is a field study in one of these national parks, where students use the processes of science to learn about the health of the natural resources in the Potomac watershed. These processes include analyzing the water quality of streams, identifying benthic macroinvertebrates, assessing runoff and suspended sediment in waterways, quantifying the kinds of trash found in the watershed, and conducting surveys of alien and native plants to discover the impact of human activity.

One of the main goals of the BTW program is to make the activities relevant to students' lives, serving to bridge the divide between science in the classroom and science in the natural world. Many students have had little or no contact with the natural environment or with national parks. This program aims to provide students with exposure to science in a natural setting, broadening their understanding of scientific study. The activities are based on sound pedagogical principles and correlated to national, state, and local education standards. As a result, the activities in all modules are inquiry-based and "hands-on/minds-on," encouraging students to experiment and then draw conclusions based on the results of the experiments. The program follows the constructivist pedagogy and uses the 5 E's of the teaching/learning cycle—Engage, Explore, Explain, Elaborate, and Evaluate—as its structure. All activities are student-directed, with the teacher acting as the guide and facilitator.

Each of the modules focuses on a particular discipline of science: chemistry, biology, Earth science, or environmental science. Nonetheless, the activities are interdisciplinary with a major emphasis on math. While each module is meant to stand alone and be used primarily in the science class on which it focuses, environmental education teachers may find it helpful to use more than one module with their students. All modules contain pre-field study activities and preparation, a one-day field study in a national park, and follow-up analysis and reflection on the experience. At the conclusion of each module, students are encouraged to engage in a service project during which they can apply what they have learned about the environment to their own community or in a national park.

The Core Modules in the BTW Curriculum: The following summaries describe the core modules in the BTW curriculum. Included in the summary is the science discipline or disciplines to which the module is most closely related.

Watershed Watchdogs: Assessing Water Quality Chemistry or environmental science students study nine parameters that will help them determine the Water Quality Index (WQI) for the Potomac River or one of its tributaries.

Water Canaries: Assessing Benthic Macroinvertebrates Students in biology or environmental science classes learn to identify benthic macroinvertebrates and then determine water quality by using the sensitivity ratings for the macroinvertebrates found in the stream during their field study.

Alien Invaders: Assessing Exotic Invasive Species Biology and environmental science students study the importance of biodiversity, learn the basics of plant identification, and explore the extent of alien plant invasion in a local national park.

Don't Get Sedimental: Runoff and Sediment in the River Students in Earth science or environmental education classes explore the impact that runoff from increasing development has on the watershed.

Talkin' Trash: Make a Litter Difference Students in any science class examine the impact of trash in their watershed. They learn how trash reveals a lot about the lifestyle of the residents that create it, how trash impacts the environment, what to do with all the trash we produce, and how personal choices can make a difference.

Additional Components of the BTW Program: The program also offers professional development for teachers and a web site with additional activities. The web site contains authentic data collected by students who have completed the program. More information about these two components follows.

Summer Teacher/Ranger Institute: Held at participating national parks, teachers work with park rangers to explore the modules in depth. The institute is held every summer. Teachers visit all six parks and learn one or more of the five modules. They are paid a daily stipend and can receive graduate credit. Only teachers who have participated in the institute are eligible to bring students to a *Bridging the Watershed* program in a national park.

BTW Web Site: The interactive web site, found at <http://www.bridgingthewatershed.org>, provides an essential link to enrich and reinforce the educational experience of the program. Participants or interested web surfers can find online activities to prepare for a visit to the parks, gain valuable knowledge about parks and their natural resources, or subscribe to receive an electronic copy of the BTW newsletter. Students' results of their field study can be uploaded to a database, making the web site a valuable community resource of watershed data. Teacher pages provide information about upcoming events, workshops, and the annual BTW institute.

Timeline of the Potomac River Watershed The timeline can be used by history or social studies classes, as well as by science students, to learn many interesting, often little-known facts about our past. The timeline begins with Native American pre-history and continues to the present day. Major events that have affected the watershed are interspersed with colorful sidelights, delighting "trivia" fans as well as historians.

Online Interactive Activities "Go Fish" is an interactive simulation game intended to appeal to students in middle and high school. During the game, virtual anadromous fish leave the open ocean each spring and travel into estuaries, coastal and freshwater rivers, and creeks to release their eggs. As the season moves into late summer and early fall, the juvenile fish leave the shelter of the upper estuary and begin a journey to the open ocean from which their parents came. During this trek, the fish encounter many perils, and not all of them will survive to reproductive maturity.

Plant and macroinvertebrate identification activities teach students of all ages basic techniques biologists use to classify organisms. The macroinvertebrates in two streams are identified with a key and then used to assess the relative health of their stream. Students learn basic invertebrate anatomy as well as how to use a key.

The plant identification key is unique in that it uses leaves as a starting point rather than flowers. Since a large percentage of plants in a sample area will not be in bloom, this technique is much easier to use to identify plants. As each plant is keyed-out, a lot of interesting information about it is presented such as whether the plant is native or an exotic introduction. If the plant is alien, reasons are given about why it is a threat to native species.

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Bridging the Watershed Activities: A Constructivist Approach

It sounds like a simple proposition: we construct our own understandings of the world in which we live. We search for tools to help us understand our experiences. To do so is human nature. Our experiences lead us to conclude that some people are generous and other people are cheap of spirit, that representational government either works or doesn't, that fire burns us if we get too close, that rubber balls usually bounce, that most people enjoy compliments, and that cubes have six sides. These are some of the hundreds of thousands of understandings, some more complex than others, that we construct through reflection upon our interactions with objects and ideas.

Each of us makes sense of our world by synthesizing new experiences into what we have previously come to understand. Often, we encounter an object, an idea, a relationship, or a phenomenon that doesn't quite make sense to us. When confronted with such initially discrepant data or perceptions, we either interpret what we see to conform to our present set of rules for explaining and ordering our world, or we generate a new set of rules that better accounts for what we perceive to be occurring. Either way, our perceptions and rules are constantly engaged in a grand dance that shapes our understanding.

