

WATERSHED WONDERINGS
AND WANDERINGS

A 5-Day Curriculum

By Stephanie Bohr

Intended for use with the

NC Museum of Natural Science's Girls in Science Club

Introduction

Intended audience

The Girls in Science Neuse River Project is an intensive eight-week watershed education program at the North Carolina Museum of Natural Sciences. Eight weekly meetings are held at the Museum after school. A Saturday afternoon field trip and overnight camping trip are held on two weekends at Museum and community field sites. The twelve 6th grade participants perform hands-on activities, study water quality in the Neuse River Basin, explore science-based careers, interact with female science mentors, and take field trips, including an overnight experience. The Neuse River project targets local gifted students in Wake County. The Museum also coordinates other Girls in Science clubs in underserved rural schools in eastern North Carolina.

This particular lesson plan would target five of the eight weekly meetings, beginning the second week of the program. The first week's meeting defines and explores the concept of watersheds and their abiotic and biotic components. Each meeting is designed to be three hours in length.

Focus

The focus of the Girls in Science club is the local watershed. Throughout the club's duration, participants explore the science and inhabitants of local aquatic ecosystems, as well as human impacts on the overall watershed system.

Rationale

The study of watersheds provides ample opportunity to address all five Tbilisi objectives towards which environmental educators strive: awareness, knowledge, attitudes, skills, and participation. This lesson series invokes awareness through outdoor field studies, journaling, and an examination of human impacts on the watershed system. Knowledge includes macroinvertebrate identification, invertebrate life cycles, point versus non-point source pollution, and abiotic factors that affect aquatic organisms' survival. By testing for pollution and observing its effects first-hand, student attitudes towards environmental stewardship improve. Adherence to the scientific method, oral and written communication, group work, critical thinking, and problem solving are among the many skills that participants develop. Perhaps most importantly, students learn how to responsibly assess environmental situations and develop and implement action plans towards a feasible and positive solution. They also learn the value of public education efforts and cooperation.

Watersheds allow for the discussion of physics, chemistry, and biology, as well as mathematics, language, and visual arts. The watershed framework is convenient and exciting for any educator wishing to address numerous Environmental Education Learner Guidelines, as well as state curriculum standards.

Environmental Education Learner Guidelines

This lesson series meets numerous guidelines of all four strands of the Environmental Education (EE) Learner Guidelines. The participants of this program are 6th grade students, so all guidelines mentioned are from the Guidelines for the Eighth Grade. Following is a list of all EE Learner Guidelines targeted over the five days. Included in each day's narrative are the guidelines specific to that day's activities.

- 1 A) Questioning
 - 1 B) Designing investigations
 - 1 C) Collecting information
 - 1 D) Evaluating accuracy and reliability
 - 1 E) Organizing information
 - 1 G) Drawing conclusions and developing explanations
-
- 2.2 A) Organisms, populations, and communities
 - 2.2 C) Systems and connections
 - 2.3 C) Political and economic systems
 - 2.3 E) Change and conflict
 - 2.4 A) Human/environment interactions
 - 2.4 E) Environmental issues
-
- 3.1 A) Identifying and investigating issues
 - 3.1 B) Sorting out the consequences of issues
 - 3.1 C) Identifying and evaluating alternative solutions and courses of action
 - 3.1 D) Working with flexibility, creativity, and openness
 - 3.2 A) Forming and evaluating personal views
 - 3.2 B) Evaluating the need for citizen action
 - 3.2 C) Planning and taking action
 - 3.2 D) Evaluating the results of actions
-
- 4 A) Understanding societal values and principles
 - 4 B) Recognizing citizens' rights and responsibilities
 - 4 C) Recognizing efficacy
 - 4 D) Accepting personal responsibility

Learner Outcomes

Following is a list of all of the learner outcomes targeted by this five-day lesson series. At the end of each day's narrative is a chart listing that day's desired learner outcomes. Each outcome is matched with a corresponding formative assessment for the day's activities. Each day's activities also contribute knowledge and skills towards the summative assessment (a children's book).

By the end of the lesson, Girls in Science participants will be able to . . .

1. Correctly identify eight common stream macroinvertebrates using a dichotomous key.

2. Describe the life cycle and identifying characteristics of their expert species.
3. Distinguish three sources and three effects of point source pollution from three sources and three effects of non-point source pollution.
4. Design an investigation of local stream water quality using macroinvertebrates as indicators.
5. Demonstrate data collection skills appropriate for biological, chemical, and physical water quality data.
6. Accurately record data.
7. Observe and describe a natural site in a meaningful way.
8. Connect surrounding environmental conditions with stream water quality.
9. Compare student-generated data to scientific water quality indices.
10. Analyze data using mathematics.
11. Explain how chemical and physical variables impact one another and local biota.
12. Conclude water quality of a local stream based on biological, chemical, and physical data.
13. Evaluate own experimental design, data collection procedures, and analysis.
14. Assess the need for an action plan based on student-generated data.
15. Formulate an action plan to improve water quality.
16. Assess action plan proposals.
17. Responsibly decide whether or not to implement an action plan.

