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INTRODUCTION

Can I Do This?

BioSITE is a hands-on learning program in which students perform authentic water quality monitoring and ecological study at a nearby creek. High school students learn principles of ecology, riparian habitats, and water quality monitoring. After practice and developing lesson plans, they teach this material to elementary school students (4th grade).

If you are considering whether this program is for you, ask whether you have...

- A desire to engage your students in real research and field study?
- An interest in science studies in an outdoor setting in addition to the classroom?
- A group of 10th, 11th or 12th graders meeting on an ongoing basis?
- Access to a creek, river, pond or lake?
- An elementary school nearby that you could invite to join in your field studies?

Wow! You have all the key elements to make this program work! You'll learn much more in the following pages, but you are off to a fantastic start. To help you succeed, in addition to this guide, we provide support, resources and materials through the BioSITE Web site at www.cdm.org/biosite.

Are you missing a few of the above "ingredients?" Don't despair! We have adapted this program when necessary to...

- Work with middle school students instead of elementary students
- Work with special education students instead of elementary students
- Recruit high school students after school as volunteer facilitators and conduct the program after school
- Engage college students as facilitators

So we encourage you to take a look beyond this page to see if it might work for you, too! And don't hesitate to contact us for advice at BioSITE online!

BIOSITE online

www.cdm.org

Why Do This?

Along with providing the curriculum for a basic ecology course and extensive experiences to build science field work and research skills, the BioSITE program prepares high school students to teach science to elementary students. This innovative combination of science research, service learning, and cross-age teaching offers the following benefits:

High School Students

- Apply science in ways that are meaningful and relevant to their lives
- Experience the use of research-quality science tools
- Apply their science skills in field-based research
- Learn to assess data and predict trends
- Build leadership and teamwork skills
- Gain first-hand experience relating to science and teaching careers
- Experience the joy of being a role model in a science learning setting

Teachers

- Learn about students' perceptions of science and teaching
- Engage in meaningful, community-based science research
- Learn about current research on the local environment
- Pursue answers to their own questions about the environment
- Help raise the profile of youth and their contributions to the community
- Connect with teachers conducting similar service learning projects and research

Elementary Students

- Benefit from individual attention while learning in small groups
- Learn to collect and interpret data
- Gain a sense of themselves as scientists
- Experience the use of research-quality science tools
- Apply science in ways that are meaningful and relevant to their lives
- Build teamwork skills

Scientists

- Help broaden students' vision of who is and can be a scientist
- Share their passion and knowledge with teachers and students
- Validate students' research and efforts
- Provide valuable advice and information to help students find answers to their questions
- Show that scientists continue to question and learn throughout their careers
- Connect student researchers with other scientists or groups related to their research

The program outlined within the curriculum is a year-long course with scheduling flexibility because it is a service learning program. It can be tailored and adapted to any age group and any time period. Companion texts are useful, but not required. Support (resources and materials) is offered on the BioSITE Web site.

"At BioSITE I have a lot of fun learning about things, but not in, like, a boring way, like sitting down listening to the teacher...it's better learning like that, by looking at it in front of you, seeing it, touching it, and hearing it."

– BioSITE student

"The [students] are not only learning science by getting their hands and feet wet, they are participating in real research for an environmental conservation project."

– BioSITE funder

Project Background

BioSITE (Students Investigating Their Environment)

In 1993, Children's Discovery Museum of San Jose (CDM) created BioSITE (*Students Investigating Their Environment*), an innovative, field-based science program focused on authentic science research. The program expanded quickly from targeting local 4th grade students, teachers, and pre-service teachers to serving students in grades 3-12 and their teachers, as well as pre-service teachers and students at local universities. With the expansion came increasing requests from teachers, parents, and schools for assistance in designing or implementing similar watershed-based science programs.

This curriculum is one response to these requests. Our hope is that it will be useful for a wide range of educators, among them:

- Classroom teachers of elementary through high school students
- Science resource teachers
- School district administrators
- Informal educators at other museums
- High school students involved in peer teaching and service learning

This diverse target audience brings to light one of BioSITE's driving philosophies, which might be called a **community of learners** approach to science investigations. Our vision of a community of learners draws from both the scientific community as a model as well as the Museum's own philosophy of approaching all program participants as both learners and teachers. In the BioSITE program, and throughout this curriculum, you will find references to learners rather than students. The term "learners" is used to refer to all BioSITE program participants - teachers, students, Museum staff, and scientists – who are together **co-creating investigations** and sharing their discoveries through participation in the three main program components:

1. Water quality research
2. Inquiry-based teaching techniques
3. Hands-on watershed and riparian science curriculum

In the following chapters you will find detailed information on each of the above components. The BioSITE program guides teachers and students toward inquiry-based science methods by providing authentic, field-based activities, small group work for student researchers, and cross-age teaching experiences that emphasize the community of learners approach. Resources for replicating these aspects of the program are woven into the curriculum's instructional units and reference information. The activities are written as detailed lesson plans with teaching tips and background information for use by teachers and high school students who are training to be science mentors.

Program Vision

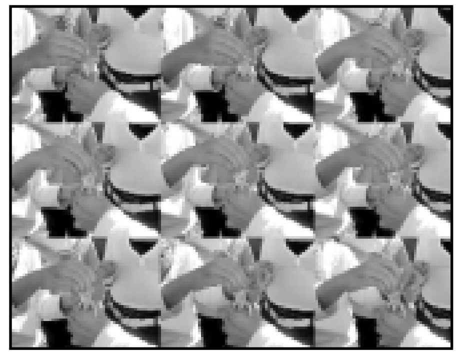
Authentic Science

What do we mean by "authentic" science? Phrases that come to mind include "real-world applications," "asking good questions," "hands-on experimentation," and "taking scientific knowledge and using it to make a difference." For the BioSITE program, we crafted the following statement to represent our goals for teachers and students in the program. You may want to develop your own vision statement to help guide your program planning.

"I think of BioSITE as the application of science rather than just science concepts."

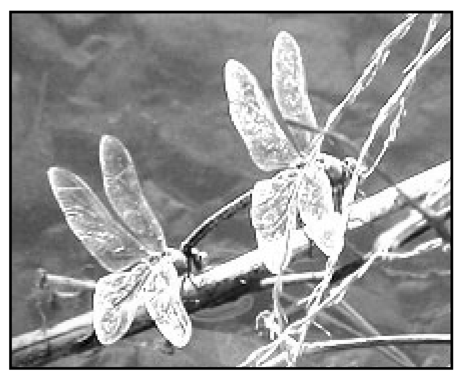
– High school facilitator

BioSITE participants will actively engage in authentic science experiences focused on research, gain watershed knowledge and apply that knowledge in broader contexts, now and in the future.



Reaching goals for authentic science experiences
When planning and evaluating the diverse parts of the program, we identified the following components as essential to providing authentic science experiences. You may start your journey with only one or two of these elements in place, and then, as you strengthen one area of your program, you may find it naturally leads toward developing or strengthening another element.

Inquiry-based science—Inquiry is integral to every branch of science and is essential to real scientific study. It is also embodied in something as simple as a baby playing with her bath toys. The inquiry process begins when a person discovers something puzzling, surprising, or interesting that perhaps raises questions or challenges his or her current understanding of the world. As a result of this discovery, the learner takes action, develops investigations or hypotheses, pursues new information, and collects and records data. Though the learner determines his or her own paths of investigation, he or she will also draw on existing reference information and the observations and questions of others. In the end, a period of reflection, comparison, and interpretation of data enables the learner to integrate his or her previous views and newly acquired knowledge to form a current understanding of the topic.



Some questions that may help you to gauge the level of inquiry in a program might include the following:

- Are the learners in the program being given the support to develop their own questions and pursue answers to them?
- Are the learners actively engaged in, excited by, and proud of their investigations?
- Are project-based learning experiences an option?
- Are teachers and students together forming a community of learners?

Field study—Imagine students studying aquatic animals by observing them in their natural habitat. This was our vision of BioSITE students. What better way to understand the effects of seasonal changes on water quality than by collecting water samples from a natural source and testing them for oxygen, turbidity and pH levels at regular intervals throughout the year? From the start, the BioSITE program was developed using field study as the framework for students to study environmental science content. Regular fieldwork not only gives learners the opportunity to study things within their natural context, but also provides opportunity to practice authentic science skills, such as recording observations and questions, collecting data, forming and testing hypotheses, developing plans for investigations, and interpreting results.

<u>Key questions to ask as you design a field study program might include:</u>

- How might it be possible to give learners the opportunity to study a subject in its natural environment, as opposed to from inside the classroom?
- Do teachers and students feel ownership over their field study—are they involved in making decisions about research goals and routines, selection of study sites, and appropriate activities?
- Are students learning basic science skills that can be reapplied to study other science content, such as recording observations and test results?

Reflection—To make sense of any inquiry process, the learner must take time to reflect on observations, compare data with the findings of others, and finally articulate the new viewpoint or understanding that has been constructed as a result of the inquiry experience. Unfortunately, as educators we are so familiar with the learning goals we set out to achieve with our students that we often neglect to ask the students themselves what they have absorbed from a lesson or experience. Without a thoughtful plan for reflection, learning may be assumed, but not achieved. Even more important, reflection is essential not only as a means of assessing learning, but also as a tool for direct learning. From our reflection activities or experiences, learners gain new information from others in their learning community and are challenged to articulate their own findings. This is a vital step in understanding new concepts. Just as the saying goes, “You never learn something so well as when you have to teach it,” reflection experiences ask the learner to draw conclusions and be prepared to explain the process which brought them to that understanding.

Following are suggestions that encourage reflection and open communication in order to enrich individual as well as group learning:

- Develop a simple reflective journal for your program. Start with providing space for recording observations, questions and data, but keep it flexible so you can change the format and add reference information or new sections as needed in response to how participants use it. See the Tools for Implementation at the end of this curriculum or BioSITE online for a journal template.

BIOSITE online

www.cdm.org

- Journals are for teachers, students, and program directors alike and can be used in all aspects of a program—in the field, in the classroom and at home!
- Assess the physical environment to see how it can provide a forum for students to share their ideas. Will it support small-group interactions? Are students' questions and work displayed in ways that reflect their investigations?
- Explore a variety of ways to translate findings: charts, diagrams, group or individual reports, group discussions on a focused topic, or photo documentation with explanations are just a few possibilities.
- Think of ways to show learners that their ideas and thought processes are welcome and valued so they feel comfortable expressing ideas and opinions.
- As a group, reflect periodically on what you are doing and why. It is important to acknowledge changes in focus and direction and evaluate as a group whether or not everyone in your community of learners is comfortable with the new direction.

Inclusion of scientists—Over the years of offering the BioSITE program, we have involved scientists in the program in a variety of ways with a range of goals in mind. Visiting scientists can be chosen to serve as role models for girls or minorities underrepresented in science; to validate students' data and research; to involve students in real research projects; and to demonstrate new field research techniques or share a special area of expertise. Some scientists have joined students for a single hour-long presentation while others have returned regularly to work with the same students throughout the year.

To involve scientists as valuable resources for your program, consider the following questions:

- Are there scientists conducting studies similar to those of your students with whom you could share your data or research results?
- Can a visiting scientist go beyond a lecture-style presentation by doing a research demonstration and involving students in the process?
- Does a visiting scientist have previous experience working with students? If not, what information and expectations would they like to have before their visit? A Guide for Visiting Scientists can be found in the *Tools for Implementation* section and on BioSITE online.
- Are there scientists with whom students can communicate via e-mail if they are unable to come to the field study site or classroom?

"There's hope that, even in this day when education seems to be more about teaching to a standard and exam performance, there are programs like BioSITE that give those students who choose to take advantage of it, a chance to explore."

– Visiting scientist

Community of Learners

What is a **community of learners**? In BioSITE, participants engage in both teaching and learning, forming a community of learners. As co-learners in the process, adult teachers, high school students, and elementary students engage in authentic science on multiple levels. When involved in both teaching and learning, every learner practices science and communication skills.

Teachers mentor high school students to teach elementary students, gaining the opportunity to observe and learn more about their students' skills and abilities. Teachers may also learn new science content alongside students in response to questions, observations and exposure to visiting scientists. High school students learn new content and gain a new appreciation for teachers as a result of having to go through the teaching experience first-hand.

Together the group of teachers, students, museum staff, volunteers, and visiting scientists explore the ecological habitat, conduct research, co-create investigations and share discoveries.

Cross-age teaching—Having teenagers teach can be effective and efficient. Young children respond well to teenage teachers (facilitators), and a team of facilitators enables younger students to be divided into small workgroups with low student-to-teacher ratios. Most dramatic, though, are the benefits to the teenagers themselves. We have found that teenage facilitators experience dramatic changes in their attitudes toward teachers and teaching while they also develop more self-confidence, teamwork and other skills to help in multiple areas of their lives. Facilitators also develop new and very personal views of science and science teaching.

"BioSITE gave me an idea of what teachers go through and has given me more respect for my teachers."

– High school facilitator

"My kids are great and I noticed that you guys were right about how much they look up to you and how it is important to be your best around them."