Consider, for example, a young girl whose only experiences with water have been in a bathtub and a swimming pool. She experiences water as calm, moving only in response to the movements she makes. Now think of this same child's first encounter with an ocean beach. She experiences the waves swelling and crashing onto the shore, whitecaps appearing then suddenly vanishing, and the ocean itself rolling and pitching in a regular rhythm. When some of the water seeps into her mouth, the taste is entirely different from her prior experiences with the taste of water. She is confronted with a different experience of water, one that does not conform to her prior understanding. She must either actively construct a different understanding of water to accommodate her new experiences or ignore the new information and retain her original understanding. This, according to Piaget and Inhelder (1971), occurs because knowledge comes neither from the subject nor from the object, but from the unity of the two. In this instance, the interactions of the child with the water, and the child's reflections on those interactions, will in all likelihood lead to structural changes in the way she thinks about water…

As human beings, we experience various aspects of the world, such as the beach, at different periods of development, and are thus able to construct more complex understandings. The young child in this example now knows that the taste of seawater is unpleasant. As she grows, she might understand that it tastes salty. As a teenager, she might understand the chemical concept of salinity. At some point in her development, she might examine how salt solutions conduct electricity or how the power of the tides can be harnessed as a source of usable energy. Each of these understandings will result from increased complexity in her thinking. Each new construction will depend upon her cognitive abilities to accommodate discrepant data and perceptions and her fund of experiences at the time.

—Excerpted from The Case for Constructivist Classrooms
by Jacqueline Brooks and Martin Brooks

The activities in this module use a constructivist, interdisciplinary approach. Students construct their own knowledge of the science underlying the problems/issues they explore. Activities include active discussions, writing, research, and the use of the scientific method to observe and gather authentic data. Students observe problems in the watershed in which they live from a historical perspective, from the perspective of being a member of the human community, and from the perspective of an environmental scientist. Working in cooperative groups, and at times individually, students work on activities that include engaging questions and situations. They are guided through field and laboratory explorations that invite them to hypothesize about what will happen, to interact with natural phenomena, to observe, and to collect data about their observations. They will test their theories, explain results, and decide whether to keep or abandon their theories.

The teacher's role is to help students express their preconceptions about the problems and ideas presented in this module. After conducting the hands-on investigations, students are provided with opportunities to modify any misconceptions. Data collection combined with class discussions about alternative theories will provide motivation for further exploration and will help students restructure their knowledge base. In the process, students gain confidence in their abilities to learn and understand science as well as gather useful scientific data about the watershed in which they live.

Several different models of instruction can help create a constructivist approach to learning. One model is based on the 5 E's (Engage, Explore, Explain, Elaborate, Evaluate), an instructional model in five phases. The phases, explained below, form the structure around which the activities and procedures are organized.

Engagement Engagement Engagement

This phase is designed to grab the student's interest. An object, situation, or problem that relates to the student's world is presented with an authentic question, a problem description, or an interactive scenario. The engagement is meant to lead the student to the task to come. The role of the teacher in this phase is to present the situation or problem and to identify the task. If this phase is successful, students are motivated to continue to the next phase: the exploration.

Exploration Exploration Exploration

Exploration activities are meant to provide students with concrete experiences, which they can build upon as they discover new concepts and learn new processes and skills. These activities bring answers and, if successful, satisfaction to the student. During the exploration phase, students need time to explore objects, events, or situations. They gather data to help them establish relationships, construct mental pictures, observe patterns, and question preconceptions. The teacher facilitates the exploration and coaches students from the sidelines. The teacher answers students' questions and helps them to begin restructuring their knowledge. At the end of this phase, students should be prepared to explain what they have discovered.

Explanation Explanation Explanation

This is the phase in which students should "see the light." The concepts, processes, and skills to which they have been exposed become clear. The learning is internalized. During the explanation phase, students and teachers agree on appropriate vocabulary to discuss the discoveries students have made. The teacher's role is to ask students to summarize what has happened in their own words. Then, the teacher begins to introduce scientific terms to describe the results. Explanation often provides order to the earlier phases and should lead quickly to the ability to elaborate on what has been learned.

Elaboration Elaboration Elaboration

This phase is designed to provide students with a chance to take what they have learned and extend or apply the concepts, processes, or skills to their lives. Often, elaboration activities are interdisciplinary and may involve writing, mathematics, or social studies. When students can clearly connect the early explorations with the explanations and the concepts with the observations, learning has been internalized. They are ready to evaluate their work.

Evaluation Evaluation Evaluation

Students need to receive feedback on whether their explanations have been adequate. Informal evaluations occur all during the learning task, but a more formal evaluation should occur after the elaboration phase. Students should evaluate their own work and understanding, as well as be evaluated by the teacher. Authentic assessment techniques can be employed to give students meaningful feedback on their individual work or any group work.

Washington, D.C. Learning Standards	
ALL SCIENCE SUBJECTS	
Content Standard	***Description of Standard***
Scientific Investigation and Inquiry	1. Know the elements of scientific methodology (identification of a problem, hypothesis formulation and prediction, performance of experimental tests, analysis of data, falsification, developing conclusions, reporting results) and be able to use a sequence of those elements to solve a problem or test a hypothesis. Also, understand the limitations of any single scientific method (sequence of elements) in solving problems.
	10. Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data.
	12. Analyze situations and solve problems that require combining concepts from more than one topic area of science and applying these concepts.
ENVIRONMENTAL SCIENCE	
Content Standard	***Description of Standard***
Standard E.2: Environmental Systems	1. Understand and explain that human beings are part of Earth's ecosystems, and that human activities can, deliberately or inadvertently, alter ecosystems.
	2. Explain how environmental change in one part of the world can impact seemingly distant places and systems.
	5. Recognize and describe the role of natural resources in providing the raw materials for an industrial society.
	7. Identify specific tools and technologies used to adapt and alter environments and natural resources to meet human physical and cultural needs.
Standard E.6: Watershed and Wetlands	2. Describe the physical characteristics of wetlands and watersheds and explain how water flows into and through a watershed.
	6. Investigate and describe how point and nonpoint source pollution can affect the health of a bay's watershed and wetlands.
	7. Collect, record, and interpret data from physical, chemical, and biological sources to evaluate the health of the Chesapeake Bay watershed and wetlands, and describe how the Bay supports a wide variety of plant and animal life that interact with other living and nonliving things.
Standard E.8: Environmental Quality	1. Differentiate between natural pollution and pollution caused by humans, and give examples of each.
	2. Describe sources of air and water pollution, and explain how air and water quality impact wildlife, vegetation, and human health.