Assessment

Girls in Science is an informal museum program, so grades and points are not given out. Therefore, most assessments are in the form of verbal and visual journal entries and participation in club discussions and activities. This five-day lesson series is assessed with two summative tasks: a journal and a children's book.

Journal

Each journal entry provides formative insight into the impact of a day's lesson. As a summative assessment, entries provide a record of the entire experience. The journals include ecological concepts, data collection procedures, data, calculations, analysis, conclusions, nature observation, proposed solutions, critiques, changes in perspective, personal thoughts and impressions, and connections between acquired knowledge in the club and previous experiences. The journals are invaluable reference tools for the girls to evaluate where their knowledge, awareness, attitudes, skills, and personal responsibility stood at each step of the program. In addition to general note-taking and answering questions and prompts, the journals include a daily Rose Reflection. This format allows for individual reflection on personal growth and changes in perspective and comfort zones. I developed this simple and quick format to ensure that every meeting concluded with thoughtful and quiet reflection:

Leaf- How I can share what I learned with others



Bud- Favorite part of the day

Thorn- Least favorite part of day

Stem- How my knowledge grew today

While each day's entry may be formative, as a complete collection of the club experience, the journal serves as a valuable summative assessment. The creation of a learning log or journal also meets numerous objectives from the North Carolina Standard Course of Study (NCSCS) for the 6th grade. All state standards presented throughout this document are from the 6th grade NCSCS.

Visual Arts 1.06- Develop perceptual awareness through the use of all senses

Visual Arts 4.03- Interpret the environment with realistic imagery

Language Arts 1.02- Create a learning log or journal.

Language Arts 1.04- Reflect on learning experiences by describing personal learning growth and changes in perspective, identifying changes in self throughout the learning process, interpreting how personal circumstances and background shape interaction

Information Skills 3.05- Describe how information and ideas are influenced by prior knowledge, personal experience, and social, cultural, political, economic, and historical events.

Children's Book

The creation of an illustrated children's book is a culminating project that incorporates new knowledge, skills, attitudes, awareness, and participation experiences. Each day's activities contribute to the story line. For each day's connection to this summative assignment, please see the "Contribution to Summative Assessment Plan" section on each day's narrative. This activity allows for reflection, research, connections, and participation in community environmental education. Following is the project prompt that participants receive:

You are to create an illustrated children's' book about your expert macroinvertebrate (remember that critter on your back?). The macroinvertebrate will be your main character. The book should include topics covered throughout this unit, including, but not limited to:

1. What the animal looks like
2. The animal's life cycle
3. What it needs to survive
4. What human actions threaten its survival
5. What its habitat looks like
6. Neighbors in the stream and/or on the banks
7. What happens to the animal and its home when the stream is polluted
8. What the reader can do to help the main character and its stream home

Your story can be fictional, but the facts *must* be accurate. Additional research may be required.

After you finish writing and illustrating your book, you will read your story to a younger class at your school. To practice for this story time, you will be able to read to each other at the final club meeting. Your children's books will also be on display at the club's Open House for the museum staff, your family, teachers, and school administrators.

Thus, the creation and sharing of your book will serve as an education project for the local community.

DAY 1: Meeting Macroinvertebrates

Activities

Hour 1: Macro what?

Guest expert: NC Museum of Natural Sciences' Curator of Invertebrates

The curator leads an adaptation of the Project Learning Tree activity "Can It Be Real?" Instead of the guide's examples, the curator reads descriptions of extreme behavior or adaptations exhibited by local stream macroinvertebrates. Students guess if the animals described are real or fictitious. After eight animals are described (half of which are real, the other half fictitious), the curator reveals the answers.

Next, the curator presents a slide show of the actual organisms, as well as other local stream macroinvertebrates. In addition to defining the term macroinvertebrate, he presents identifying characteristics and life history information for each species. The slide presentation is supplemented with both live and preserved specimens.

Hour 2: Key to Success

Present students with a standard table setting. Guide the class in creating a dichotomous key for a spoon, fork, knife, plate, glass, and napkin. Students will learn how to create guiding questions with only two options, until all objects are narrowed to a specific identification.