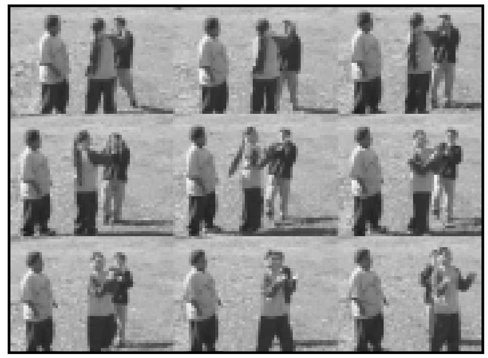
– High school facilitator

BioSITE strives to make the teaching component of the program real and self-directed for the facilitators. To help facilitators succeed at the task, we incorporate the following training and class organization techniques:

- Provide teenagers with a solid introduction to children's behavior and level of understanding, multicultural understanding, classroom/group management skills, communication and team building skills;
- Make sure that facilitators are comfortable with content before teaching it to others;
- Encourage facilitators to use open-ended questions that encourage investigation, observation and thinking;
- Divide elementary students into small groups (3-5) so that facilitators can listen carefully to students' ideas, comments and questions and can encourage student dialogue;
- Provide clear and consistent planning direction to students so that they understand what they are doing and why, and they can then become self-directed in their lesson planning and teaching;
- Consider having facilitators work in pairs to teach as a small group;

- Encourage communication by providing many opportunities for facilitators to provide feedback, respond to feedback, and learn from one another; and
- Give facilitators a "bag of tricks" (quick easy games and activities) that they can use with the younger students when they are unsure of what to do.

Additional benefits to teenagers' teaching can be:
- Students gain a better understanding of the subject as a result of teaching.
- For many high school students, the teaching experience is an opportunity to discuss job skills, potential careers and expectations for the work experiences they'll encounter following graduation.
- Often students who may be struggling in either high-risk environments in their lives or with subjects in school find teaching a positive and rewarding experience and see how they make an immediate difference in a young person's life.
- Teaching experience in the BioSITE program often counts towards service learning or community service credits.
- Participation in innovative community service programs is an excellent addition to college applications.



Mentor training—In addition to gaining and practicing skills in science, teenagers who serve as BioSITE facilitators find themselves in the position of mentoring young students, particularly when they share similar backgrounds. Young students will look to the teenagers differently than their regular classroom teacher. Teenagers have the opportunity to consider how their behavior influences young people and act accordingly, to be a positive role model for the students. Leadership development and mentoring skills are important, integral components of this program.

Tips to promote positive mentoring experiences for the teen facilitators include:
- Begin by having teenagers teach from an established, directed curriculum. Through the course, allow a transition towards the facilitators making their own decisions on how to teach the material.
- Set up facilitators to succeed by setting incrementally higher expectations.
- Reflect upon and discuss the mentoring role and responsibilities. Encourage sharing and class discussion when a difficult or challenging situation arises and allow the facilitators to participate in making decisions or recommending alternative solutions.
- Constantly promote positive development and use plenty of positive reinforcement, recognition and rewards.

Essential BioSITE Concepts

What essential concepts do we want to have lasting value beyond the classroom? What big ideas do we want students to comprehend, appreciate, and carry with them when they leave the BioSITE program? The following core philosophies and themes run through each unit and are experienced through the specific facts, skills and processes embedded in the activities.

Self as Scientist

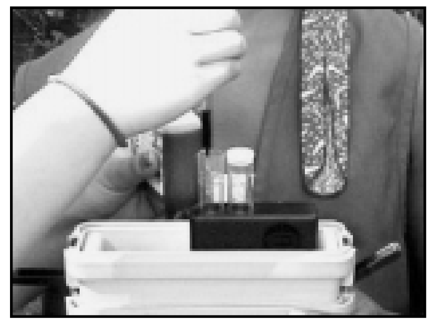
Students will:

- Gain practice in inquiry-based science—developing good observation skills and questions, planning and following a method for investigations, evaluating the results and generating more questions based on the results;
- Learn through examples how science affects our lives; and
- Understand and assess the process of exploring, questioning and learning in themselves and in the students they teach.

Ecological Balance

Students will:

- Understand how the natural habitat needs a balance of variables to support a healthy community of flora and fauna successfully;
- Demonstrate their knowledge by identifying variables of a habitat, explaining sources and consequences of an unbalanced system, and interpreting data from their research; and
- Evaluate humans' impact on the natural environment.



Mentor Teaching

Students will:

- Gain experience teaching younger children;
- Acquire a greater appreciation of teaching as a way of learning and experience the value of being a teacher as well as a learner; and
- Practice leadership skills and teamwork.

Environment and Community

Students will:

- Engage in authentic, proactive environmental stewardship;
- Recognize, critique, and evaluate aspects of their personal existence that positively and negatively impact the natural environment;
- Identify and discuss examples of environmental education, conservation, and preservation, from local to global levels;
- Be better equipped to make environmentally sound decisions to help ensure a better quality of life for all; and
- Share what they've learned with their community.

Curriculum Framework

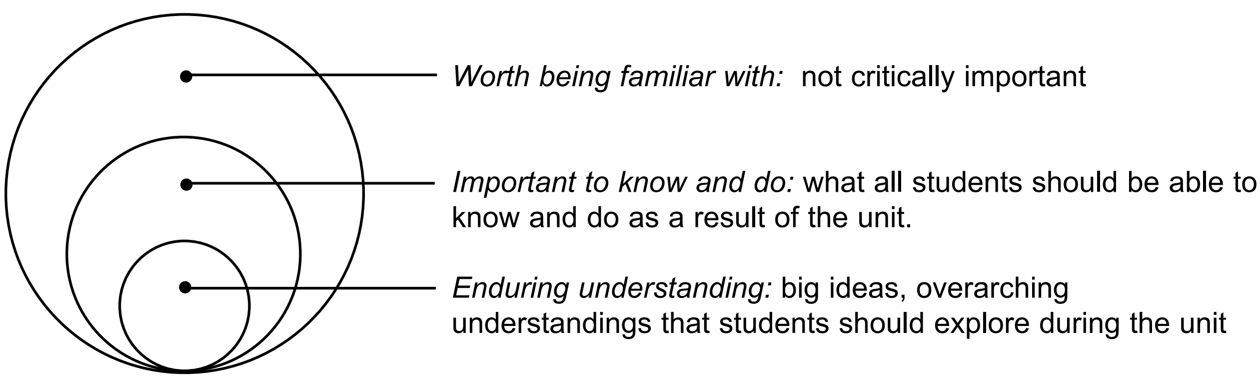
Audience
Over the years, the BioSITE program has been adapted to serve a broad age range (preschool through college). This curriculum includes elementary activities but is written more specifically for the high school classroom teacher and the high school student (facilitator) who will be teaching elementary students.

Curriculum Overview
Each unit gives an overview and learning outcomes to aid in planning and assessment. The *Reading,* and *Activities 1 and 2* are the primary material that facilitators will learn and teach to elementary students. The reading and research in the Advanced Study section, along with *Activity 3*, provide opportunities for in-depth study and reinforcement of the material. Facilitators draw upon this knowledge for their teaching, and may adapt *Activity 3* for a younger audience.

Curriculum Design Model
BioSITE integrates two curriculum design models as an underlying framework for the curriculum. Understanding By Design, by Grant Wiggins and Jay McTighe, provides an overall inquiry-based, learner-centered approach to the curriculum. The 5-E Instructional Model, by Biological Sciences Curriculum Study (BSCS), provides a compatible structure for the activities.

<u>Understanding by Design (UBD)</u>
The goal of this approach is to develop curriculum that aligns student understanding, assessment, and activities. The UBD framework is a curriculum writing process that considers first the goal of student understanding, then designing lessons to meet that goal (rather than jumping quickly to activities that may be fun but may not get at the goal of understanding).
The 3-step UBD process:

1. **Identify desired results.** Consider what we want students to understand, at three levels.



   In BioSITE the enduring understandings are similar across units, so they are incorporated as “themes for enduring understanding” within the Introduction. The Goals and Objectives within each unit identify aspects of the curriculum that are important for students to know and do.

2. **Determine acceptable evidence.** Use a variety of assessment tools that evaluate, and are appropriate for, different levels of understanding. UBD recommends that the curriculum assess the enduring understandings and know and do. In the BioSITE curriculum the goals, objectives and activities are aligned with assessments.

3. Design learning activities. The activities are developed according to the BSCS 5-E Model (below), which considers how to get students to achieve desired results.

5-E Instructional Model

The 5-E instructional model fits well with the natural cycle of inquiry and the methods with which BioSITE is taught. The activities have been written to align with this model. The 5-E Instructional Model is as follows:

1. **Engage.** The learner engages in the concept and prepares to learn something new.
2. **Explore.** The learner explores various dimensions of the concept.
3. **Explain.** The learner develops an explanation of the concept.
4. **Elaborate.** The learner elaborates the concept, building on understanding and increasing breadth and depth.
5. **Evaluate.** The learner evaluates his or her understanding of the concept, demonstrates it to others and continues the cycle back to Step 1 with either a challenge to his or her current understanding of concept or a new concept related to previous study.

Linking to Standards

BioSITE's inquiry-based approach to science reflects the standards framework set forth by the National Science Foundation. Beyond the national level, BioSITE can easily be adapted to meet state and local district science content standards. See BioSITE online for more information about standards.

Examples of how BioSITE activities are linked with national standards (2001):

Standard 2: The student understands and applies concepts of life science	
Owl Pellet Dissection:	Scientific tools and techniques; energy flow, predator-prey relationships, food chain, anatomy.
Salmon Egg Incubation:	Life cycle studies, water quality conditions, scientific experiment set-up, written stories to demonstrate understanding.
Standard 4: The student thinks scientifically	
Field Journal:	Record observations, label drawings, record and analyze data from water quality tests. Draw conclusions from observations made during activities and experiments. Form good questions and hypotheses.

Tips for teachers...
See *BioSITE online* (www.cdm.org/biosite) for a matrix of how this was done in the San Jose Unified School District, and for tips on linking activities to California State Content Standards.

Standard 6: The student understands and uses scientific tools and technologies	
Water Quality Testing:	Use research-quality monitoring test kits and equipment to perform various water quality tests. Record and analyze data, interpret and graph results, apply concepts to make conclusions regarding watershed health.
Field Study:	Use tree height gauges, densiometers, and compasses as part of riparian ecology study.
Field Methods:	Use digital cameras and Palm Pilots to document and enter field data into BioSITE online Web site to share with community. Visiting Scientist: Introduce tools to students.
Standard 7: The student communicates and understands scientific information and processes	
Field Day Debriefing:	Facilitators and students review observations, record and discuss water quality test results. Community of learners—teachers, facilitators, and students—debriefs after each field day.
Student Presentations:	Articulate learning to peers, teachers and other groups in oral and written forms. Share observations, test results, interpretations. Create portfolio that includes data compilation and interpretation, self-evaluation and revision of field activities, creative interpretation of BioSITE experience, final self-evaluation of progress as a science teacher.
Standard 8: The student understands how developments in science and technology affect society and the environment	
S.T.E.P.:	Incubate and care for eggs of threatened native salmon species in a freshwater aquarium through their first three life cycle stages. Release in appropriate local stream.
Stream Restoration:	Activities coincide with a local water district restoration project. Study the process of environmental management and recovery first-hand. Document restoration project, perform water quality monitoring, and observe recovery of natural balance.
Visiting Scientist:	Introduce tools to students, share examples of research connected to local environment.

Companion Texts

The BioSITE program uses the following curricula as companion texts. These are great references to have in the classroom and offer many activities and material that can supplement your program. Refer to the Additional Resources section for a full reference listing.

- *Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods* by Tom Murdoch, Martha Cheo and Kate O'Laughlin;

- *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools* by Mark K. Mitchell and William B, Stapp; and

- *Water Quality: A Field-Based Water Quality Testing and Monitoring Program for Middle Schools and High Schools* by the San Diego County Water Authority.

PROGRAM LOGISTICS

Overall Program Structure

This curriculum describes basic logistics for Children's Discovery Museum of San Jose's BioSITE program at Pioneer High School in San Jose, where the program has operated since 1997. At Pioneer, BioSITE is a year-long program. High school students gain elective science credit, community service credit, and service learning credit as part of the school's Service Learning program. CDM and Pioneer partner with three local elementary schools whose students come out to the creek site on a biweekly basis for field study instruction by high school facilitators.

BioSITE can be modified to meet the given needs of a teacher, school district or museum. Though the current BioSITE program at Pioneer High School is offered as a regular science class, it was initially coordinated as an after-school program. Depending on the partnership of the formal and non-formal learning institutions, the program and curriculum can be adapted for a year-long course or a series of short field-trips, as well as for a variety of age groups.

BioSITE uses the local natural resources of the watershed as a context for inquiry-based science instruction. High school students read about an element of their watershed, engage in activities to explore the topic, and then plan how to teach related lessons to elementary school students. On field days, high school facilitators and elementary students study a nearby stream and riparian corridor.

Working in small teams at the stream, students practice observation and field study skills and perform a series of water quality monitoring tests on a regular basis. Together they collect and record data, then analyze it to interpret trends in water quality. They also engage in field-based science activities, such as identifying birds and plants, catching and identifying aquatic insects, and measuring tree height, that correspond with the natural cycles of the ecosystem. Combined with water quality data, this information helps give a complete picture of watershed health.

This structure reinforces science concepts for facilitators and helps them develop mentoring, teaching, and science skills. Elementary students engage in hands-on learning and small group activities, and gain positive experience with a mentor. Teachers (both elementary and high school) watch their students interacting in new ways and reflect on their own teaching. Visiting scientists come into the classroom to share their experience "from the field."

Program at-a-Glance
Here is an example of how the BioSITE program operates at Pioneer High School in San Jose, CA:

Children's Discovery Museum
- Provides teacher training and curriculum for water quality monitoring and watershed studies
- Supports high school teacher in classroom and in field, especially with cross-age teaching component
- Identifies and secures field site at creek

Pioneer High School
- Offers BioSITE as science course for 30 10th - 12th graders
- Teaches high school level content, water quality monitoring techniques, plus activities to be taught to elementary students at the field site
- Walks students to the field site on a weekly basis to conduct water quality tests and teach elementary students

Elementary School
- Supports teachers in attending BioSITE training
- Bus or walk students to field site on biweekly basis
- Follow up with activities and journal in class

Program Participants


High school facilitators prepare for a field day

Facilitators. High school students teach elementary students in the field along the local river site. Ideally a pair of high school facilitators works with a small group of elementary students.