Maryland Core Learning Goals

ALL SUBJECTS
Goal 1: Skills and Processes

Content Standard	*Description of Standard*
Expectation 1.3	The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.
Expectation 1.4	The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.
Expectation 1.5	The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.
Expectation 1.6	The student will use mathematical processes.
Expectation 1.7	The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.

ENVIRONMENTAL SCIENCE
Goal 6

Content Standard	*Description of Standard*
Expectation 6.1	The student will explain how matter and energy move through the biosphere (lithosphere, hydrosphere, atmosphere and organisms).
Expectation 6.2	The student will investigate the interdependence of organisms within their biotic environment.
Expectation 6.3	The student will analyze the relationships between humans and the earth's resources.
Expectation 6.4	The student will develop and apply knowledge and skills gained from an environmental issue investigation to an action project which protects and sustains the environment.

CHEMISTRY
Goal 4

Content Standard	*Description of Standard*
Expectation 4.5	The student will explain that matter undergoes transformations, resulting in products that are different from the reactants.

Virginia Standards of Learning	
EARTH SCIENCE	
Content Standard	***Description of Standard***
ES.1	The student will plan and conduct investigations in which: • technologies, including computers, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions; • scales, diagrams, maps, charts, graphs, tables, and profiles are constructed and interpreted.
ES.3	The student will investigate and understand how to read and interpret maps, globes, models, charts, and imagery. Key concepts include: • maps (bathymetric, geologic, topographic, and weather) and star charts; • imagery (aerial photography and satellite images); • direction and distance measurements on any map or globe; and • location by latitude and longitude and topographic profiles.
ES.7	The student will investigate and understand the difference between renewable and nonrenewable resources. Key concepts, include: • dependence on freshwater resources and the affects of human usage on water quality.
BIOLOGY	
Content Standard	***Description of Standard***
BIO.3	The student will investigate and understand biochemical principles essential for life. Key concepts include: • water chemistry and its impact on life processes

Module Organizer

Mine Over Matter Activities		
Title	**Goal(s)**	**Materials List (per group)**
Pre-Field Study Activities		
All That Glitters	Convey the history of Prince William Forest Park and provide a framework for understanding acid mine drainage.	• Thaxton graphic "novel" download for students or read online • Pencil for completing the final frame • Instructor questions for activity assessment
A Look at Cabin Branch Mine: A Three-Part Lesson in Learning History Through Maps & Images	• To provide students with an opportunity to improve map reading skills • To provide students with a foundation for interpreting aerial images • To integrate information from these three different sources (political maps, topographic maps and aerial images) to get a better understanding of the cultural and physical history of Prince William Forest Park	For each group of 4 students, you will need: • Topographic map of Cabin Branch Pyrite Mine area of Prince William Forest Park • Political map of Prince William Forest Park • Enlargement of topographic map for the Powells Creek region of Prince William Forest Park • Cardboard for topographic map lesson option #1 • Plastic salad bar containers for topographic lesson option #2 (8 per group) • Washable or permanent markers for topo lesson #2 • 6 aerial images of the Cabin Branch Pyrite Mine area • Glue or other adhesive for the topographic map model • String for measuring trails
Field Study in Prince William Forest Park		
Pyrite Mine Reclamation Field Study	To assess current water quality of Quantico Creek as well as the soil quality in the vicinity of the former Cabin Branch Pyrite Mine by testing these environments upstream, downstream and within the reclamation area of the Cabin Branch Pyrite Mine site.	• Appropriate clothing • Adequate food and drink • All other are materials provided by BTW educators
Post-Field Study Classroom Activities		
Reflect on your visit to Prince William Forest Park	Get student feedback on what they experienced on the field study	Notebook and pencil/pen
Pyrite Mine Data Analysis	Compare data with groups which collected samples in other locations (up-stream/downstream/in the hot spots) to make some hypothesis about the different results achieved.	• Data sheets from field study • Notebook/paper for recording data and observations
New Visitor Center Environmental Impact Statement (EIS)	• Analyze and interpret information using a variety of maps, data from field study and parameters provided in EIS scenarios; • Understand the environmental and human impact of different land use decisions; • Develop and present the case for a land use decision	• Cover sheet detailing the assignment • A topographic map of Prince William Forest Park • Political map of Prince William Forest Park • Profiles of the various stakeholders • Most recent aerial/satellite image of the park • Large drawing paper so students can do a mock-up of their center • Background information (provided below) • Soil and water data from field study • Internet Access for additional research

Module Organizer for M.O.M.

This module is divided into three sections: activities completed prior to the park visit (Pre-Field Studies), activities conducted in the park, and the activities completed subsequent to the park visit (Post-Field Studies). In the Pre-Field study activities, students will examine the history of the Cabin Branch Pyrite Mine, and will become familiar with tools for assessing the impact of acid mine drainage on the soil and in Quantico Creek adjacent to the former mine site. In the field study, your students will collect authentic soil and water data in Prince William Forest Park. Back in the classroom, students will gather in their field study groups and, using the data collected by all of the groups, will prepare an environmental impact statement which addresses one of the scenarios proposed in the lesson.

Introduction to Mine Over Matter

Students don't usually think of science as being fodder for storytelling. So, *Mine Over Matter*, Bridging the Watershed's park specific curriculum highlighting Prince William Forest Park, might come as some surprise.

Depending on how it's written, the story of Prince William Forest Park could be about fair pay for a day's work or a business owner's right to fire everyone, lock the doors and walk away. It could be about racial integration in the workplace and segregation at quitting time. It could even be about soil and water ecology or recreation and tourism. It could focus on government regulations or using natural resources for building wealth.

While all these stories are touched on in the introductory activity, our goal with *Mine Over Matter* is to focus on the impact that the abrupt shut down of the Cabin Branch Pyrite Mine in 1920 continues to have today. This particular time in the park's history gives us a chance to explore the relationship between minerals and human wealth; it allows us to see how freshwater resources are influenced by geologic processes and human activity; and it gives students an opportunity to see how decisions made nearly 100 years ago continue to impact quality of life today.