Hand out the stream macroinvertebrate dichotomous keys that will be used as a reference on the field trip. Divide the students into pairs. Each pair receives representations (live, preserved, or photographed) of eight local stream macroinvertebrates. Using the provided keys, students try to identify all eight of the organisms.

Hour 3: Mac Attack!

Place one photograph or drawing of a stream macroinvertebrate on each student's back. Students circulate around the room, asking only yes/no questions about the appearance and behavior of the organism on their back. Once all participants have identified their macroinvertebrate, inform the students that the organism on their back is their "expert critter." They are in charge of researching this animal and should be able to share the animal's life history and key identifying characteristics with the class.

Homework (Journal): Macro maturation

For homework, students will write a poem about their expert specie's life cycle. They must also create an art piece representing the animal and its identifying characteristics through all life stages (collage, photograph, drawing, model, etc.). Students should be prepared to present their poem and art to the club the following week.

Following each club meeting, students complete a Rose Reflection in their journals. This format allows students to reflect on their learning experiences for the day:



Bud- Favorite part of the day

Leaf- How I can share what I learned with others

Thorn- Least favorite part of day

Stem- How my knowledge grew today

Learner Outcomes	Formative Assessment
By the end of the lesson, Girls in Science participants will be able to . . .	This outcome will be demonstrated by . . .
1. Correctly identify eight common stream macroinvertebrates using a dichotomous key.	- Correct identification of eight specimens using the dichotomous keys - Correct identification of their animal and accurate clues for other participants in <i>Mac Attack</i>
2. Describe the life cycle and identifying characteristics of their expert species.	- Poem explaining life cycle - Art piece depicting animal and its identifying traits in all life stages

Tbilisi Objectives Awareness, attitude, knowledge, skills

EE Learner Guidelines

2.2 A) Organisms, populations, and communities

State Standards

All standards listed throughout are from the North Carolina Standard Course of Study for 6th grade

Science 7.01- Describe ways in which organisms interact with each other and with non-living parts of the environment.

Science 7.06- Investigate processes which, operating over long periods of time, have resulted in the diversity of plant and animal life present today (natural selection, adaptation)

Visual Arts 1.01- Plan and organize for creating art

Visual Arts 1.02- Explore strategies for imagining and implementing images

Visual Arts 4.03- Interpret the environment with realistic imagery

Language Arts 2.01- Explore informational materials by restating and summarizing information, determining the importance and accuracy of information, making

connections between works, self, and related topics/information, comparing and/or contrasting information, drawing inferences and conclusions.

Information Skills 1.08- Select and use independently a variety of resources and formats

Information Skills 1.09- Recognize that ideas are produced in a variety of formats

Community Resources

Museum Curator of Invertebrates, Museum specimen collection, live specimens from community stream

Contribution to Summative Assessment Plan (children's book)

What the animal looks like, the life cycle of the organism

Sources

American Forest Foundation. "Can It Be Real?" Project Learning Tree: Environmental Education PreK-8 Activity Guide. 2003.

Murdoch, T., ed. and M. Cheo, ed. The Streamkeeper's Field Guide. 1991. Adopt-A-Stream Foundation.

University of Wisconsin-Extension and Wisconsin Department of Natural Resources. "Key to Life in the Pond." Based on a key developed by Riveredge Nature Center, Newburg, WI.

Wallace, Marianne. "What's Under Those Rocks?" *Wildlife in North Carolina*. September 2002.

DAY 2: What's in a Watershed?

Activities

Hour 1:

Homework Share Time

30 min- Students share their poem and art depicting their expert critter's life cycle and identifying characteristics at all life stages.

Pollution Problems

10 min- As a class, create a list of conditions that stream macroinvertebrates need to survive (clean water, dissolved oxygen, shelter, food, etc.). Predict what might happen to the animals if those necessities were compromised.

20 min- *Who Polluted the Potomac?* From Population Connection

Before class, prepare and label film canisters with the following ingredients:

Construction site: ½ tsp. dry clay soil

Trees: dry, crumbled leaves

Family picnic: assorted litter

People fishing: tangle of fishing lines

Farmer: ¼ tsp. baking powder

Barnyard: ½ tsp. cold coffee

Homeowner: full canister of diluted yellow food coloring and toilet paper

Coal mine: ¼ canister vinegar

Electricity plant: ¼ canister vinegar

Commuters: ¼ canister vinegar + couple of drops of vegetable oil

Gardeners: ¼ tsp. baking soda

Antifreeze: 1 tsp. of blue/green food coloring

Washing the car: ½ canister soapy water

Motorboat: 1/8 tsp. vegetable oil

Beach party: assorted litter

Mystery liquid: 1/8 tsp diluted red food coloring

Fill a clear gallon jar nearly to the top with water. Give each student a canister until all canisters are distributed. Instruct students to not open their canisters or reveal the labels on their canisters. Explain that you are going to tell a story, and when they hear the name of the character on their canister, they should pour the contents into the jar of water, which represents the river. Read the story included in "Who Polluted the Potomac?," changing the name of the river and cities to Neuse and Raleigh.