Students. 4th grade elementary school students. Work in teams of 4 to collect water quality data and participate in activities. One to two elementary classes (approximately 65 students) are engaged in each field study day with Pioneer High School facilitators (one class—approximately 30 students) once every two to three weeks for a total of 8 to 10 field days per year.


Elementary students in the field with high school facilitator

Program Leader. Develops curriculum, organizes program, reviews progress of teams in the field. Trains facilitators in teaching methods, provides content, support and advice. Supports the high school teacher. Writes grants and reports. (The existing program has a museum educator in this position, but this staff person could be a teacher or other qualified person.)

Lead Facilitators. Smaller programs can function without this position. Lead facilitators assist the program director. Review teams and gather assessment data. These people typically have experience working with environmental education or youth programs.


Program leader debriefing field study team

Teachers. High school and elementary school teachers review and monitor groups and gather assessment data. High school teachers lead classroom-based lessons that follow themes of field activities and model inquiry and hands-on teaching methods, assist with lesson planning, and guide post-field day reflection. Elementary school teachers lead students in pre-and post-field day activities and assist during field days.

Visiting Scientists. Research scientists recruited from partner organizations and community-based projects have been an invaluable addition to our high school curriculum. Field biologists, watershed monitors, and researchers give high school facilitators first-hand experience in current research methods and findings. Each visiting scientist plans one in-class presentation with the support of the classroom teacher, and then follows up with a field experience visit. BioSITE students work alongside scientists in projects such as habitat restoration, bird counts, watershed clean-up and wildlife surveys. To help scientists prepare for visits, we have included guidelines on lesson planning and student management in the Tools for Implementation section.

Program Overview

Duration/Schedule
The BioSITE program at Pioneer High School is designed as a year-long science elective course for sophomores, juniors and seniors. Each unit spans 3 to 4 weeks. During each week, students are in the classroom for instruction 3 days and in the field teaching 2 days (see sample week below). This schedule has changed dramatically over the years as the program has grown and more elementary schools have become involved. A newer or smaller program would most likely meet with elementary students once a week or even once biweekly.

BioSITE Sample Weekly Calendar
The schedule at Pioneer benefits from a Block Schedule, in which some classes are twice as long as a typical period to accommodate the Service Learning period. While field study can be adapted to a shorter amount of time, these longer time periods are especially good for field study.

WHEN	WHO	WHERE	WHAT
Monday	High School/Elementary	Field Study Site	Field Day: WQ monitoring, activities, journals
Tuesday	High School	Classroom	Environmental Content
Wednesday	High School/Elementary	Field Study Site	Field Day: WQ monitoring, activities, journals
Thursday	High School Teacher, Scientists	Varies: Classroom or Site	Training Day for field study
Friday	High School	Classroom	Meetings, individual help (no required attendance due to block schedule)

Classroom Study
"Classroom study" is what we are calling all class time for high school students without elementary students present. Most days, these studies take place in the classroom, but often an activity or lesson might be better taught in the field and the class meets there. The areas covered during this "classroom study" time include:

- review and discuss reading
- engage in activities
- listen to visiting scientists' presentations
- plan for field study days
- practice teaching
- reflect and evaluate field study sessions

Field Study
At a local stream, high school facilitators meet their group of elementary students. The structure of each field study day is described below. Keep in mind the time allotments are a guideline. It is important to maintain some flexibility for things such as responding to a teachable moment, adjusting for late students, addressing questions, etc. Also keep in mind the number of high school and elementary school students involved the Pioneer program, which serves two elementary schools at once on a field day. A newer program would most likely start out about half this size.

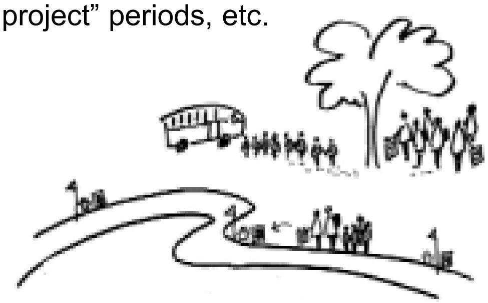
Field Study Agenda

1. Greeting students (15-30 min.)
   - Daily introduction
   - Question of the day
   - Reminders of past lesson
   - Site walk
2. Testing (30-45 min.)
   - Water quality (perform water quality tests)
   - River observations
   - Record data
   - What have you learned?
3. Activity (15-30 min.)
   - Making connections (activity varies every time)
4. Journal (15-20 min.)
   - Daily page (related to topic)
   - Scientific observations
   - Water quality monitoring and data analysis

Recommended total: 2 hours

Tips for teachers...

- The short end of the range reflects a program using one class period, in which case you might need to modify by cutting some components of the program (for example, only do water testing, no activities, or vice versa.)
- As the program matures and flows well, experiment with adding components back in.
- The longer time reflects the ideal time for the program but requires creative scheduling, such as two periods blocked together, or using the last period of the day and continuing field work after school, or using only seniors who sometimes have "senior project" periods, etc.



Organization in the Field

Three stations along creek site:
1) Upper Stream, 2) Middle, 3) Lower

Four teams at each station:

Each team is composed of 2 facilitators and 4 elementary students. Each team performs the following tests and records data:

- Team 1: Turbidity
- Team 2: pH
- Team 3: Dissolved Oxygen
- Team 4: Rate of Flow, Temperature, and Conductivity/Total Dissolved Solids

Note: The number of teams can vary. Depending on the number of students, there could be one to two teams at each station. Just make sure each test is performed at the same location on the creek once each field day.

Materials and Set-Up

Each field day is coordinated by the program leader, teachers or lead facilitator. To make the field study run smoothly, it is best to plan and prepare beforehand.

Along the stream, the leader sets up 3 field stations before students arrive. Each station should have the following materials.

Field Station I.D. Flag
- Tall flags labeled "upper," "middle," or "lower."

Field Data Chart
- See template for recording data in Tools for Implementation.

5-Gallon Bucket
- Contains shared items not used regularly such as first aid kit, drinking water, etc.

Field Packs
- Leader prepares Field Packs that contain the essential items the facilitators will need for teaching and water quality testing in the field. There should be one field pack per team. The field pack consists of journals, supplies, test kits, clipboards, and other resources and reference materials. See *Tools for Implementation* section for complete checklist.

Teaching Boards
- Leader prepares teaching boards (oversized 24"x36" clipboards) for each team that contains laminated topographic maps of the site and large paper that students use as a "chalk-board" throughout the field study to draw and communicate content to the students.

Curriculum

Curriculum Components

This curriculum is a compilation of the BioSITE program created at Pioneer High School by CDM. Each unit gives facilitators background content and activities to lead through a comprehensive study of the riparian environment. Each unit can be supplemented with additional reading, activities, and assessments of your own.

Each unit begins with an **introduction** written for the high school students in the program, to give them a sense of what the unit will be like for them. The **overview** outlines what will be covered in the unit. The **background reading** sections provide content and terminology that all students should become familiar with.

Activities 1 and 2 are core to teaching elementary students. High school students experience these activities first, discuss what and how they learned, and then are guided on planning the activity for their elementary students.

Activity 3 is geared to high school facilitators for more in-depth exploration of the material, or investigative research. They can develop a modified activity for elementary students from this, but the activity is not written for that age group.

The **evaluation** section at the end of each unit prompts students to debrief and reflect on their experiences and learning.

Teachers help facilitators plan and prepare for teaching field days. In the *Tools for Implementation* section there is a discussion of and a *Template: Team Lesson Plan Worksheet* to assist with this. After facilitators teach the field day they evaluate the activities, their experience, and their performance.

"The most helpful thing was the games and some of the lectures. It helped us out in the field because it was exactly like what we teach in the field. It made me become a better field mentor in that I learned all the stuff and incorporated it into my teachings."

– High school facilitator

UNIT 1: PROGRAM ORIENTATION

INTRODUCTION

Welcome to BioSITE (Students Investigating Their Environment)! You are about to begin a program that was designed with the goal of changing the way teachers teach and students learn science. In this course, all participants (teachers, students and visiting scientists) are considered a "community of learners" who together learn about the local environment.

The BioSITE program was created by Children's Discovery Museum of San Jose in partnership with local schools and community groups. In our experience as a group of museum educators, teachers, high school and elementary school students, and scientists creating this program, we found that by working together to conduct real research and sharing with each other what we knew, what we didn't know, what we wondered about, and what we discovered, in the end we had:

- Gathered important scientific information on our river;
- Gained new knowledge and skills in science;
- Experienced why science is important and how it is useful in our lives;
- Taught each other and the community about our local environment and its current "health";
- Developed an incredible team that challenged everyone to contribute; and
- Learned about our individual talents, interests and leadership skills.

We have enjoyed (and continue to enjoy) the experience so much that we decided to use our program to create this curriculum and guide. **In Unit 1, we will introduce the hands-on approach to science that is at the heart of the BioSITE program and give you important background information on how the program works.** We don't expect your experience will be exactly the same as ours, but we do know that what you develop and study as a community of learners will be just as valuable and will contribute greatly to the program as a whole. And, don't forget—we hope you will find the time to share your experiences with us and others using this guide through our program Web site (www.cdm.org/biosite).

UNIT OVERVIEW	
Engage	**Introductory Activities** *Introductory Activity: Group Juggle* Reading: Program Introduction
Explore	**Activities to Explore Material:** *Activity 1: Field Study Methods* *Activity 2: Inquiry Study*
Explain and Elaborate	**Advanced Study** Reading: Teaching Techniques *Activity 3: The Puzzle of Children*
Evaluate	**Debrief and Reflect**

LEARNING OBJECTIVES

At the end of this unit students will begin to:

- Articulate the values of hands-on science;
- Explain the format of BioSITE and accept a commitment to the program;
- Know how to use journals to record observations;
- Use different senses to observe the natural world;
- Ask questions, make and record observations;
- Explain basic principles behind each water quality test and what it measures;
- Draw from a variety of teaching techniques and develop their own style;
- Be familiar with potential challenges in working with elementary students and propose potential solutions;
- Have familiarity with teaching models and techniques;
- Take on more responsibility over time; and
- Identify the level of their awareness and understanding of environmental quality

INTRODUCTORY ACTIVITY: GROUP JUGGLE

This game is designed as an icebreaker and teambuilding exercise, and a good way to get to know everyone's name.

Materials

- 15-20 balls (Koosh balls, yarn balls, balls that are easy to catch)
- Funny items to throw (rubber chickens, stuffed animals, etc.)

Getting Started

Begin by telling students you are going to do a group juggle. Get in a standing circle, facing towards the center. Make sure there is enough room for people to toss and catch balls without colliding with people, furniture or trees.

Explain to students

- They're going to throw the ball to someone in the circle as a way to learn names and get to know each other better. Before they throw it, they need to introduce themselves and ask the name of the person they are throwing to.
- The person receiving the ball thanks the person who threw it, also using his/her name. Before throwing the ball again, each person says one thing they know about the environment you're about to study and one thing they want to know.

Begin the game

1. Start by tossing a ball to one person.
2. Throw to a new person every time.
3. Eventually the ball comes back to the facilitator because nobody throws to you first. When it does, thank everyone for sharing their experiences and thoughts. Note any commonalities or diversity that will help make a stronger team.
4. Ask if, as a challenge, everyone thinks they can remember the pattern they just did. Students do not have to use names this time. It is okay for students to help each other.
5. Tell students: "Now go through the steps faster." This time, after the pattern has started, add in another ball (do the same pattern). Keep introducing balls until the pattern breaks down and everyone is laughing. Check to see how many balls were in the air last.
6. Gather the balls back. Ask, "Can we succeed in juggling more balls?" Tell students, "Now that you know I'm going to give you a challenge, let's strategize ways to work as a team to do this." Suggestions will likely come up such as calling each other's name, making eye contact before you throw, etc. Now, set a goal together for how many balls you can successfully keep going in the pattern (if there is disagreement, set the goal as a range – "Would people feel confident if we could juggle 8 to 15 balls?").
7. Do the toss for one or two more rounds and then toss balls back to the game leader. Note: throwing a few funny items like rubber chickens, dolls or fish gets people laughing…

Reflection

- Explain to facilitators that they can use this game with their students when teaching. It's a great way to get to know each other and to build team spirit. Everyone is working together in a fun way.
- Facilitators also get to hear about what people know and want to know about the environment. Asking what you know and want to know is part of inquiry-based learning. Another part to ask after you've done investigations is "What have you learned?" Before starting any study, try to use this K-W-L model (What you **K**now and what you **W**ant to **L**earn). It's nearer to student-directed learning.
- Go back to classroom for a brainstorming of the K and W for the group and talk about them as goals for the year.

K	W

Reading: Program Introduction

What Is BioSITE?

BioSITE (Students Investigating Their Environment) is a hands-on science program that engages students in authentic science research. High school students study ecology and environmental quality by monitoring and testing the water quality of a local creek. Another key characteristic of the program is that high school students teach the science to groups of elementary students. By getting a chance to be the teacher, high school students test their science skills and understanding and experience what it's like to teach. In the process, they become important mentors and role models for younger children. In joining BioSITE, you will be amazed at the attachment the elementary students feel for their facilitators. It is one of the most rewarding and interesting parts of the program.

How Does BioSITE Work?

The program is organized with the philosophy that all who participate in BioSITE are part of a learning community. This means that the traditional lines between student and teacher are sometimes erased. Students get a chance to teach as they facilitate small groups of elementary students. Teachers get a chance to learn as they listen to the presentations of visiting scientists. This philosophy respects the contributions each person makes to the process of inquiry.