Of course, in order to understand land use issues, the activities highlight map reading skills and provide opportunities for soil and water chemistry sampling and analysis.

Finally, we'll be presenting students with a scenario wherein they are asked to prepare and present an Environmental Impact Statement (EIS) about the development of a new visitor center at the park. While a new visitor center isn't in the works, the rigorous EIS process is one that national parks go through whenever they create new permanent structures within their boundaries.

And, while the lesson is mostly academic, the soil and water data that your students collect will, in fact, be forwarded to the biologists at Prince William Forest Park to assist them in monitoring the ongoing reclamation efforts along Quantico Creek.

We look forward to working with you and your students and invite any feedback on this curriculum.

All That Glitters:
Mining the Story of Prince William Forest Park… featuring Thaxton

E N G A G E M E N T

Pre-Field Study Classroom Activity

Goals:
To understand the cultural history and geology of Prince William Forest Park.

Class Time:
One Class period

Group Size:
Whole Class

Special Considerations:
We encourage you to print out copies of the graphic novel for each student. However, if you prefer, students can read it online.

Background Information:

Depending on how it's written, the story of Prince William Forest Park could be about fair pay for a day's work or a business owner's right to fire everyone, lock the doors and walk away. It could be about racial integration in the workplace and segregation at quitting time. It could even be about soil and water ecology or recreation and tourism. It could focus on government regulations or using natural resources for building wealth.

Prince William Forest Park is a remarkable little gem within a stone's throw of one of the world's most famous cities. It's remarkable not only for its beautiful scenery and vastness, but because of its rich history which mirrors human events over a long period of time. Our goal was to condense many stories of the park into a single class period.

So we enlisted the assistance of graphic designer, and Prince William Forest Park summer intern, Jesse Miller to help us tell this story in a compelling way. She, in turn, got some help from Thaxton, a rather animated cube of pyrite who has witnessed a lot of the events in the park.

We hope you will find this graphic novel a, well, novel way to learn about Prince William Forest Park. Keep your eyes peeled for some wonderful little touches that Jesse's added to make this history/chemistry/biology/ecology/business/civics lesson a little more playful.

Be forewarned: there is a surprise ending. It's so surprising; *we* don't even know what it is.

Of course, we've included a few questions so that you can see how well Thaxton gets his points across.

Procedure:

1. Have students read novel.
2. Have students finish the story, in one or more cels, to predict/suggest the mine site's future.
3. Lead class discussion of the mine and reclamation, and their suggested futures. Suggested questions and responses follow:

According to Thaxton …

Q: What is Pyrite?

A: Pyrite is sulfur and iron.

Q: List five of the jobs that men held in the mine and a brief description of each.

A: Drillers (bored holes for the dynamite), powdermen (carried and set the dynamite), muckers (loaded the ore in wagons and hauled it out of the mine), timbermen (built the wooden supports to keep the mine from caving in), and blasters (supervisors).

Q: What were the working conditions like?

A: Horrible. Men and boys would work 10-hour shifts, six days a week, in the mine. Explosions, from dynamite used to extract pyrite, were always a concern. Pay was roughly $4 a day, or $7 by today's standards.

Q: Why didn't they quit and get new jobs?

A: The mine was the only employment around. Also, some of the pay would come in the form of script or coupons, which could only be spent at the overpriced, company store. This was considered debt bondage.

Q: What are mine tailings, and why do they matter?

A: The stuff remaining after most of the ore had been extracted. At Cabin Branch, the tailings contained sulfur and iron. When exposed to air and water, they leach sulfuric acid into the creek.

Q: What was the Clean Water Act of 1977 all about?

A: In short, it required the testing of streams and rivers in the United States. This is when officials discovered acid running off the tailings had contaminated Quantico Creek.

Q: What is reclamation?

A: Reclamation is the process of making an environment habitable after it's been degraded.

Q: Describe some of the reclamation efforts at Cabin Branch

A: The reclamation efforts at Prince William Forest Park have included building a storm water conveyance, covering tailings with overburden, capping the mines, and revegetating the mine hillside.

A Look at Cabin Branch Mine:
Learning History through Maps & Images

E X P L O R A T I O N

Pre-Field Study Classroom Activity

Goals:
• Investigate and understand how to read and interpret a political map and a topographic map, and understand how to compare/ contrast aerial images.

• Integrate information from these three different sources to get a better understanding of the cultural and physical history of Prince William Forest Park.

Class Time:
30 minutes for the political map activity; 45 minutes for the topographic and aerial imagery activities

Group Size:
Whole Class

Background:

This lesson provides two map reading activities and an aerial photo activity designed to help students understand how the location of the Cabin Branch Mine contributed to the contamination of Quantico Creek, and how the results of the reclamation efforts can be observed. The first activity helps students understand how to interpret information on a political map. The second activity guides students through the process of interpreting information on a topographical map. Topography, the shape of the land, played a huge role in the acid mine runoff at Cabin Branch. Finally, the third activity, an exploration of aerial images taken over a span of seven decades, allows students to see how the field study area has changed.

If you find that your students need some supplementary information on map reading, the resources section of this module provides detailed information on understanding political maps, topographical maps and aerial imagery.

Materials:

This represents the materials list for all three subsections in the mapping activity. The specific list for each individual lesson will also precede that activity. Each group of students will need the following:

- Physical map of Cabin Branch Pyrite Mine area of Prince William Forest Park
- Political map of Prince William Forest Park
- Enlargement of black & white topographic map for the Powells Creek region of Prince William Forest Park for map lesson options #1 or #2
- Cardboard for topographic map lesson option #1
- Glue or other adhesive for the topographic map lesson option #1
- Plastic salad bar containers for topographic lesson option #2
- Washable or permanent markers for topo lesson #2
- Set of 6 aerial images of the Cabin Branch Pyrite Mine area

Prince William Forest Park Map: Let's Get Oriented

E X P L O R A T I O N

Post-Field Study Classroom Activity

Goal:
To interpret information on a political map.