Ask students for their observations on how water quality changed. Discuss how these pollutants would affect the abiotic factors that stream macroinvertebrates depend on. Ask students to write down a list of all pollutants from the story to be used in the homework assignment.

Hour 2: Neuse Nuisances

*Guest speaker from NC State University's Water Resources Research Institute

The professor gives a presentation of current research methods and findings on pollutants of the Neuse River. In addition to an electronic slideshow with photographs, charts, tables, graphs, and key points, water samples and specimens are provided. The presentation includes:

1. Definitions of point and non-point source pollution and explanation of their impacts on water quality and stream organisms
2. Discussion of local threats to water quality, such as eutrophication and *Pfisteria*
3. Research design and methods
4. Explanation of additional variables affecting stream life, including pH, dissolved oxygen, phosphate and nitrate concentrations, and turbidity. The professor will use examples from university research to illustrate how changes in these variables may impact stream biota.
5. Hands-on demonstration of sampling techniques for abiotic variables, as well as macroinvertebrates.

Hour 3:

30 min-“Macroinvertebrate Mayhem” from Project WET

By having students move with varying degrees of freedom in accordance with their level of pollution tolerance, this activity demonstrates the concept of biotic classes of stream organisms, and that tolerance to environmental conditions differs among stream macroinvertebrates. This concept is central to understanding the water quality indices that will be used to analyze stream fieldtrip data. This activity also illustrates how diversity and abundance provide clues to water quality.

30 min- Based on the information from the presentation and *Macroinvertebrate Mayhem*, students now get to design their own research project. As a club, students develop an experimental design using stream macroinvertebrates to assess water quality.

Explain that students will have access to sampling nets for macroinvertebrates, chemical testing kits for phosphates, nitrates, pH, dissolved oxygen, and temperature, and equipment for measuring flow, turbidity, depth, and width. Using what they have learned, guide students to:

-develop a hypothesis relating diversity and number of stream macroinvertebrates to abiotic factors like pH, phosphate, nitrates, temperature, dissolved oxygen, flow, and turbidity (i.e., if abiotic factors are poor, the number and diversity of stream organisms will be low)

-define the dependent (organisms) and independent variables (abiotic factors) in their design

-devise sampling techniques of macroinvertebrates (D-nets, aquarium nets, kick nets)

-decide how to measure independent variables (chemical testing kits, neon ping pong balls, secchi discs)

-ensure experiment can be replicated

-determine how experiment will demonstrate if dependent variables are related to independent variables (biotic and water quality indices)

Typically, students come up with this general experimental design on their own. Since sampling equipment, data sheets, and indices are pre-made, some facilitation may be necessary to ensure student design can be implemented with the resources available. The overall experimental design and answers to the above questions must be recorded in each student’s journal for reference on the field trip.

Homework (journal):

Rose reflection

Journal prompt: Review the list of pollutants from the story about the Neuse River. For each pollutant, mark whether it is point or non-point pollution. Select three examples from the list for each type of pollution (6 total). In 5-6 sentences each, predict the possible effects on the macroinvertebrates living in a stream with these pollutants.

<i>Learner Outcomes</i>	<i>Formative Assessment</i>
By the end of the lesson, Girls in Science participants will be able to . . .	This outcome will be demonstrated by . . .
1. Distinguish three sources and three effects of point source pollution from three sources and three effects of non-point source pollution.	- Accurate identification of point and non-point pollution types on the story list - Appropriate journal response to prompt
2. Design an investigation of local stream water quality using macroinvertebrates as indicators.	- Participation in group discussion - Journal entry detailing experimental design and answers to design questions

Tbilisi Objectives Knowledge, attitude, awareness, skills

EE Learner Guidelines

- 1 A) Questioning
- 1 B) Designing investigations
- 2.2 C) Systems and connections
- 2.4 A) Human/environment interactions
- 2.4 E) Environmental Issues
- 3.1 A) Identifying and investigating issues
- 3.1 B) Sorting out the consequences of issues
- 4 D) Accepting personal responsibility

State Standards

Science 1.01- Identify and create questions and hypotheses that can be answered through scientific investigations.

Science 1.02- Develop appropriate experimental procedures for given questions and student generated questions.

Science 1.04- Analyze variables in scientific investigations.