When classes are held in the classroom, high school students learn science content and activities, and plan lessons for the field days with the elementary students. Field study happens near the creek. Here, high school students facilitate small groups of elementary students, teaching science, performing water quality tests, and engaging in activities. Following the field study, students reflect and evaluate their process.

BioSITE focuses on hands-on learning for all students. We recognize the importance of students realizing the power of learning and teaching, of and for themselves. We hope to encourage young people to take responsibility for their actions and the environment around them by involving them in meaningful field studies. One year, BioSITE students could not find any aquatic insects in the stream. After a creek restoration project, in which planting native plant species along the stream bank stopped the erosion, they monitored the habitat's recovery and soon counted many different species of aquatic insects. They learned first-hand about how caring for the environment makes a difference.

Doing Field Study Research

Just as doctors use tools and methods to help determine whether someone is healthy or not, scientists use tools and methods to determine the health of a river environment. Scientists approach their study with the process of **inquiry**, which is more systematic than simply asking questions. The inquiry process begins with observation and asking questions, then developing a hypothesis, collecting evidence to test the hypothesis, evaluating whether that hypothesis was true, and asking more questions. Scientists who study the environment rely on field study for their data collection. Not having a laboratory, but rather a dynamic natural environment, means that the tools and methods of study are different for the field than in a typical lab environment.

Maintaining accuracy and objectivity (non-biased) is a key requirement of science study. It allows scientists to interpret the variation in data, rather than the variation occurring because the data collection was inconsistent or subjective. So scientists use special tools and techniques to try and ensure consistency and objectivity even in variable field conditions. **The primary methods and techniques you will use in BioSITE are described below.**

Observation

Scientists tune their senses to observe the environment. Observation in scientific terms goes beyond plain sight to watching or noting for a scientific or special purpose. Scientists see, hear, touch, and sometimes even taste to record the environment. This differs from typical, every day observation in that scientists maintain objectivity when they collect information. They record things as they are observed, without interpreting the data. For example, a scientist would note: “Approximately half of the oak tree’s leaves are yellow” rather than, “Almost the whole oak tree is yellow because of the heat.” The first note contains objective information and attempts to describe the situation accurately without projecting a subjective view or interpretation about the observation. The second gives less information and makes assumptions about the reason. The scientist will collect data over time and interpret the patterns to determine the cause of the problem. Scientists also observe and note changes over time.

A scientist observes river appearance (height, rate of flow, color, evidence of stream bank erosion, etc.), river channel features (shallow areas, pools, etc.), evidence of human impact (litter, construction, etc.), weather, vegetation and animal life (actual animal sightings, or evidence of animals such as nests, droppings, footprints).

Observation is one tool of many that scientists use to measure and record data in the field. The data they collect using observation may not be data that they can reproduce, nor may it be as exact as that which is measured in standard units (such as a meters or inches) because field conditions are always variable.

Data Collection

Even though each data collection period is brief, what you collect and record over a long period of time will build to create a picture of riparian stream health. Using several types of water quality tests, you will see what types of variations exist in the environment. BioSITE has been collecting student data for several years, so you can log onto BioSITE online and compare your data with that of students in previous years. By observing trends in data, BioSITE students studying the Guadalupe River saw how a plant restoration project led to an increase in the diversity of aquatic insects, an indicator of a healthier creek.

BIOSITE online

www.cdm.org/biosite

Measurement and Sampling
Scientists collect samples from the environment and perform tests to analyze content, composition and quality. These samples are taken from a variety of places to give a picture of the overall area. Types of samples may include water, soil, and vegetation. Samples can inform things like what animals are eating, foreign chemicals in the water or soil, and the rate of growth for plants in the environment.

To make sure that the data is objective, everything is done in an organized manner. Since the environment is dynamic, organic, and variable, scientists impose a method for observing and measuring that gives them a consistent way to count and collect data. You will explore these further in Unit 2.

Journal
Scientists record their observations in a field journal, which will be described fully in Unit 2. Along with these observations they note the time of day, weather conditions, etc. each time they go out. In this way they can gauge their observations against inconsistencies or seasonal patterns over time.

Field scientists often collaborate with others who are studying streams. Since each group or governmental jurisdiction may have a different interest of study, pooling data will give everyone a better understanding of the creek environment's health. By gathering data on the diversity of plants, animals and the composition of the creek, scientists can get a picture of how healthy it is. Journals are also for writing questions and ideas for investigations.

Water Quality
Scientists look at a number of factors that show whether a creek environment is healthy or not. First, they look at the actual physical structure of the stream. The shape of the stream and condition of the stream banks are physical features that determine how much sediment, or eroded soil, flows into the stream channel. Even though it's natural, large quantities of sediment can have harmful affects on some riparian plants and animals.

They also look at what else is in the water. When monitoring water quality, scientists use a number of tests to collect data about what substances are in the water. They perform tests to measure salinity (dissolved salts) and nutrients, such as phosphates and nitrates. Salinity levels vary depending on the season and type of water body (freshwater stream vs. saltwater ocean). Phosphate and nitrate levels often result from human development and waste. Levels of these nutrients can rise as a result of fertilizer, animal waste, and detergents washing into the streams. Measuring the pH of water indicates levels of alkalinity or acidity that can result from pollution from acid rain, industrial pollution and storm drain inlets. Dissolved oxygen, temperature, and turbidity tests are used to measure the amount of oxygen and heat, and the clarity of the water. Imbalance in natural water qualities can result in excessive sediment and algae growth and create unhealthy conditions for fish and macroinvertebrates that live in the stream.

Throughout BioSITE students will record data for five of these water quality indicators and analyze them to assess the health of the stream. You can download charts for recording data along with Water Quality Cheat Sheets from BioSITE online. Or, you can find a template in *Tools for Implementation.*

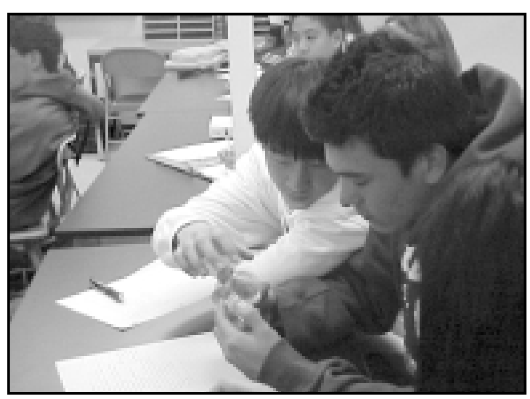
Teacher Training

People often say that the best way to learn is to teach. Why is that? How would you know what was the most important part of a subject to teach someone else? High school students learning about the watershed and water quality will also teach it to students younger than they are. To do this takes not only an understanding of the material, but also an understanding of appropriate teaching methods – how to teach material so students are engaged and learn. It also takes an understanding of how to work with and manage a group of young children – skills that develop over the course of the class. These skills are useful beyond the program because they include the fundamentals of leadership, communication and teamwork.

Teaching is an integral part of BioSITE's philosophy of a community of learners. By sharing knowledge in the form of teaching, people find they understand material better and why it's important. Sharing information is also an important part of science. By sharing information, scientists get feedback on the quality of their work and see how it fits in to what others are doing. Scientists learn more about their work through communicating and presenting it to others who may ask thought-provoking questions or challenge their assumptions. By teaching what you've learned to younger students, you share knowledge and learn something in the process. By sharing your teaching experiences with other high school facilitators, you also deepen your understanding of your learning about being a mentor and teacher while giving your peers more ideas and support to draw on.

"Dissecting the owl pellets in class definitely prepared me for the field. When I heard we would dissect owl pellets I was grossed out and disgusted. I also knew I would have to get over this because if I expressed disgust it would reflect on how the children view the pellets."

– High school facilitator



High school students prepare and practice lessons in the classroom before going in the field with their students

Unit 1: Activity 1: Field Study Methods

In this activity, facilitators will experience making observations in preparation for field studies. Facilitators will practice these techniques throughout the program to gain mastery.

Students learn…
- The art and skill of observing nature
- To differentiate observation from inference and interpretation; and
- The importance of being able to use detail to investigate and interpret field study experiences

By doing…
- Still object observation

Then reflecting on…
- Their first observations as compared to more thorough observations;
- How to expand descriptions to build better understanding; and
- How to derive helpful information and evidence from careful observations

Materials
For groups of 5 students:
- Leaves collected beforehand from field study area (several different kinds for each group)
- Magnifiers
- Journal pages

Getting Started
Begin by prompting students to talk about their observations of common areas at the school site. For example, "Can you give me a description of the auditorium?" Explore the level of detail shared and ask questions about things that may have been overlooked (shape of campus, paths, colors, etc.). Ask students what level of detail and observation would a scientist try to achieve and why. Brainstorm ways scientists are able to record careful observations and how they use this information. All students and teachers in the program will be scientists as well, so practice your observation skills!

Introduce the steps
1. Before passing out leaves, ask students to first draw in their journals pictures of leaves that they can remember seeing at their homes, school, and park.

2. Pass out leaves and magnifiers.

3. Explore, draw and describe in detail.

As each student works on his/her own drawings and records details of his/her leaves, encourage students to write down descriptive words that point out specific characteristics of their leaves.

Model the steps
4. Group students in clusters of three or four; give each group different leaves. Have them share drawings and details and discuss things that may have been overlooked.

5. Have teams make a list of **subjective**, descriptive terms (such as "pretty," "large," that describe the leaves).

6. Have teams make a list of **objective** terms that explain the specific qualities of the leaves (such as texture, color, and shape).

7. Return leaves and set aside.

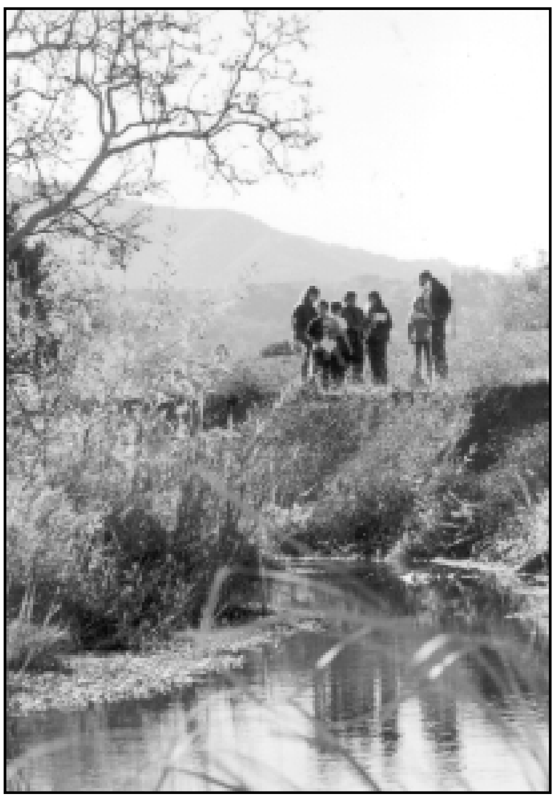
Share observations
- Ask what was challenging.
- Have students compare their first drawings with their final observations.
- Have students identify what the team discovered that was different from their individual observations.
- Give students the opportunity to share their drawings.

Scientific explanations
- Provide leaf charts for class to study different leaf characteristics and terms used in plant keys.
- Share pictures, drawings, or media of native plants and unique leaf structures.
- Discuss leaf adaptations.
- Share journal entries of naturalists (John Muir, Annie Dillard, etc.).

Activity 1 cont'd

Journal reflection
Now that students have explored the work of being a good naturalist and learning from careful observations, give students a chance to test their journal notes and drawings as they explore these bullets for journaling:

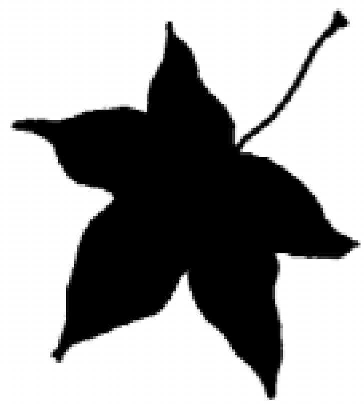
- Have students go back to their observation drawing and try to pick out their leaf from the group of leaves all together.
- In journals, have students collect and draw three leaves from their backyards and record detailed observations with their drawing. Back in class, students can share with each other to see if they may have some of the same kinds of plants.

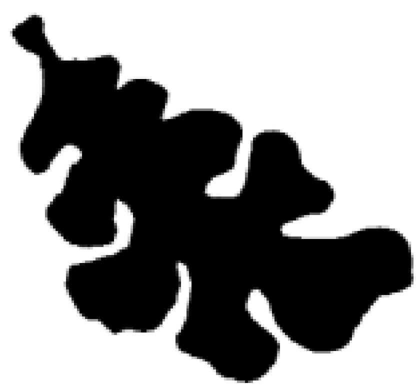


Tips for teachers…
This is a good activity to do at the first-of-the-year training.

You can also do this with an object other than leaves.

You can also do three levels of drawing and/or observing:
1. From memory;
2. After looking at leaves for a limited time (30 seconds) without touching; and
3. With unlimited access to the leaves





Unit 1: Activity 2: Inquiry Study

In this activity, students will deepen their observation skills and engage in the cycle of inquiry, developing scientific questions, providing explanations, reflecting and evaluating.

Students learn…
- Open-ended questioning techniques;
- Inquiry-based teaching techniques;
- Observation techniques; and
- Creature appreciation

By doing…
- Open exploration of snail;
- Careful observations of given various materials; and
- Brainstorming and discussions on process

Then reflecting on…
- The process of generating questions:
  How did they learn?
  What made it happen?
  What next?