Class Time:
30 minutes

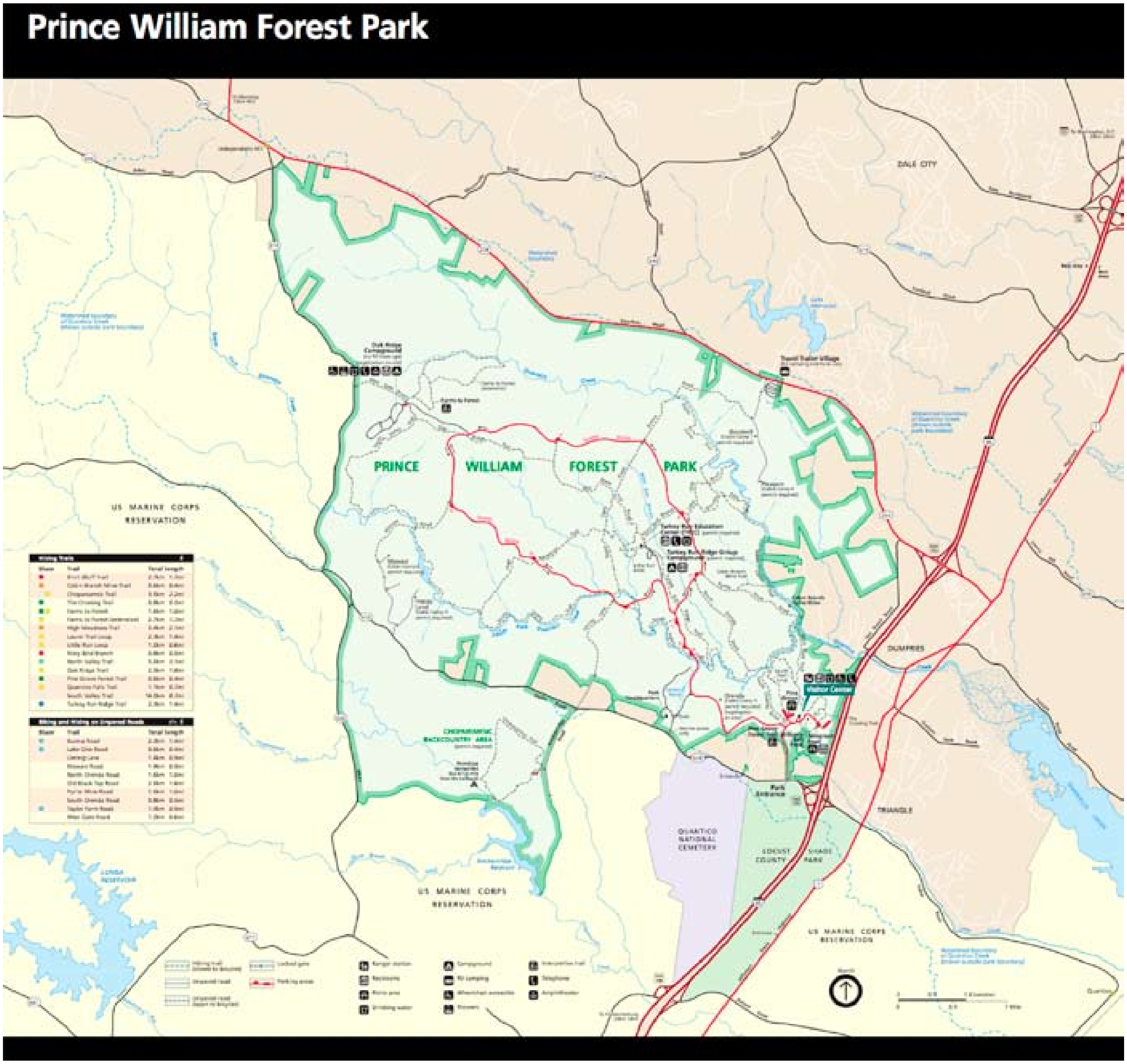
Group Size:
Whole Group

Materials List:
For each student, you'll need one copy of the National Park Service's Prince William Forest Park map, included in student booklet, and two small pieces of string (per student) for trail activity.

Map Activity #1

Procedure:

1. Provide students with maps and strings
2. Prompt students to find some basic information on their maps: legend, scale, etc.
3. Ask students to locate the following on their maps:
   - Visitor Center
   - Pyrite Mine Road
   - South Fork of Quantico Creek
   - Quantico Creek
   - Boundaries for the Quantico watershed.
4. Following the field study at Prince William Forest Park, if we have time we'll be walking back to the Visitor Center. The two choices are the Birch Bluff Trail and the Laurel Loop Trail. The legend indicates how long the trails are. However, if you didn't have that information, how could you determine how long the walk would be? (Students can lay strings along both trails and then stretch them out side-by-side to determine the longest trail.)
5. Later on, we will look at how activities in the park impact residents outside the park. Take a moment to identify towns that would be impacted by any development or hazardous runoff from within the park. Make a list of those.
6. Any sediment or contaminants that get introduced into a creek will, eventually, make their way into the larger bodies of water. Take a moment to look at the map of Prince William Forest Park and trace the path that contamination will take if it starts in Quantico Creek. This, by the way, is called a "watershed address." You first list the smallest body of water and then continue to the larger bodies to which that water drains.
7. Is there any information missing from this map that you think would be helpful for park visitors?


Prince William Forest Park
PRINCE
WILLIAM
FOREST
PARK
US MARINE CORPS RESERVATION
DALE CITY
DUMFRIES
TRIANGLE
QUANTICO NATIONAL CEMETERY
LOCUST SHADE COUNTY PARK
US MARINE CORPS RESERVATION
Visitor Center

How Topography Tells the Story

E X P L O R A T I O N

Post-Field Study Classroom Activity

Goal:
To have students create a 3-dimensional model from a 2-dimensional topographic map, and to understand how the shape and relief of the land can influence runoff into the Potomac River.

Class Time:
One 45-minute period for constructing each topographic model. Allow more time if your students aren't familiar with reading topographic maps. A basic lesson on topography is in the resource section of the module.

Group Size:
Groups of 4 students

Activities:
To demonstrate the different elevations shown on a two dimensional topographic map, you can construct a 3-dimensional model. This is particularly helpful for students who can't make the conceptual leap between contour lines and elevation. We provide two methods for model making.