Science 3.06- Evaluate ways in which human activities have affected Earth’s pedosphere and the measures taken to control the impact

Science 3.08- Conclude that the health of environments and organisms requires monitoring the pedosphere, taking steps to maintain soil quality, and stewardship.

Science 7.01- Describe ways in which organisms interact with each other and with non-living parts of the environment

Science 7.02- Investigate factors that determine the growth and survival of organisms including light, temperature range, mineral availability, soil/rock type, water, and energy

Science 7.03- Explain how changes in habitat may affect organisms

Healthful Living 3.03- Describe individual behaviors that can harm or help the health of the environment

Language Arts 1.03- Interact appropriately in group settings by listening attentively, showing empathy, contributing relevant comments connecting personal experiences to content, and monitoring own understanding of the discussion and seeking clarification as needed.

Community Resources

NC State University professor from Water Resources Research Institute

Contribution to Summative Assessment Plan (children's book)

What the organism needs to survive, what human actions threaten that survival

Sources

Population Connection. "Who Polluted the Potomac?"

www.populationconnecton.org/education.

The Watercourse and Council for Environmental Education. "Macroinvertebrate Mayhem." Project WET: K-12 Curriculum and Activity Guide. 2000.

DAY 3: Let's Get WET!

Activities

30 minutes: Transportation to first stream site

30 minutes: Allow students to individually journal (verbally and visually) their overall impression of the stream site. Prompt them to observe weather, shade, trash, color and movement of water, odor of water, landscape, surrounding area draining into stream, terrestrial animals near stream, etc.

30 minutes: Go over safety procedures, areas to avoid, and stream etiquette, both for each other and the natural environment. Put on waders, gloves, and goggles where appropriate. Allow participants to practice with sampling equipment on land before sending them into the stream. Include time for questions.

1 hour:

Students work in three teams to complete data collection. Groups rotate through three data stations: biological, chemical, and physical. Students work as a group to accurately collect data at each station, with a museum educator at each station to assist. Each group spends twenty minutes at each station.

Biological: Students use D-nets, aquarium nets, and kick nets to sample the stream's macroinvertebrate populations. Provide dichotomous keys and field guides to aid with identification of each animal collected. Each group completes a data sheet listing what species are found and how many of each species.

Chemical: Students use a GREEN (Global Rivers Environmental Education Network) Introductory Water Quality Monitoring Kit to measure water temperature, pH, dissolved oxygen, and phosphate and nitrate concentrations.

Physical: Students use a secchi disc, neon ping pong ball, thermometer, and measuring tape to gather data on stream temperature, width and depth, clarity, flow, and volume.

30 minutes: Transportation back to Museum from stream site.

Homework:

Rose journal entry

<i>Learner Outcomes</i>	<i>Formative Assessment</i>
By the end of the lesson, Girls in Science participants will be able to . . .	This outcome will be demonstrated by . . .
1. Demonstrate data collection skills appropriate for biological, chemical, and physical water quality data.	- Participation at stations (judged by museum staff at each station) - Complete and accurate data sheets
2. Accurately record data.	- Complete and accurate data sheets
3. Observe and describe a natural site in a meaningful way.	- Rose journal entries - Written and visual observations of stream site

Tbilisi Objectives Skills, knowledge, participation

EE Learner Guidelines

- 1 C) Collecting information
- 2 A) Organisms, populations, and communities
- 2 C) Systems and connections

State Standards

Science 1.03- Apply safety procedures in laboratory and field studies (recognize potential hazards, manipulate materials and equipment, and conduct appropriate procedures)

Science 1.04- Analyze variables in scientific investigations

Science 7.02- Investigate factors that determine the growth and survival of organisms including light, temperature range, mineral availability, soil/rock type, water, and energy

Visual Arts 1.06- Develop perceptual awareness through the use of all senses

Visual Arts 3.01- Recognize and discuss the elements and principles found in the environment

Visual Arts 4.03- Interpret the environment with realistic imagery

Language Arts 1.02- Generating a learning log or journal

Language Arts 1.03- Interact appropriately in group settings by listening attentively, showing empathy, contributing relevant comments connecting personal experiences to content, and monitoring own understanding of the discussion and seeking clarification as needed

Language Arts 1.04- Reflect on learning experiences

Community Resources

Local stream site in downtown or suburban Raleigh

Contribution to Summative Assessment Plan (*children's book*)

What habitat looks like, stream neighbors, inspiration for book illustrations

Sources

GREEN (Global Rivers Environmental Education Network) Introductory Water Quality Monitoring Kit. Kit materials, instructions, and background information. Ordered from www.acornnaturalists.com

Murdoch, T., ed. and M. Cheo, ed. The Streamkeeper's Field Guide. 1991. Adopt-A-Stream Foundation.