Materials
For each student or per team of 2:
- Snail tray and snail
- Cup of water
- Sand paper
- Smooth plastic strips
- Small piece of twine
- Magnifier
- Ruler
- Journal
- Cornmeal
- Strips of leaves, lettuce, apple
- A list of snail facts on chart paper for entire class

Getting Started
Open with simple introduction, explaining that this will be an activity focused on the inquiry process. They will observe snails for about 30 minutes and write observations. Do not be tempted to cut this activity short! Allow students time to develop their own ideas and questions.

Introduce the steps
1. Pass out trays, snails, all non-food items, journals and water to start. Keep snail fact sheet out of view at this point.
2. As students are exploring, facilitate by walking among them, asking open-ended questions such as "What's your snail doing?", "I noticed you gave it water. Why did you decide to try that?" etc.
3. After 10-15 minutes of observation, pass out cornmeal, fruit and lettuce for more experimentation.
4. Students continue observing and journaling. Facilitator continues to encourage and question.

Share observations
- For discussion, ask students to conclude observations and set materials out of reach.
- Ask group, "What did you notice?"
- Write down responses of the group. People often talk only about appearance at first. Ask, "What else besides that?" Sometimes you can add, "Did anyone else notice…"
- Show students snail fact sheet. Compare list of student observations with fact sheet. They will likely have come to the basic facts (or more) through their own inquiry process.
- Ask, "What questions do you still have about snails?" "How might you investigate them?"

Scientific explanations
- Discuss snail facts
- Review learning cycle –
  how our answers lead us to questions

Journal reflection
Now that students have practiced observation skills and engaged in the process of generating questions, have them explore these bullets:
- How was this experience different from or similar to science experiences you have had before in school? (Common differences: got own materials, lots of choices, self-directed, could share information and see what others are doing, able to discover on my own first)
- Ask students to put on teacher hat and think about what the facilitator was doing when introducing materials: asking questions, being actively involved, not drawing conclusions, challenging assumptions, debriefing, etc. Write in journal the elements they want to remember as they become facilitators.
- In journals, have students write down questions to which they still want to find answers. Have students write next steps for finding these answers.

Reading: Teaching Techniques

Adapted from Teenagers as Teachers

Why is teaching part of BioSITE? Why do teenagers teach elementary students about watersheds, ecology, and water quality rather than having their regular teachers teach? That would take less effort, less money, and less time. But BioSITE believes that having teens teach is an essential, enriching part of the program.

One reason is that BioSITE believes that teens learn the material better when they teach. High school facilitators will organize science content into lessons that elementary students can understand and give students both positive and constructive feedback. When faced with the task of teaching students, facilitators have to learn and review the content, distill the important information, reformat it by creating lesson plans and visual teaching tools, and teach it in terms that students understand.

"The thing that works for me as far as getting output from the students is asking questions: 'So what happens to the fish when they spawn?' or, 'Why do we need this to survive?' etc."

– High school facilitator

Another is that changing roles (high school students become teachers, their teachers become observers or students) gives each member in the community of learners an opportunity to behave and learn differently. Relieved of teaching duty, teachers can participate in the lesson by observing and asking questions. They also see and evaluate their high school students in a different light as they take on new roles and responsibilities. As teachers, or facilitators, high school students have a chance to be asked questions rather than to be the ones asking. Elementary students hear a new voice, giving them an opportunity to learn from someone who is not their regular teacher.

High school facilitators often gain a sense of accomplishment and self-confidence as they become successful teachers and as elementary students look up to them in that role. In addition to that responsibility, elementary students also respond to teens as role model. They may engage more in an activity or with the science content if they see teens are interested in the same subject.

Characteristics of 4th Grade Student

To be a good teacher, you will need to be prepared with the material you are going to cover, but it is also helpful to know something about the students. Who are these children? What should facilitators expect from the students they will be teaching? Most of the students in BioSITE are in the 4th grade, typically 9 years old. At this age, they share the following characteristics:

- Admire and imitate older boys and girls;
- Enjoy verbal and physical games;
- Change interests rapidly, jump from activity to activity;
- Like to be with children of the same sex;
- Are active, energetic;
- Are easily motivated and eager to try new activities; and
- Develop rituals and traditions

How might those characteristics translate into how you will approach teaching? Some initial ideas from BioSITE's previous experience are:

- Teens are in a position to be a good role model;
- Students respond well to word games, visuals, jokes and riddles, and codes;
- Long activities should be broken into short pieces, divide work in small tasks
- Groups or partners could be allowed to be all boys or all girls;
- Clear directions should be given;
- Field days should be structured;
- The pace should be kept moving - plan ahead with extra games or lessons to fill in during down time; and
- Group activities are important - encourage routines, rituals and traditions to evolve

Teaching Tips

Now that you know something about what and whom you will be teaching, let's review some strategies for teaching in groups and drawing out the scientific inquiry and discussions you hope to achieve with your students. Throughout the program, the high school leader should try to model teaching techniques that will be useful for the facilitators when they are teaching. Facilitators can model and practice teaching with their peers (in this unit, you will explore some activities and techniques) and then work with children in the field days. At the end of each field day, you will always reflect on and evaluate the experience so that lessons learned can be incorporated into the next day of teaching.

Safety first!
Working in nature and near water has certain risks involved. Student safety should be considered a number one priority, and you shouldn't be afraid to tell students "no" if they are putting their safety or the safety of the group at risk.

Give clear and specific directions.
This helps students be successful in the activity. Telling a student to "mix until it turns yellow" gives them an opportunity to use their own judgment. Telling them only to "mix" means they have to rely on the teacher to tell them when it's done. Also allow children to correct their own mistakes. This allows them to learn from their mistakes and be independent.

Give good feedback.
Part of the learning process is communicating about the student's performance. When you talk with a student, focus on his or her behavior and what was said or done, not his/her personality. Specify suggested improvements for the future and be non-judgmental about the actions you observed. Respond with statements that start with both of these phrases. "I like the way you…" and "Next time it would be helpful if you...".

Anticipate and plan ahead.
Think ahead of time about potential problems or challenges that you may come upon during teaching, and think of possible ways to prevent or resolve the problems. Talk about these potential challenges with the facilitator team before the day elementary students arrive.

Allow each child to participate in a meaningful way.
If there is only one water quality test kit, give other children important jobs like writing data, being a second measurer, collecting water, adding the chemical, shaking, etc. This helps children stay interested.

If the process isn't working, stop and fix it.
Sometimes the activities and lessons that teachers plan don't work for any number of reasons. If this happens, try something different that will still help get the message across: choose a different game; act something out instead of using the teaching board; write in field journals, etc.

BioSITE high school facilitators offer these tips, in their own words, based on their experiences teaching younger students:

Do:
- Try to be interested;
- Plan and write down new games;
- Take time to listen to students when they are talking;
- Try to relate to them;
- Get water quality tests completed first to ensure accuracy and allow yourself enough time;
- Be prepared clothes-wise and also if a water bottle is needed etc.;
- Work with the students, don't just teach. Get them involved. Work with them;
- Be happy to be there; and
- Be prepared to teach.

Don't:
- Don't talk disrespectfully about teachers because they [elementary students] will think that's okay to do;
- Don't wear new shoes out there during the winter;
- Don't ignore them;
- Don't be too hard (scold them for everything) on the students. Help them;
- Don't lose track of time;
- Don't take too much time to get started;
- Don't get too off-track; and
- Don't single out or favor one student over the others.

ROLE-PLAY: TEACHING TECHNIQUES

Try It!
To get you started practicing teaching, try these role-playing and group activities to learn and practice three fundamental teaching strategies to use in the field with elementary students.

1. Open & closed questions
OPEN questions start with WHAT, WHEN, WHERE, HOW, DESCRIBE, and WHY.

CLOSED questions generate YES or NO answers and don't stimulate critical thinking and thoughtful responses that open questions do.

For example,

- CLOSED: "Do you know what the word camouflage means?"
- OPEN: "What do you mean by camouflage?" "What comes to mind when you hear the word camouflage?" "What different meanings are there for the word camouflage?"

To stimulate critical thinking in your students rather than getting guesses or yes or no responses, start questions with:
"To what extent?"
"How might this?"
"Under what circumstances?"
"Why do you think?"
"Compare and contrast"

Role-Play Activity
In small groups, re-word the following questions so that they are more open and draw out many possible responses rather than "yes," "no" or the one "correct" response. Take turns being the question-asker. The question-asker asks a CLOSED question as it is listed below. Each of the other students offers an alternate response that would make the question more open.

CLOSED Questions

- Does anyone notice anything?
- Can you see another way these are different?
- Are there other ways these are alike?
- Is there another thing you notice?

OPEN Questions

- What do you notice?
- How else are they different?
- What are other ways these are alike?
- What else did you notice?

2. Using KWL to Introduce Inquiry
KWL is a teaching model that can be used to encourage purposeful science learning and gather information to help with teaching. It is basically a short form of the scientific method.
K = What I Know
W = What I Want to Know
L = What I Learned

Ideas, questions, and results are recorded on a chart for the whole class or for individual students, first just K and W, then L.

Examples might be:
K = The stream appears muddy
W = Is a muddy stream bad?
K = I saw a frog near the stream
W = Is this their native habitat?

This method provides a structure for any reading, research or investigation. Ideas and questions recorded at the start of the project are reviewed as students offer responses for the "What I Learned" section of the chart at the finish of the project to see if the questions were answered. An additional question, "What new questions do I have?" may be added to start the cycle of inquiry again.

Tips for teachers…
It will make a "why" or "how" question less intimidating and more friendly if you personalize it by asking, "How do you think" or "Why do you suppose"...

K: Activates and organizes what students already know (or think they know).
W: Generates questions for investigation or of personal interest to focus attention during reading or investigation.
L: Helps students reflect on what they learned, sums up findings, and generates further questions

Activity:
You can try this method in a couple of different ways. You can observe an object, such as a plant or an insect and fill in a KWL chart. After observing and writing for a few minutes, students should pair up and compare their charts. Students can also practice this method by brainstorming about a problem in the school or community, or in BioSITE. A teacher or student can facilitate the brainstorming discussion and write student responses to the chart.

KWL is best used at the beginning of the project and during the students' investigations and inquiry (when they can actually refer back to the chart).

3. Hub and Spoke Model

How do you decide whether it is more effective to teach the whole class at one time, or break up into small groups? BioSITE field days are structured to combine both techniques using the Hub and Spoke model.

In BioSITE, the entire class of facilitators gathers together (the HUB) for an overall introduction to the content and organization of the session by the group leader.

After the introduction, small groups of students, each led by a facilitator, spread out (like SPOKES) to engage in the hands-on portion of the session: data collection, conducting tests, observing, recording data, and participating in focus activities.

To conclude, the small groups return to the HUB and share the results of small group activities. The group leader provides a review, answers questions, and assists in drawing conclusions about the day's ecological concepts. Small groups can use the model on a small scale.

Considerations:
- To avoid repeating instructions, have the whole group listen, participate and travel as a unit.
- Make sure facilitators (or elementary students if you're doing this on a small scale from group to individual students) are comfortable with the content and procedure of each activity so they can operate independently in the small groups.
- Provide enough equipment so that each small group can be working at the same time.
- Keep "commuting" time between the HUB and SPOKE groups to a minimum by selecting a fairly compact study area and providing activities of an appropriate length.

Unit 1: Activity 3: The Puzzle of Children

This activity gives students an understanding of BioSITE's philosophy and approach to learning–creating a community of learners.

Students learn…
- What a 4th grader likes and is comfortable doing; and
- Skills for being a positive science mentor

By doing...
- A puzzle of characteristics of a 9 to 12 year old (see Template 3 on page 159);
- Practice of teaching strategies for being a science mentor; and
- Team-building activities

Then reflecting on…
- What is a 4th grader;
- Memories of self in elementary school;
- Team challenges and roles; and
- Individual strengths

Materials

For groups of 3 students:
- Puzzle of children template, (Template 3) with pieces cut out prior to activity so that students have to solve puzzle
- Each student's elementary school photograph

Getting Started
- Begin by asking students if they remember what it was like in elementary school. Encourage students to share stories of kindergarten, 3rd-4th grade, and then as they graduated and went on to middle grades (vary the format of this – some sharing in pairs, some small groups, group circle, juggle). What do they remember? What were some feelings common to all – share list for the class.
- Have students bring in pictures of themselves in elementary school and talk about their memories. Ask them to ask their parents to share a memory of elementary school. Lead a discussion on changes that have taken place over time and commonalities of growing up.
- Create a bulletin board of pictures.
- Have students brainstorm what they think their students might be like.

Introduce the steps
1. Label chart paper with: "What This Means to Me as a Teacher" and "How I Need to Plan"
2. Pass out puzzle pieces that you have photocopied onto card stock for each team of facilitators (3 – 4 per group)
3. Encourage each group to read puzzle pieces and discuss what they mean, bringing into the discussion their own shared memories.
4. Have groups complete their puzzles.

After all groups have completed their puzzles, read aloud to the whole class each behavior/characteristic. Have groups briefly discuss what each characteristic will mean to them as teachers and then share with entire class.

Model the steps
5. Fill in the chart as you lead facilitators through this discussion.
6. "What This Means to Me…"
7. "How I Need to Plan…"

Share observations
- Make a Good Teacher/Bad Teacher Chart and have students share what characteristics they feel teachers need in order to encourage students to be active learners, and which characteristics have a negative impact on students.
- Make a chart of 4th grader characteristics and list to the side strategies that facilitators think may be ways to address each characteristic – and leave room for a third column to add games, strategies, and activities where appropriate.

Activity 3, cont'd

Scientific explanations

Inquiry: Show class examples of inquiry cycles, scientific method, learning steps and styles and discuss how each relates to individual facilitators. Talk with group about the strength of working in a team during scientific investigations.