Map Activity #2

Option #1: Corrugated Cardboard Topography Map

Purpose:

To make paper models that portray, in three dimensions, features represented by contour lines on a topographic map.

Materials List for Each Group:

- Corrugated cardboard
- Photocopy of the topographic map of the Powells Creek area of Prince William Forest Park. This area was selected because the contours are well defined and far enough apart for this particular exercise.
- Adhesive (glue or tape)
- Scissors

Procedure:

1. Place the photocopy on top of a piece of corrugated cardboard.
2. Carefully cut along the thick contour line representing the 250' elevation. To make this project a bit easier, just use the one long curving section of the 250' elevation and ignore the shorter 250' line segment. Label the center of the cardboard with a "1." This is the first level of the model that you will build.
3. Set aside that cardboard shape.
4. Place the photocopy of the map on top of another piece of cardboard and carefully cut around the next contour line. Label the center of the construction paper with a "2." This is the second level of your model.
5. Repeat this procedure until you have cut out all of the contour lines. Don't forget to label the layer with the appropriate number.
6. Now you are ready to build your 3-D model. Take layer number 2 and glue it onto the top of the first layer. If you'd like, you can also separate the layers with small squares of the cardboard. This gives the model dimension.
7. Repeat Step 6 with the rest of your layers until you have built your model.

Option #2: Plastic Food Container Topography Map[1]

Materials:

- Clear hinged 8in x 8in x 2in plastic clamshell salad containers. Make sure they are clean, have smooth (untextured) bottoms and are stackable. You need 8 containers for each group of two students. These can be purchased from a restaurant supply store, from a local restaurant, or online at http://www.bizrate.com/kitchensupplies_utensils/oid798396428.html. If you cut them at the hinge, the tops and bottoms can be used as separate sets.
- One marker for each group. If you don't use permanent markers, the containers are reusable.
- Photocopy of the topographic map of Powells Creek area of Prince William Forest Park.

Procedure:

1. Take one of the plastic containers. Position it on the topographic map so that the largest area is in the center of the container's bottom. Using a fine point marker, trace the contour of the lowest level, in this case the 250' contour.
2. Take another container and place it inside the first. This time, trace the contour line that shows the next highest elevation.
3. Take a third container and add it to the stack. Remove the bottom container and set it aside. (If you have too many containers together, it becomes difficult to see the contour lines on the map.) On this third container, trace the next highest elevation.
4. Nest a new container on the stack and remove the one on the bottom. (This one will become the top container on the other stack.) Trace the elevation. Continue on in this way, adding a container to the top and removing the one on the bottom, until you've completed all the elevations.
5. When you're done, stack all the containers in order, with the lowest elevation as the bottom of the stack and the highest elevation on top. Now you have a three-dimensional model showing the topography of the area around the mine.

Assessment:

1. Identify the landforms on your topographic maps (hills, valleys, basins).
2. Using the information on your topo map, guess how water would flow down the hill, in a major rainstorm.
3. Looking at the spacing of the contour lines, would you say that the slope is pretty even, from top to bottom? What distance, in elevation, does each contour line represent?

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[1]Decoste, Kim, ed. *It's Our Water: a Water Quality Curriculum for Earth/Environmental Science Classes in North Carolina*. Raleigh: The Environmental Education Fund, 2004. 43-45.

Eye in the Sky:
A Bird's Eye View of the History of Prince William Forest Park

E X P L O R A T I O N

Post-Field Study Classroom Activity

Aerial Imagery Activity #3

Background:

This concept of looking at the world from a bird's eye view brings us to another tool we'll be using to determine the pyrite mine's impact in Prince William Forest Park. Aerial photography, pictures from satellites or airplanes, records all visible features on the Earth's surface from an overhead perspective. It's remarkable to see a photo of the same area taken over a period of months, years or even decades. Pictures taken over a period of time can help you see how the landscape has changed and, in some instances, what has changed it. These images aren't maps and don't provide the written clues or keys available in topographic maps or road maps. Instead, understanding them relies on observational skills and the ability to identify features through photo interpretation.

Materials List:

- Information on aerial imagery found in the Resource Booklet
- Set of 6 photographs of Prince William Forest Park for each group of students

Procedure:

- If students aren't familiar with interpreting aerial imagery, walk them through the background information in the Resource Booklet. This provides a common vocabulary to use when assessing information in photographs of the pyrite mine area.
- Have each group work with the photographs provided, to determine the proper chronological sequence of the images. Students have six different pictures of the Cabin Branch Pyrite Mine, spanning from 1937 (when the Civilian Conservation Corps was building cabins and facilities for the Chopawamsic Recreational Demonstration Area) to a photo of the site today. Lay these out side-by-side and, using the information provided about aerial photography interpretation, determine a logical order for the photos — earliest to most recent.

Assessment:

- How does the tone change from photo to photo?
- What does the texture tell you about the effectiveness of the reclamation efforts?
- On one of the photos, you can see some straight lines fanning out across an open area, ends pointed toward the creek. Any guesses about what these are? Why are they here?
- What observations can you make about how Quantico Creek's path has changed over time?
- Make an estimate the percent of land cover from each photo?
- In which image would runoff pose the biggest problem (in terms of adding sediment to the creek, leaching contaminants from the soil into the creek and eroding the hillside)?

Photo #1

1937 Identifying characteristics include the huge swath of barren land stretching from the center to the northwest corner of the picture and the bleached white area continuing from the center to the southeast corner of the picture. The Pyrite Mine Road is clearly visible along the left side of the picture. Taken during spring or summer.

Photo #2

1954 You can still see the bright area without vegetation, but the one barren piece of land, which was so visible before, is now covered with evergreens. Picture taken sometime in the fall/winter, as the deciduous trees are bare. Area just downstream from the hillside is beginning see some reforestation.

Photo #3

1998 Again a late fall/winter photograph, judging by the canopy cover. You can see evidence of the mineshafts by the straight lines pointing down the hillside to Quantico Creek. Keep in mind that about this time trees had been planted (with marginal success due to flooding shortly after the trees went in the ground), the entire area seeded, mine shafts sealed and much of the area had been treated with lime and covered with topsoil. You can also see the curve of the diversion channel which moved storm water drainage away from the most contaminated hillside area.