University of Wisconsin-Extension and Wisconsin Department of Natural Resources. "Key to Life in the Pond." Based on a key developed by Riveredge Nature Center, Newburg, WI.

DAY 4: So What Does It All Mean?

Activities

Throughout the lesson, students should record key discussion points, calculations, results, conclusions, and analysis in their journals. These journal entries will serve as analysis materials.

30 minutes: Discuss the participants' overall impressions of the stream site. Have volunteers share their sketches and observations. Compare the group's sketches and observations to the habitat section of the "Aquatic Integrity in Urban Watersheds" poster. Match conditions of the local stream to the appropriate integrity rating on the poster. Ask students to identify possible sources of pollution in and around the stream site, such as overpasses, parking lots, construction, etc.

30 minutes:

Create a table like the following with the class data on macroinvertebrates. This data may also be represented with a bar graph comparing number of individuals found per species. Students may also create a pie chart. To determine the biotic index score for each species, consult the Biotic Index reference sheet. To calculate the *average* biotic index score, multiply the biotic index score by the total number of individuals found of that organism. Once this is done for all species, add the multiplication products. Lastly, divide this value by the total number of organisms found.

Species	Biotic Index Score	Total Number of Individuals Found	(Biotic index score x total number of individuals)
Ex. Dragonfly nymph	2	5	10
Mosquito larvae	1	9	9
Total		14	19

$19/14 = 1.36 \rightarrow 1.36$ is much less than 3, so the water quality of this stream is poor

Three is the best possible score, so compare the class average biotic index score to three to determine water quality of local stream. If time allows, discuss the importance of biodiversity and the interdependence of stream organisms.

30 minutes:

Compile class chemical and physical data in a table like the one below, then average for each variable. Compare to the Water Data Analysis Information in the "Water We Have Here?" activity from WOW! The Wonders of Wetlands. Students should draw conclusions on stream water quality based on this index. Discuss possible sources/causes of each variable.

Variable	Group 1	Group 2	Group 3	Average
Water temperature				
Clarity				
Flow				
pH				
Dissolved oxygen				
Phosphates				
Nitrates				

45 minutes: Data Draw

List each of the chemical and physical variables from the chart above twice on separate scraps of paper (14 scraps total). Place all pieces of paper in a container. Divide students into pairs. Each student draws one piece of paper (variable). If the same variable is drawn by both partners, simply draw again. Each pair discusses the following talking points and records the answers in their journals:

1. Predict how your variables might influence one another. Explain why/how the variables impact each other.
2. How could this interaction affect the macroinvertebrates in the stream?
3. Check your data sheet. Does your prediction match our class data? Propose reasons why our data may be similar or different from your prediction.

Each pair then shares their talking points with the class. The facilitator may need to clarify some variable relationships and provide examples.

15 minutes: Ask students to reflect on their water quality conclusions from all three indices. Compare the results from the indices. Discuss how each index measures a different component of stream health and why conclusions may be similar or different for each. Synthesizing all of their data and conclusions, students then compose a final conclusion on the overall health of the stream.

30 minutes:

Ask each participant to identify a possible source of error in data collection or analysis. Explore how the class' experimental design could be improved. Evaluate whether the experimental set-up, data collected, and analysis indices are a good measure of stream health.

<i>Learner Outcomes</i>	<i>Formative Assessment</i>
By the end of the lesson, Girls in Science participants will be able to . . .	This outcome will be demonstrated by . . .
1. Connect surrounding environmental conditions with stream water quality.	- Journal entry - Discussion participation
2. Compare student-generated data to	-Journal entry

scientific water quality indices.	- Discussion participation
3. Analyze data using mathematics.	-Journal entry
4. Explain how chemical and physical variables impact one another and local biota.	-Answers to talking points in journal
5. Conclude water quality of a local stream based on biological, chemical, and physical data.	-Journal entry
6. Evaluate own experimental design, data collection procedures, and analysis.	-Journal entry - Discussion participation

Tbilisi Objectives Skills, knowledge, participation

EE Learner Guidelines

- 1 D) Evaluating accuracy and reliability
- 1 E) Organizing information
- 1 G) Drawing conclusions and developing explanations
- 2.2 C) Systems and connections
- 2.4 A) Human/environment interactions
- 2.4 E) Environmental issues
- 3.1 A) Identifying and investigating environmental issues
- 3.1 B) Sorting out the consequences of issues