Questioning: Show facilitators a chart of examples of good questions and poor questions. Discuss how to encourage open discussions and lead brainstorming sessions with their students.

Mentor Strategies: Show students an example of KWL planning. Show students the hub and spoke model as an efficient way to provide time for review, extension sharing, and exploring questions.

Journal reflection

Now that students have discussed the importance of being a positive role model as well as being a successful science teacher, have facilitators reflect on individual goals for the year. Give students time to reflect on exercises and explore these bullets for journaling:

- Students write out things they would like to learn and things they would like to teach during this year.
- Students also write down steps and notes that will help them teach, manage, and engage their students.
- Have facilitators make a three column chart in their journals showing characteristics of 4th graders, their own personal strengths, and strategies that may help their teaching. (Example: 4th graders like to do puzzles/ I enjoy doing new things/ Our team will create new puzzle games to help our students understand new concepts)

High school facilitators work as a team

BioSITE high school students prepare for their job as facilitators

Tips for teachers...

Two great resources for inquiry-based science curriculum and program materials are:

- Biological Sciences Curriculum Study (BSCS) at (www.bscs.org)
- Understanding by Design (UBD) Exchange: (www.ubdexchange.org)

EVALUATION

Discussion

Now that you have completed the Unit 1 Introduction to BioSITE, it is time to reflect on where you are. You are about to embark on exciting research which will both gather valuable information on the health of our environment and teach others in the community about it. Before you start, record your personal interests and goals.

- What environmental issues are most important to you and why?
- Do you currently practice environmental conservation in any way? This could include activities such as recycling, creek restoration projects, taking public transportation, etc.
- How do you expect your practices to change as a result of this program?

Journal

Reflect on your introduction to BioSITE:

- What are you most excited about in the program?
- What are you most concerned about?
- What do you most want to learn? How will you know when you have learned it?
- What personal skills do you bring to the program?

In your journal, write down your thoughts about these questions so that you can keep a record of your experience in BioSITE.

UNIT 2: FIELD JOURNALS AND RESEARCH

INTRODUCTION

By the end of this program, you will most likely know more about your creek site than anyone else – even the local scientists in your community! Does this surprise you? As you meet scientists through your studies, you will begin to see how each researcher relies on others—to collect data, to compare data, to challenge findings, and much more. To understand something so complex as the natural environment takes seemingly infinite time to observe, experiment and question; a lone scientist has limited time and resources to look at every site and detail, so they rely on the pool of information in the scientific community. Because the BioSITE program puts students and teachers in the role of scientists, you will be collecting information on the environment in ways that other scientists can make sense of and share. This is one of the most exciting things about the program and also what makes it very unique. You will find you are not only gaining new skills and knowledge for yourself, but also giving your community—scientists, friends, teachers, younger students, family—valuable information about your own discovery of the environment.

In Unit 2, you will learn about the methods and meaning of the research that is part of this program, and the many ways that it can be shared. Based on our real BioSITE experiences, these are some of the types of things you might find you have to share as a result of your research and work on this project.

- You might find yourself sharing with friends your amazement the first time the elementary students you teach begin to make predictions about the water quality tests you take with them each month.
- With a visiting scientist, you might share the story of finding nesting red-winged blackbirds at your research site.
- With your teacher, you will share some of the new questions and concerns you will have about the results of your water quality tests, what they mean for local wildlife, and what can be done to protect the water quality.
- With elementary students, you may share new confidence and excitement that science can be used by everyone—students, teachers, and scientists alike—to understand the world and make a positive contribution for the future!

UNIT OVERVIEW	
Engage	**Introduction to New Material**
	Introductory Activity: Draw a Scientist
	Reading: Field Methodology and Sampling Techniques
Explore	**Activities to Explore Material**
	Activity 1: Creek Walk
	Activity 2: Surveys & Transects
Explain and Elaborate	**Advanced Study:**
	Readings: Connecting Scientists with the Classroom and Examples of Naturalist Journals
	Activity 3: Teaching with Journals
Evaluate	**Debrief and Reflect**

LEARNING OBJECTIVES

At the end of this unit students should be able to:

- Explain and practice scientific habits and skills, such as developing and asking good questions and observing objectively;
- Understand what it's like to work in the field;
- Exhibit accuracy and reliability in data collection;
- Practice teamwork; and
- Discover that, if accurate and reliable, sharing can lead to more scientific findings.

INTRODUCTORY ACTIVITY: DRAW A SCIENTIST

This activity encourages dialogue about who scientists are and what they do. It also connects strongly with BioSITE's goal of building a sense of the "self as scientist."

Materials

For each student:

- Paper
- Pencil

For teacher or group leader:

- Chart paper, pens and tape (or use the blackboard)

Getting Started

Introduce the activity by asking students to picture a scientist at work. Ask them to do this silently. Ask them to picture details in the scene. What is the scientist wearing? What is the scientist doing? With what tools does the scientist work? After giving students a few minutes to think and visualize, ask them to draw a picture of the scientist they imagined. Let them know they will not be judged on their artistic talent! Stick figures are fine – what is important is to capture all the little details they imagined. They can label them with words if they like.

Tip for facilitators...

You can do this activity in the field without the drawing component. Have students close their eyes and imagine, and then discuss their images of scientists. Move quickly to describing the variety of work that scientists do and comparing the work of BioSITE students to scientists.

Reflection

When students are finished with their drawings, ask students to share some of the details of their pictures. Use the following questions to get the discussion going:

- How many people pictured a male scientist?
- How many were wearing lab coats? Were they holding bubbling test tubes?
- Do any of the scientists have crazy hair? Glasses?
- Did they picture a certain ethnicity?

Quickly brainstorm a list of the key characteristics of this stereotypical scientist (some may even call it the "mad scientist"). Where do they think this stereotype comes from? Do they think it is accurate?

After having this discussion, think about scientists that don't fit the stereotype.

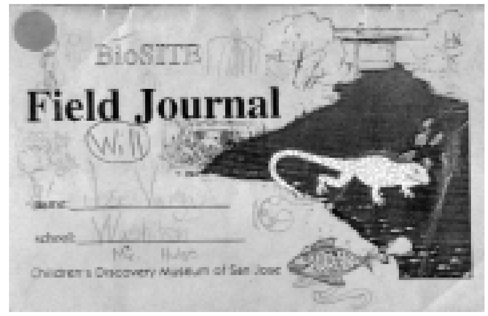
- Did anyone draw a female scientist?
- Did any drawings picture a scientist outdoors?

If anyone drew a scientist that was radically different from the stereotype, ask them to share who they were picturing and why they think they imagined a different type of scientist (often this is because of a personal experience).

Challenge the group to come up with a list of the different kinds of work that scientists do (Think about biologists, astronomers, oceanographers, botanists, etc.). This list could be posted and added to throughout the year. Connect the list with the work that the group will be doing in BioSITE. Ask the group whether or not they think students can be called scientists. Compare what they will be doing in BioSITE with the work of scientists (collecting data, observing a field site, conducting research, etc.). Encourage them to think of themselves as scientists and revisit this conversation as the year progresses.

Reading: Field Methodology and Sampling Techniques

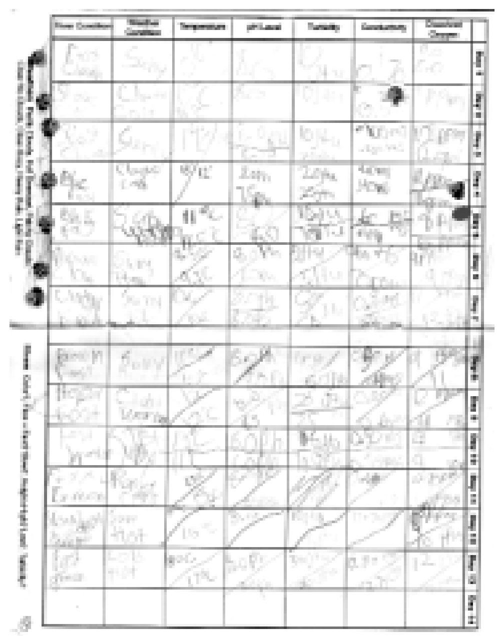
Tools for Environmental Science and Field Biology
Field scientists – namely ecologists and biologists – study the natural environment. Their observations and records about animals, plants, and ecosystems are only useful for science if they are accurate and reliable. To ensure reliability field scientists follow strict guidelines for observing and recording data in the field. The methods and techniques that we'll be using for BioSITE are listed below.



Field Journal

The field journal is an essential tool for recording data in the field. Field scientists write in the journal on a regular basis. The field journal is organized so that information is categorized and can be found easily at any time. The field scientist observes and records other information (such as date, time, location, temperature, wind direction and speed, weather) in addition to data about his or her research subject. This other information may be important for prompting questions and when making assumptions and predictions about the subject.

For example, if a biologist studying river height only measured and recorded river height and nothing else, he or she would not know what factors may influence the height. If the date and weather conditions are also recorded, patterns in the data may emerge over time that suggest river height is higher on rainy days, or that river height is lower in summer months.



Example of data page from student journal

Your field journal should be a bound or stapled booklet so that pages cannot be lost. Write your name, date and the title of the project on the cover. See the sample Field Journal in the *Tools for Implementation* and print out template pages from BioSITE online.

Each time you go out in the field, develop the habit of writing your responses with the date, time, location, and weather conditions before making any observations. Then, you can continue by filling in the data section with sketches; descriptive notes about what you saw, found, or observed; questions you have; and water quality test results.

BIOSITE online

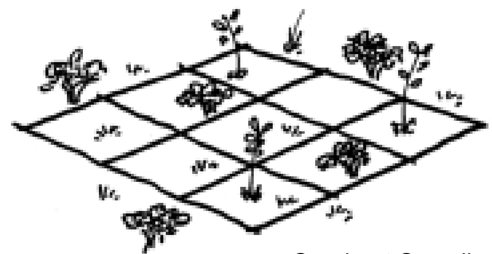
www.cdm.org/biosite

Field Data

Field scientists focus on collecting unbiased, random sampling so as not to impact the objectivity of the data negatively. Collecting both good and bad information will give a more complete picture of environmental quality than recording only the good things, or things of a particular personal interest.

In both observation and measurement, you will want to focus on accuracy and reliability of your data. Scientists take great care to make studies and experiments that other people can replicate. This means they collect data accurately according to standard units of measurement. A journal entry of “The air temperature is 75 degrees Celsius” is more useful to scientists than an entry of “It feels hot today.”

When measuring, we try to be both accurate and precise. **Accuracy** is how close the measurement is to the true measure of the object. **Precision** is when that measurement is obtained a repeated number of times with no variability.



Quadrant Sampling

In the field you may find yourself without standard measuring tools. If this happens, use another object that has a fixed measurement (the length of your shoe, for example, is more reliable than your outstretched arms). Then you can translate the dimension into units (feet/meters) in your journal.

Field Sampling

Quadrant Sampling

This technique is used to measure coverage of plants and/or organisms. A grid of known size (such as 50 feet x 50 feet in 5 foot increments) is laid out, and all of the organisms and plants are counted within each square of the grid.

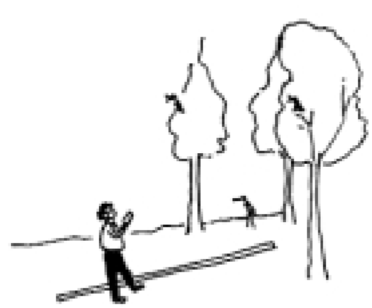
Line Intercept

Line Intercept

This measuring technique is also used to measure coverage of plants. Lay a measuring tape on the ground between two points and count all the individual plants that intersect the tape at the base of the plant.

Strip Census

To count birds or larger mammals, a strip census is used. Instead of counting what intersects the measuring tape, walk along the tape line and record what animals you see in the distance.



Strip Census

Plant Studies

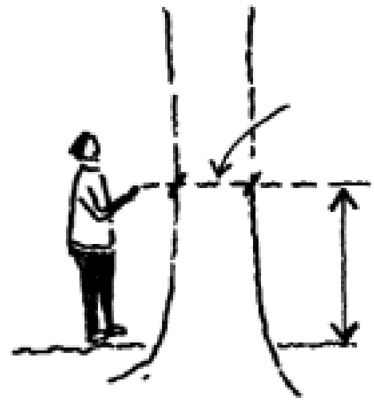
Foliage: A densiometer reading measures the percent of shade cover of the tree canopy over a given area.

Tree Circumference: DBH ("diameter at breast height") is a standard unit used by arborists, specialists in the research and care of trees. Tree diameter is measured at the height equal to the average adult chest height (approximately 1.2 meters high).

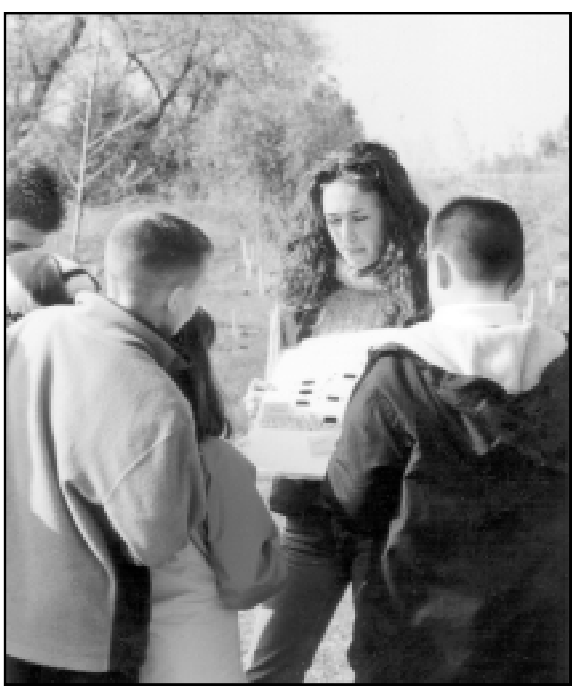
Tree Height: A practical way to measure tree height is by comparing it to a smaller object. For example, you can stand a meterstick on the ground and measure the shadow it casts. Then, measure the shadow that a tree casts (from the base of trunk to the tip of shadow). Use a shadow to height ratio to determine unknown height of tree.

$$\frac{\text{Tree Shadow}}{\text{Tree Height}} = \frac{\text{Meter Stick Shadow}}{\text{Meter Height}}$$

Plant Succession Study: Succession is used to signify forest regeneration. Some plants are the first to grow following disturbance (such as erosion) in an area.