Photo #4

2000 In this photo, you can see (if you're looking for it) the revegetation of the hillside. There's just a bit of texture to signal some ground cover moving in. You can also see some shadowing of the evergreens. This photo also gives us a good look at Quantico Creek.

Photo #5

2003 Mostly subtle differences from the photo three years ago, like the mine scars on the hillside appearing more muted. Historically, this was about the time a lime cap was added to the soil across from the hillside, and soil samples were being taken to determine the need for additional amendments. You can now see evidence of the boardwalk along the northeast side of the creek.

Photo #6

2008 All surface evidence of the mine is pretty obscured today. You can see evidence of the Virginia pines filling in along the hillside. The hotspot on the south side of the creek is beginning to fill in with vegetation as well. The diversion channel is less apparent as well.

Field Study in a National Park

You're in Charge of the Clean-Up

EXPLORATION

In a couple of days, your class will go to Prince William Forest National Park to conduct a series of field studies. They'll take water samples from the creek and soil samples from various areas around the site of the former Cabin Branch Mine, in order to assess the status of the reclamation efforts.

While they are doing their studies, we'd like them to keep the following questions in mind.

- Is the reclamation process having positive results? What information suggests that? If you don't think so, on what do you base your opinion?
- Can you see areas where the ground contamination might still be at elevated levels?
- What other information would you need to have to be able to scientifically determine the status of Quantico Creek and the surrounding mine area?
- Since most of the Quantico Creek Watershed is located within Prince William Forest Park, where will most of the stream impact be created? Does development have much of an impact on the creek?
- Other than soil and water tests, can you think of another way the park rangers might be able to determine the health of Prince William Forest Park? (Think food chains and food webs.)

Visit the Parks

Plan Wisely for Your Students' Field Study in the Park

Goal:

To help students plan and prepare for their field study in a national park.

Background Information:

It is crucial that all students be prepared for the field study in the park. For many students, working outdoors will be an unusual and challenging experience. The information in this section should be reviewed carefully with the class to help them prepare mentally for the field study and to ensure that they have the appropriate dress and supplies to be successful in the park. It may be beneficial to review this information several times before the park visit to be sure all students understand the required preparations and plan well for their visit.

Before the trip to a park, review the information about the field study in the Student Booklet and the Resource Booklet.

Be Prepared for Your Visit:

Students need to be *dressed appropriately* and have *adequate food and drink*. Expensive clothes and shoes are not appropriate for work in the out-of-doors, and wearing these expensive items makes students reluctant to engage in field studies. Advise students not to wear skirts, shoes with high heels, or sandals.

The BTW educator will have all the other supplies for the field study activities. Students do not need to bring Student Booklets, Resource Booklets, or data collection sheets; all materials will be available in the park.

Park Information:

Students can review information about the park on the *Bridging the Watershed* web site at www.fergusonfoundation.org to gain an understanding of the park's location and other pertinent information.

Prince William Forest Park
Soil And Water Data Collection

E L A B O R A T I O N

Field Study in a National Park

Goal:
To collect water and soil chemistry data from various sites in Prince William Forest Park, and to determine lingering impact of acid mine drainage from Cabin Branch pyrite mine.

Class Time:
Field study will be completed in a single visit to Prince William Forest Park.

Group Size:
Students will be divided into groups of 4 to conduct soil and water tests.

Procedure:

1. Work in assigned groups to complete data collection in the park. One person will record for the group.
2. Complete the Park Observation Sheet. Sketch the study site. Include any features of the landscape that may affect your findings.

Students will use the Prince William Forest Park Pyrite Mine Reclamation Field Study Data Sheet to assess the stream and soil quality. Your Educator and Ranger in the field will provide directions and assistance you need to complete this activity.

Pyrite Mine Data Analysis

E L A B O R A T I O N

Post-Field Study Classroom Activity

Goals:
To determine the relative health of the ecosystem at the Cabin Branch pyrite mine, and to explore the success of the Cabin Branch pyrite mine reclamation.

Class Time:
90 minutes

Group Size:
Same as field study group (3–4 students)

Materials list for each group:
Data Sheet

Procedure:

1. Each person should copy the recorder's data from their field study data sheet into a personal copy of the field study data sheet.
2. Record data from all the groups in the class data sheet.
3. Each group will use the class data to prepare a report with conclusions about the success of the reclamation effort. Begin the report by defining the study area and weather conditions using data from the field study data sheet.

Questions for class discussion:

Q: Compare your findings to the 'acceptable' range for that parameter: did you find higher or lower levels?

A: Answers will vary. pH in the soils at the site is typically much lower than considered acceptable, due to leaching from the mine. Levels in the water will be closer to acceptable, because the soil's impact is diluted by the runoff diversions channels. Water quality downstream of the mine site should show more of an impact than the upstream findings.

Q: Why do you think your water quality findings upstream of the mine site might be different than the results from the downstream site?

A: Most of the water that would run through and over the mine site, picking up the metals and nutrients in the soil and bringing them into the stream, is diverted in channels built in a u-shape around the mine site. However, whenever a rain event occurs, rain (or other precipitation) falls directly onto the soils affected by the mine, and causes runoff into the stream. This is called acid mine drainage. The difference in upstream and downstream results will be most pronounced after a heavy rain. The effects of runoff from the mine site may be difficult to see during a dry spell.

Q: Compare your finding for the soil to your finding for the water. Which is higher? Are both either higher or lower relative to their acceptable range?

A: Answers will vary. Again, water quality results are expected to be less dramatic than soil findings because the stream runs for miles upstream of the mine site and has numerous other inputs.

Q: Based on what you have found, and your comparisons to acceptable ranges, what do you think of the quality of the water and soil?

A: Answers will vary.

Q: What did you notice about plants growing in the mine reclamation area? What does this suggest to you about the soil quality and/or the levels of the various parameters in the soil? Does this make sense, based on your findings?

A: There is little diversity in the mine area. There is some colonization by Virginia pines, which are very acid-tolerant, making them well-suited to be pioneers in the area. Other acid-tolerant species, such as cedar trees, have been planted. Sericea lespedeza, an invasive plant, is also rather abundant. It is also very tolerant of acidic soils.[2] The lack of other species that are seen in other parts of the park (even at the top of the hill) is due to the total die-off caused by the acid mine drainage.