State Standards

- Science 1.04-* Analyze variables in scientific investigations
- Science 1.05-* Analyze evidence to explain observation, make inferences and predictions, and develop the relationship between evidence and explanation
- Science 1.06-* Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations
- Science 1.08-*Use oral and written language to communicate findings and defend conclusions of scientific investigations
- Science 7.01-* Describe ways in which organisms interact with each other and with non-living parts of the environment
- Science 7.02-* Investigate factors that determine the growth and survival of organisms
- Science 7.03-* Explain how changes in habitat may affect organisms
- Mathematics 1.04-* Develop fluency in addition, subtraction, multiplication, and division on non-negative rational numbers; analyze computational strategies, describe the effect of operations on size, estimate the results of computations, and judge the reasonableness of solutions
- Language Arts 1.03-* Interact appropriately in group settings by listening attentively, showing empathy, contributing relevant comments connecting personal experiences to content, and monitoring own understanding of the discussion and seeking clarification as needed

Community Resources Not applicable

Contribution to Summative Assessment Plan (*children's book*)

What happens to organism's home when the stream is polluted

Physical effects on organism itself

Sources

"Biotic Index" reference sheet. *The particular index used at the Museum is only available in hard copy. It has been used for several years, with no indication of the original source. However, there are many biotic indices available on the Internet. A particularly good one is through The Stream Study (www.people.virginia.edu/~sos-iwla/stream-study/).*

Sacco, Phil and Dale Jones. Poster of "Aquatic Integrity in Urban Watersheds." 1999. CHSM Hill.

Slattery, Britt E. and Alan S. Kesselheim. "Water We Have Here?" WOW! The Wonders of Wetlands. 1995. Environmental Concern and The Watercourse. p. 185.

DAY 5: From Activities to Action

Activities

*Guest expert for the lesson: The Neuse Riverkeeper from the Neuse River Foundation

The Neuse Riverkeeper represents for a non-profit organization dedicated to the protection and restoration of the local watershed. As an educator and advocate in the community, he has considerable experience with developing, implementing, and assessing action plans. Rather than lecturing, this guest speaker floats among groups, answering questions, guiding discussions, and helping students refine their action plans. The Riverkeeper uses examples of actual local action plans to prepare students for brainstorming their own action plans. Stories of real-life action plan success inspire students to act consciously and thoughtfully for all sides involved. Additionally, the Riverkeeper facilitates a discussion of the Action Analysis Criteria questions.

30 minutes: Assess the need for an action plan

Ask students to summarize their water quality conclusions from the previous week.

Some discussion questions include:

How would you rate the water quality of the stream we sampled?

What data supports this rating?

What are some potential sources of pollution in the area?

Which of these pollution sources may be improved through citizen action?

30 minutes: Formulate an Action Plan

Brainstorming session: With the list of pollutants generated above, ask students to devise action plans to improve a specific pollutant or problem. Each participant should contribute at least one proposal. After all ideas are presented and recorded on the board, students should narrow this list to their top three action proposals. If necessary, this may be done with a vote.

1 hour: Assess action plan proposals

Divide the class into three groups. Assign each group an action proposal to explore.

Each group answers the following questions in their journals:

1. Does this plan directly address a threat to water quality? Which threats does it address?
2. What is the basic outline of the action proposal?
3. If implemented, how would this plan improve the situation?
4. Does the pollution source also provide a service to the community (social, economic, political, recreational, etc.)? How will this action plan change that service?
5. Who will implement this plan?
6. How long will the plan take to implement?
7. Is money needed to implement the plan? If so, how much? Where will the money come from? What else might that money go towards?
8. Will this plan respect the rights of others?

9. Is the plan reasonable for our club, at the present time, with the present resources?
10. Will there be a cost or harm to other members of the community? How might those costs be avoided?
11. What are other issues associated with this action plan? Are there any other benefits? Any other problems?
12. How will the progress of this plan be evaluated?

Each group records their answers, and then shares them with the club. Once all three action proposals are reviewed, students vote on their preferred action plan.

45 minutes: Decide whether or not to implement the action plan.

The Riverkeeper uses the following 14 questions to help participants decide whether or not the proposed action plan should be implemented (Hungerford et al, 1992). He uses examples of current, local issues and action plans to guide students in their answers.

1. Is there *sufficient evidence* to warrant action on this issue?
2. Are there *alternative actions* available for use? What are they?
3. Is the action chosen the most *effective* one available?
4. Are there *legal consequences* of this action? If so, what are they?
5. Will there be *social consequences* of this action? If so, what are they?
6. Will there be *economic consequences* of this action? If so, what are they?
7. What are the *ecological consequences* of this action?
8. Do my *personal values* support this action?
9. Do I understand the *beliefs and values of others* who are involved in this issue?
10. Do I understand the *procedures* necessary to take this action?
11. Do I have the *skills* needed to complete this action?
12. Do I have the *courage* to take this action?
13. Do I have the *time* needed to complete this action?
14. Do I have all the *other resources* (other than the above) needed to make this action effective?