Plant study techniques



Student team charting tree information.

Unit 2: Activity 1: Creek Walk

This activity begins the experience with the creek site. You will walk the creek and use your journal to record observations and first impressions. As the year of study continues, you will add to what you have written and refer to first impressions during later study.

Students learn…
- Characteristics of field study site;
- Basic field study methods; and
- About other watershed study projects

By doing…
- Initial creek walk with guided questions;
- Exploration of study area; and
- Brainstorming for field research

Then reflecting on…
- Field study site issues;
- Past, present and future of study site; and
- Objectives for mentoring experience

Materials
Per pair of students:
- *Creek of Dreams* Guide, see (www.cdm.org/biosite)
- Journal
- Binoculars
- Field packs

Getting Started
Begin by asking students how much they know about the field study site. Ask what kinds of things they are curious about.

Introduce the steps
1. Introduce the field site by walking the area first. Explain to the group that this is a time to gather first impressions. Encourage students to make general observations as they walk the site.
2. From a central location, discuss the big picture: What are the surrounding influences on the study area?
3. Pass out *Creek of Dreams* Guide.
4. Discuss what kinds of observations would be important for each question.
5. Split group into teams.

As students explore the creek site, encourage each individual to write his/her own impressions while discussing each survey question with team partners.

Model the steps
6. Encourage students' answers to be directed toward information about habitat conditions, flora and fauna needs, and influences of human and natural processes.

When students have completed the questions; gather the group for reflection. If time permits, keep students in the study area during reflection time.

Share observations
- Have students work in pairs now, different from the teams who walked the site together.
- Give pairs a chance to discuss the questions.
- Using the evidence they gathered, brainstorm with the group any issues needing further study. Have students write questions in their journals about what they would like to find out.

Scientific explanations
- Share information on other creek studies.
- Share information on local environmental action groups.
- Review characteristics of a healthy creek environment.
- Have students research EPA goals and current issues regarding watersheds and creeks.

BIOSITE online

www.cdm.org/biosite

Activity 1, cont'd

Journal reflection

Now that students have learned about other creek restoration projects – have them return to their own initial study. Working in new teams, have students review the main points of their initial observations, brainstorming and questions they listed in their journals.

- Have students discuss what observations may point to negative impacts on the environment. Have students list concerns about the study area.
- Have students list what observations point to evidence for positive conditions of the study area. Have students list goals to support or improve the quality of life for the natural community.
- Have students visit another creek site or natural area, and write in their journals to compare with their observations of the study site. Have students list human factors that have made the two natural areas different from one another.

Once they are finished with these reflections, they can take time and further reflection to "improve" their journal entries by adding more details. For example, add watercolor or sketches, draw simple maps or diagrams and reflect on what they wrote earlier.

Tips for facilitators…

- Time to explore is most important, but also the greatest challenge in this type of study. Plan ahead to help the elementary students focus on a few survey questions that have the most impact.

- Over the field study year, you will be able to address all of the issues, but for the first journal study along the creek, one or two topics will be all you can cover.

- Assist elementary students in making connections between observations and your overall discussion of habitat issues and field study possibilities.

Unit 2: Activity 2: Surveys and Transects

Students learn…
- Inventory methods;
- Field survey techniques; and
- Mapping techniques in order to be able to represent data graphically

By doing…
- Surveys;
- Transects; and
- A base map of the field study site

Then reflecting on…
- Types of natural features that contribute to good field studies;
- Materials and methods useful for current site study; and
- Importance of quality data

Materials
For each team of 2
- Variety of maps from different places
- Map of study site
- Aerial photo of study site
- Field map paper
- Meter tape
- Journals

Getting Started
Begin by asking what students would like to learn more about during their field study. Remind them of their creek walk earlier. Review what they discovered and what questions they still have. Introduce the steps
1. Show students different maps and give them time to explore them.
2. Brainstorm the idea of mapping the environment to include not only quantitative information but also qualitative information, for example what students feel about the field site.
3. Discuss the importance of sharing their knowledge of field study with the community to build an awareness of how humans impact natural communities in both positive and negative ways.
4. Make a list as a class of essential elements for a field study map and a list of possible features to illustrate on the map so that it fully describes the field site and its relationship to the community.

As students explore different maps and create their list of possible features, give each team a large piece of paper on which to draw out their ideas. Encourage teams to make several drafts to show all their ideas, what kinds of information they hope to include over the entire period of field research, and how information will be pictured. Plan field time to introduce the basic techniques of collection data for their maps as described below. Good sample data is available in the *Streamkeeper's Field Guide* reference section, or check *BioSITE online*.

Making a base map is the first step in collecting data for your field site map. A base map includes information on distance, direction and detail of natural or human elements found in the field. It contains a scale, key or legend, and a compass rose for telling direction. Be sure to include the boundaries of the study area and several landmarks to serve as basic reference points.

Tips for teachers...
This could ultimately become a portfolio assessment piece to be mounted and with credit given to student artists.

Students displaying the site map they created

Activity 2, cont'd

Model the steps

Base Map:

5. Pass out map paper and teaching boards.
6. Review what needs to be included in base map.
7. Help students determine N-S-E-W with and without a compass.
8. Students will learn their individual pace length in relation to a measured 10 meter length so that any time they want to determine a distance in the field all they would need to do is walk, or "pace," it off.
9. Measure out a 10 meter length and have students walk it several times to determine the average number of steps it takes each person to walk a ten meter distance.
10. Students record their individual pace/10 meters. A person of average height may take 15 steps (15 steps/10 meters = 1.5 steps per meter). A taller than average person may take only 13 steps (13 steps/ 10 meters = 1.3 steps per meter). Record pace in journals.
11. Have students make a key for the main details of the base map (e.g., stream, tree, rock).
12. Have students mark a distance on the map (from tree to rock) and include scale conversion reference at bottom of map (for example, 10 centimeters = 14 paces = 100 meters).

As students are working on their maps, walk through the study site and visit each team to help with map information. Remind students of the three main components of a base map: distance, detail, and direction. As time allows during this phase of training, demonstrate with students how to complete other surveys and transects to add data to their base maps.

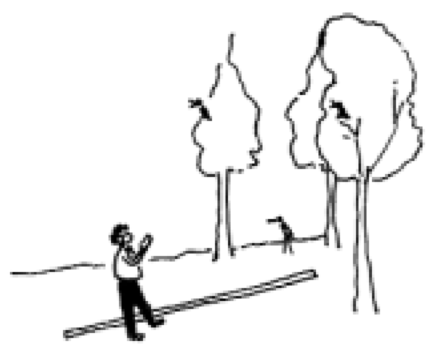
Line Transect:

Have students measure out a 100 meter line anywhere in their study area. Have students note the location of start and finish and direction the line points toward on their base map. Have students walk along the line and at every plant intersection, record type, description (if known), and measurements of vegetation.

Strip Census:

Have students measure out a 100 meter line anywhere in their study area. Have students note the location of start and finish and direction the line points toward on their base map. Have students walk along the line and at every 10 meters record what birds they see along an imaginary line perpendicular to their transect. Have the students record type (if known), description, and behavioral observations of each bird.

Line Intercept

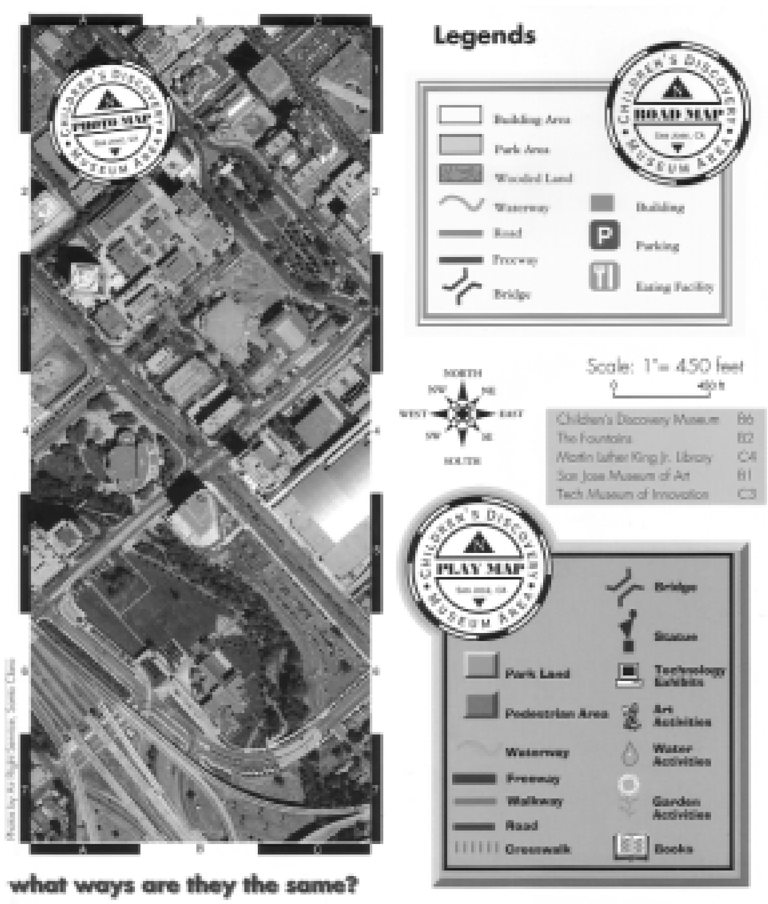


Strip Census

Activity 2, cont’d

Share observations

- Display maps in classroom as often as possible.
- Encourage students to be creative in how they add details to their maps, but most important is to be accurate in collecting measurements and quantitative data as well as qualitative data.
- Have groups share their journal notes with other teams to discuss challenges and successes.



Scientific explanations

- Share with the students how to read information (topography, latitude and longitude, key symbols) on different types of maps.
- Show students data from a local survey of plants, birds, stream flow, etc.
- Show students data collected and pictured from a line transect and plot transect.

Journal reflection

Now that students have explored maps and discussed their team goals for the map project, it’s time to start practicing skills and recording their efforts. Students can practice in journals in the following ways:

- Have students complete a small scale map in their journals.
- Have teams create a map plan in their journals and list what they hope to include on maps.

Reading: Connecting Scientists with the Classroom

Throughout the program, the BioSITE teacher will invite practicing scientists into the classroom to talk about their work. The broad topics of water quality and ecology that you are studying in BioSITE relate to the work of science professionals in many types of careers. For example, one visiting scientist may be a chemist who performs detailed water quality studies using technical equipment in a laboratory. Others may be field biologists who investigate the seasonal activities of small mammals. An ornithologist, who studies birds, could present her work on human impact on the diet of owls. Wildlife and restoration ecologists may present research on preservation and conservation efforts in the riparian ecosystem, such as how to increase salmon populations, or how riparian forests regenerate after natural impacts, such as fire and erosion.

Your teacher may also bring in scientists to talk about the nature of their work itself, regardless of the topic they study. Inviting scientists to speak about the role of women and minorities in science, the range of options for careers in science (field scientists, government jobs, laboratory work, university professors, etc.), or the skills and processes of science itself can be helpful and inspiring as you begin authentic scientific study yourself.

Questions, Questions, Questions

Consider the questions you might have for visiting scientists based on their life experience or the content at hand. As questions come up throughout the program, ask them! And jot them down in your journal to remember for the next time a scientist visits. These visits are unique opportunities to feed your curiosity about subjects of interest to you, or about questions or problems you're experiencing in the field. The people who come to visit your classroom will be very interested in helping and encouraging young scientists. Your questions will make them feel valued and appreciated.

The Nature and Processes of Science

Though they might specialize in a wide range of topics, scientists share a way of thinking and processing information that distinguishes their profession from others. Science is open-ended, but scientists predict theories that can be tested, and then work with expectations and observations towards that theory. Theory gives scientists a framework, or focused way in which to think about their study.

Examples of visiting scientists and their presentations to BioSITE students:

Rick Austin, Vegetation Specialist for Santa Clara Valley Water District Restoration Project (Plant Restoration Project Overview)

Kevin Murray, State Water Regional Control Board Watershed Project Creek Walk (Watershed Restoration Policies)

Jamie Alonzo, Fisheries Biologist (Hatcheries vs. Natural Populations of Salmonid Species)

Marilou Seiff, Marine Biologist (Invasive Species and Mitten Crab Survey)

Laura Seldon, Environmental Studies Student (Lake Tahoe Watershed Issues)

Dave Johnston, University of Santa Clara (Bat Survey Research in Guadalupe River Watershed)

Virginia Robinson, Clean Streams Clean Bay Project (Monitoring PCBs and Mercury in Guadalupe River Watershed)

Kathy Machado, Santa Clara Valley Water District (Almaden Fish Ladder along Guadalupe River Watershed)

ASK SCIENTISTS WHAT YOU'RE CURIOUS ABOUT!

"How do scientists know when they've collected enough data?"

"How do scientists choose a good question?"