Q: Overall, how successful would you say the reclamation has been?

A: Answers will vary. Vegetation has returned to a significant portion of the slope where the mine was based, but it is just Virginia pine, not the hardwood forests typical of the area. Water quality results may not seem as dramatically unacceptable as you would expect in a 'contaminated' area, but this is very dependent on the recent weather. A heavy rain causes a big flush of the contaminants to enter the stream, but these higher levels pass downstream quickly.

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[2] http://plants.usda.gov/factsheet/pdf/fs_lecu.pdf accessed on 5/27/08. USDA Natural Resources Conservation Service. *Plant Fact Sheet: Chinese Lespedeza*.

Prince William Forest Park
New Visitor Center
Environmental Impact Statement

E V A L U A T I O N

Post-Field Study Classroom Activity

Goals:
• Analyze and interpret information using a variety of maps
• Understand the environmental and human impact of different land use decisions
• Develop and present the case for a land use decision.

Class Time:
Three Class Periods

Group Size:
Whole Class

Suggested Level:
High School

Materials:

One information packet for each of the four groups. Each packet will include:

- Cover sheet detailing the assignment
- A topographic map of Prince William Forest Park
- Political map of Prince William Forest Park
- Profiles of the various stakeholders
- Most recent aerial/satellite image of the park
- Large drawing paper so students can do a mock-up of their center
- Background information (provided below)
- Soil and water data from field study

Internet access:

The National Park Service has some fabulous cultural and natural history resources on the Prince William Forest Park website. These can be accessed at http://www.nps.gov/prwi/. The narratives are well written and are accompanied by great photographs. Some students may choose to use these in their presentations. Of course, they might also need to research additional data, from the number of parking places needed for a new venue to restrictions on archeologically sensitive area.

Background:

The increasing popularity of Prince William Forest National Park is placing a strain on the park's small visitor center. While the exhibits provide basic information about the park's cultural history, surveys indicate that visitors want to know more about the Cabin Branch Mine and the company towns of Batestown and Hickory Ridge, the park's history as a top secret military installation where the Office of Strategic Services operated training schools in World War II, its development for the Chopawamsic Recreation Demonstration Area, as well as the rich natural history of the park.

The National Park Service (NPS) is considering building a new visitor center. Ideally, it would be built on the hillside where the operations for the Cabin Branch mine were located. The new Prince William Forest Park Visitor Center and Museum would include displays for all of its artifacts, a research lab for ongoing archeological studies, a theater for multimedia presentations showing films about the park's history, offices for park staff, and a bookstore.

But the first choice may not be the best. Before the NPS gets to put a shovel in the ground, it must prepare an environmental impact statement or EIS. An EIS is a document that provides information about the reason and justification for a project, the proposed plans, and potential environmental effects that construction, increased traffic, and noise (to name a few) will have on water and soil quality, wildlife and vegetation. An EIS analyzes not just the agency's first choice of action (in this case, a specific design and location of the new visitor center), but also a few alternatives to the project including "no action," which is, as it suggests, an option not to build a center.

Creating an EIS is required as part of the National Environmental Policy Act (NEPA). Before an EIS can become final, it must be shared with communities for a public comment period. Any interested member of the public can share feedback with NPS on the project, and have that input considered in the final EIS.[3]

The park supervisor and the regional director for the National Capital Area region of the National Park Service will make the final decision. You may want to assign students to these roles, or bring in other faculty — or members of the community — to perform this function.

Procedures:

1. In advance, prepare one packet for each of the groups,[4] each one containing:

    • Cover letter describing the group's task

    • A topographic map of Prince William Forest Park

    • Political map of Prince William Forest Park

    • Profiles of the various stakeholders

    • Most recent aerial/satellite image of the park

    • Large drawing paper so students can do a mock-up of their center

    • Background information (provided below)

    • Soil and water data from field study (the data from all of the water and soil tests sites should be shared among the students)

    • If your class had an opportunity to do benthic macroinvertebrate studies, this data should be shared as well.

2. Have the students read through the scenario for the Environmental Impact Statement.

3. You might walk them through the maps, particularly the topographic map, so they can spot the location of the current visitor center. For the groups recommending a new site, this will help them identify suitable sites for a new center.

4. Tell students that they will be dividing into four groups, each group taking on one of the options for the Prince William Forest Park's new visitor center. The groups will have to defend the position assigned to them. These are:

    a) to build on the top of the hill, which was the actual site of the Cabin Branch Pyrite Mine operation;

    b) to build on a different site in the park;

    c) to build a new center on the existing visitor center site; and

    d) take no action.

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[3] Council on Environmental Quality, Executive Office of the President. *A Citizen's Guide to the NEPA: Having Your Voice Heard*. http://www.nepa.gov/nepa/Citizens_Guide_Dec07.pdf.

[4] If you have more than four groups, you can provide two groups with a given scenario.

Regardless of which argument they are asked to make, they will need to do research to defend their position during the public comment period.

5. Provide students with enough time to work through the implications of the task at hand. If they don't know where to begin, have them start with the National Park Service's need for more display/interpretive/research space for Prince William Forest Park. What do they really need? What does location have to do with telling the many stories of the park? What would the park have to give up in order to create a better space for visitors? For the group charged with no action, they will still need to go through the exercise in order to determine why new construction is ill-advised.

6. Once they consider the brick and mortar questions, then they need to think like stakeholders. How will this project effect these individuals and their interests? Have them reread the profiles and come up with some research questions.

7. Students will then be asked to present their position to the group. Encourage the students to anticipate arguments to their presentation. There are always groups at these meetings who will be quite vocal in their disagreement with proposals to change the status quo. And, remind students that some people learn best through visuals, so if they can intersperse oral presentations with some photos and diagrams (either presented on a screen or simply passed around the room), that would reinforce a compelling argument. Suggest that the class invite individuals to serve as members of a panel who will make a recommendation to the EPA.

8. After all the presentations are made, allow time for students to comment on the lesson, and provide some feedback on which ideas were most promising, which ones failed to address certain environmental concerns and even how they might like to modify the lesson to be more relevant.