After all 14 questions are thoroughly discussed as a class, students will vote yes or no to implementing the action plan. If the majority votes “no,” then the remainder of the club will focus on alternate lessons and science experiences. If the participants vote yes, then planning, implementation, and evaluation of the action plan will be worked into the remaining club calendar. The club lasts eight weeks, so three more weeks are available for implementation of the plan. If appropriate, subsequent clubs could evaluate the action plan according to the current club’s evaluation scheme.

15 minutes:

Assign and go over the summative assessment (children’s book). Extend the concept of environmental action to include public education (if students have not already included education in their brainstorming session). Distribute a copy of the following assignment page to each student.

A Student Today, an Author Tomorrow

You are to create an illustrated children's book about your expert macroinvertebrate (remember that critter on your back?). The macroinvertebrate will be your main character. The book should include topics covered throughout this unit, including, but not limited to:

1. What the animal looks like
2. The animal's life cycle
3. What it needs to survive
4. What human actions threaten its survival
5. What its habitat looks like
6. Neighbors in the stream and/or on the banks
7. What happens to the animal and its home when the stream is polluted
8. What the reader can do to help the main character and its stream home

Your story can be fictional, but the facts *must* be accurate. Additional research may be required.

After you finish writing and illustrating your book, you will read your story to a younger class at your school. To practice for this story time, you will be able to read to each other at the final club meeting. Your children's books will also be on display at the club's Open House for the museum staff, your family, teachers, and school administrators. Thus, the creation and sharing of your book will serve as an education project for the local community.

<i>Learner Outcomes</i>	<i>Formative Assessment</i>
By the end of the lesson, Girls in Science participants will be able to . . .	This outcome will be demonstrated by . . .
1. Assess the need for an action plan based on student-generated data	- Discussion participation
2. Formulate an action plan to improve water quality	- Discussion participation
3. Assess action plan proposals	- Journal responses to assessment questions
4. Responsibly decide whether or not to implement an action plan	- Journal responses to 14 action analysis criteria questions

Tbilisi Objectives Skills, participation, knowledge, attitude, awareness

EE Learner Guidelines

- 2.2 A) Organisms, populations, and communities
- 2.2 C) Systems and connections
- 2.3 C) Political and economic systems
- 2.3 E) Change and conflict
- 2.4 A) Human/environment interactions
- 2.4 E) Environmental issues
- 3.1 A) Identifying and investigating issues
- 3.1 B) Sorting out the consequences of issues
- 3.1 C) Identifying and evaluating alternative solutions and courses of action
- 3.1 D) Working with flexibility, creativity, and openness
- 3.2 A) Forming and evaluating personal views
- 3.2 B) Evaluating the need for citizen action
- 3.2 C) Planning and taking action
- 3.2 D) Evaluating the results of actions
- 4 A) Understanding societal values and principles
- 4 B) Recognizing citizens' rights and responsibilities
- 4 C) Recognizing efficacy
- 4 D) Accepting personal responsibility

State Standards

- Science 1.08*-Use oral and written language to communicate findings and defend conclusions of scientific investigations
- Science 1.10*- Analyze and evaluate information from a scientifically literate viewpoint
- Science 3.08*- Conclude that the good health of environments and organisms requires monitoring of the pedosphere, taking steps to maintain soil quality, and stewardship
- Language Arts 1.03*- Interact appropriately in group settings by listening attentively, showing empathy, contributing relevant comments connecting personal experiences to content, and monitoring own understanding of the discussion and seeking clarification as needed
- Language Arts 3.02*- Explore the problem solution process by preparing group presentations that focus on the diagnosis of a problem and possible solutions

Language Arts 4.03- Recognize and develop the stance of a critic by considering alternative points of view or reasons, remaining fair-minded and open to other interpretations, and constructing a critical response/review of a topic

Healthful Living 3.03- Describe individual behaviors that can harm or help the health of the environment

Community Resources

Guest expert: Neuse Riverkeeper from Neuse River Foundation

Contribution to Summative Assessment Plan (children's book)

What the reader can do to help the organism and stream habitat

Sources

Action Analysis Criteria from:

Hungerford, H., R. Litherland, R. Peyton, J. Ramsey, and T. Volk. 1992. *Investigating and Evaluating Environmental Issues and Actions: Skill Development Modules*. Champaign, IL: Stipes Publishing.