"What do scientists like about working in the field and in the laboratory?"

By now, you have probably already learned this as the scientific method, in which the method for solving a problem is to ask questions, determine a hypothesis (a testable theory), test the hypothesis, evaluate whether the hypothesis is true, and ask questions again. How does that actually work? What do you have to do to make this happen? The core scientific thinking processes, as outlined by the Science Framework for California Public Schools (1990) are:

- Observing: Gathering objective information. Scientists ask, "Tell us what you see and hear," and "Give us information about its size, shape, and properties."

- Communicating: Conveying ideas through social exchanges. Scientists present the results of their observations to an audience or small group for discussion. Scientists make their data available to others by plotting data on a graph and drawing pictures of what they see.

- Comparing: Pointing out similarities and differences. "How are these alike and different?" and "Which is smaller/larger, wetter/drier, softer/rougher?"

- Ordering: Organizing patterns of sequence and series. Scientists ask, "What is the range in the data you've gathered" and "In what order did these events take place?" They further organize, "Give evidence when the pattern repeats itself."

- Categorizing: Considering the patterns of groups and classes. For example, "Put together the objects you think belong together," and "Identify several characteristics you used to classify these rocks."

- Relating: Concerning interactions between things. Questions such as "What is the relationship between an animal, its color, and its predator?" are relationship questions.

- Inferring: Regarding ideas that are remote in time and space, predictions and determinations. "Explain how we know about bird migrations" and "How would you determine how many frogs live in a pond" are examples of inferring. These questions require facts to support the predictions.

- Applying: Using scientific knowledge to solve a problem or give form to an idea. For example, "Design a way to keep an ice cube on your desk all day without it melting."

You can use these too, as you embark on your scientific study. Try to practice these habits of scientists as you pursue the answers to your questions.

"The best thing about this program is learning science in a fun way...in this program I actually learn in a way I like."
– High school facilitator

Reading: Examples of Naturalist Journals

You have started your own journal, and will be using it throughout the program to record your observations. Here are some examples from journals of renowned naturalists. You don't need to copy their style – you will write with your own voice – but notice what they choose to write about and what words they use to describe things. Notice how their observations are noted yet this is not scientific writing. These are good models to reflect on for your own personal journal entries.

Naturalist speaks with students

"Storms are fine speakers, and tell all they know, but their voices of lightning, torrent, and rushing wind are much less numerous than the nameless still, small voices too low for human ears: and because we are poor listeners we fail to catch much that is fairly within reach."

~ John Muir

"For each home ground we need new maps, living maps, stories and poems, photographs and paintings, essays and songs. We need to know where we are so that we may dwell in our place with a full heart."

~ Scott Russell Sanders

"It's not what you find, it's what you find out."

~ David Hurst Thomas

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

~ Aldo Leopold

"…And that is just one step in learning where we really are and how a place works. Learning "how it all works" is an enormous exercise, because we are not taught to think in terms of systems, of society or of nature."

~ Gary Snyder

"If you want to do something, and work hard enough, and take advantage of every opportunity, and never give up, you'll find a way. Follow your dreams. If you really want to do something, don't let anybody tell you that you can't."

~ Jane Goodall

Unit 2: Activity 3: Teaching with Journals

Students learn…
- What is in the journal, its sections and uses;
- How to use a journal with elementary students; and
- How to record data, observations, and use resource pages

By doing…
- Journal scavenger hunt;
- Daily observation page; and
- Resource page

Then reflecting on…
- How to introduce journaling to their younger students; and
- How to use the journal as a teaching tool

Materials
- Journals (Journal pages included in *Tools for Implementation* section and at *BioSITE online*)

Getting Started

Begin by asking the facilitators what students think is important about writing field observations. Talk about memories of places and how pictures help us to remember places and things that have happened in the past. Discuss and share different types of journaling, such as diaries, letters, naturalists' journals, memoirs, etc.

Introduce the steps
1. Have facilitators explore the entire journal.
2. Tell facilitators that they are going to learn what is in the journal by going on a scavenger hunt.
3. The scavenger hunt can be led by one person, or you can pass out cards to facilitators and have each student read one step of the hunt (example: find a page with a plant leaf)
4. Have students explore each section of the journal as they find pages from the scavenger hunt.

As facilitators discover what is in their journals, for each page brainstorm with the class what kinds of activities may go along with each page. Encourage facilitators to think ahead about knowledge they can share with their students for each resource page.

BIOSITE online

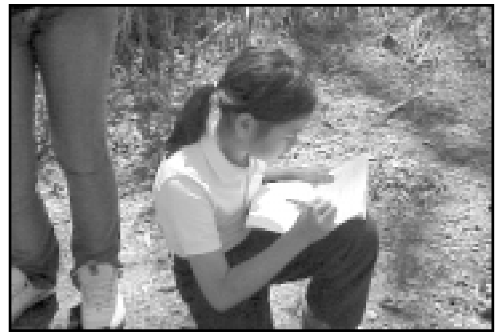
www.cdm.org/biosite

Model the steps

5. Explain each section of the daily field journal page (see page 166) using 5E guidelines (see page 17) as described in the next steps.
6. Discuss how each phase of a field day relates to the daily journal page. For example, the first step is to *engage* your students with an introductory activity that will give them a little information about the field day but generate more questions about what they want to find out.
7. Next, during your *exploration*, have students write and draw about what they are doing. Have them include in more detail the questions they have.
8. After the main scientific exploration, have students *explain* in their own words what happened. Encourage students to use diagrams, labels, explanations of the science content information they have learned that helps to explain what happened and *evaluate* learning.

Share observations
- Working in teams, discuss how they explored at each step.
- Ask questions about how they were learning new things and what they still wonder about?
- Ask how this new understanding might relate to other knowledge they have.

Activity 3, cont'd



Scientific explanations
- Share journal excerpts (scientists' or naturalists')
- Lead a drawing exercise. Practice drawing nature by having students make a labeled, detail drawing of a flower and its parts.
- Use teaching board for charts, diagrams, new words.

Journal reflection
Now that students have had an introduction to journals and how to use them, continue with the 5E guidelines to elaborate and evaluate, giving students time to further review journals and complete journal entries.

Classroom discussions following field days are rich and essential for students learning as a community. Each team experience is different, and students need time to share and learn from each other.

Have students complete the following bullets for journaling:
- Have the class discuss its field journal entries for Creek Walk and First Journal Entry.
- Have students finish their journal pages by writing what they have learned from others.
- Have students explain in their own words why the information for the field day is important and how it can relate to future field days.
- Have students note more questions to be explored.
- Have facilitators visit another creek site or natural area to make a detailed journal entry to share with their team partners. Have facilitators list what observations they feel are most important in understanding the overall health of the area.
- Have teams create a list of most important things to include in field journaling.
- Have students share with partners their journal entries.
- Have students decide who will lead each journal entry section, who will teach using the teaching board, and who will help students one on one in their writing and drawing.

Tips for teachers….
Giving some ideas for writing and drawing at first will help students find direction in their field journaling. Then ask students to decide what else they will include for their first entry.

Practice journaling

In addition to practicing field observation and writing in field journals, high school facilitators should be given a chance to review their elementary students' journals after several field visits (more often if feasible). This is a great tool for reflection, evaluation, and self-assessment. Facilitators get the chance to read over their students' observations and see how the lessons were interpreted.

Facilitators also get the opportunity to write encouraging comments to their students. Facilitators may add questions such as, "What do you think?" Why might this work?" This practice of review has proven to be an excellent way for high school facilitators to evaluate their mentoring skills and to bond with their individual students.

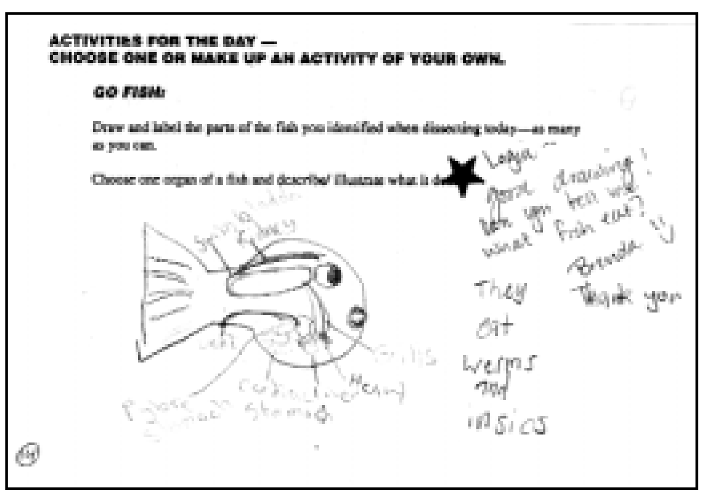
Reviewing student journals

Providing encouragement and feedback to your students is an incredibly important part of teaching. Of course, you will be doing this while you are with them, but you can also support them by writing comments in their field journals.

Because the time you have together is limited, you may not always have a chance to give each student equal attention. Field journal feedback is a great way to recognize each student individually. We recommend reviewing and commenting on journals as often as possible, but if it is only possible a few times per year, even that level of feedback means a lot to the students.

Here are some suggestions based on our experiences:

- Remember that students may forget what you tell them, but a written record can be read over and over again.
- Tell students things you appreciate about them and that make your job easier.
- Save any critical feedback for talking face to face—a written comment can be misinterpreted and result in hurt feelings.
- Avoid generic comments like "Good work!" Write something that shows you really looked at their work.
- Challenge students with questions that you think they may be able to investigate on their own at home or at school.
- Ask students for their feedback, like what activity they enjoyed most, in order to help them reflect on what they did.
- Encourage students to finish drawings or writing that they started in their journal but were unable to finish.
- Provide answers to students' questions, or advice on how to go about finding the answers themselves.
- Try not to label students as one type, such as "the good listener." Praise them for multiple skills.



Example of facilitator's comments in journal

UNIT 3: WATERSHEDS

INTRODUCTION

Get ready to teach—the BioSITE way! With this unit, you will begin to teach and mentor elementary students as you involve them in your research at the creek. As an introduction to studying the creek with young students, in BioSITE we have always asked first, “What is a watershed?” It is not an easy question to answer, but it is one that is very important. If we could help every person to understand the definition of a watershed and how all the activities within a watershed affect the creeks, rivers and, ultimately, the oceans, then everyone could contribute to maintaining clean water supplies for people, animals and plants.

To help you introduce such an important concept, we have chosen one of the most fun and engaging (and effective!) activities to share with your group of students. Together, you will be able to create watershed maps. You’ll even get to make it rain so you can follow the water as it falls into a watershed and flows downstream. In addition to the watershed activity, you will explore other aspects of the “big picture” of water and water quality. These will include identifying the water cycle and discussing effects of geography and human developments, in general, before turning to more specific study of your particular creek and field study site.

By the end of Unit 3, you and your students will have explored where the water in your creek comes from and where it is going. In future units, as you begin to discover more about the amazing variety of animals and plants living within the limits of your study site, we hope you will pause regularly to remember this watershed lesson and how your study site reflects the health of the creek both upstream and downstream.

UNIT OVERVIEW

Engage	**Introduction to New Material** Readings: The Water Cycle and Watersheds
Explore	**Activities to Explore Material:** *Activity 1: Watershed Map Making* *Activity 2: Locate Your Watershed*
Explain and Elaborate	**Advanced Study** Research: Research your Watershed *Activity 3: Pollution Soup* Facilitator Field Day Planning
Experience	**Field Study and Teaching:** Watersheds
Evaluate	**Debrief and Reflect**

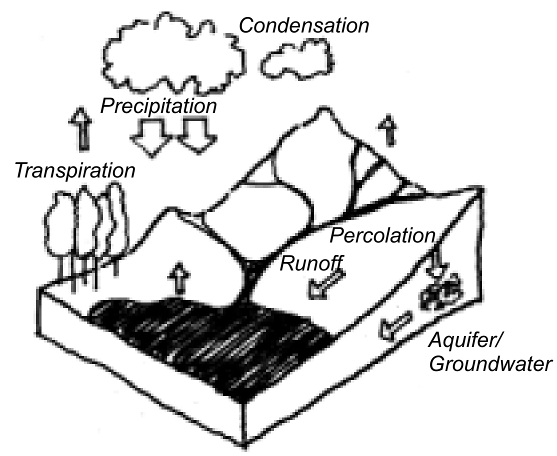
LEARNING OBJECTIVES

At the end of this unit students should be able to:

- Explain what a watershed is and know which one they live in;
- Locate the Guadalupe River on a map, and describe the relationship between the river and other natural features within the Santa Clara Valley basin by mapping or modeling;
- Know the physical parts of nature that make up the watershed;
- Understand how pollution in one area of a watershed may affect other areas downstream;
- Make the connection between the importance of a healthy watershed and living things in and along the creek;
- Understand what processes affect a drop of water as it travels through the water cycle and how this cycle controls the amount of water in our creek;
- Explain (verbally or graphically) the relationship between the water cycle and a watershed; and
- Create a presentation for a broad audience to share knowledge of current watershed issues and general health of the creek.

Reading: The Water Cycle

Exploration of a river may inspire us to ask bigger questions about water like, “Where does it come from? How does it flow? Where does it go?” To answer these questions we look to the **hydrologic**, or **water cycle** – the continuous movement of water from the ocean to the atmosphere, to land, and back to the ocean.



The two basic components of the water cycle are evaporation and precipitation. **Evaporation** occurs when the sun’s energy changes water from a liquid to a gas, or water vapor, which rises into the atmosphere. As the water vapor cools it changes again, through **condensation**, back to liquid form. When water molecules in clouds combine together, the liquid water falls back to earth as **precipitation** in the form of rain or snow.

Once precipitation falls, it can take one of many routes. If it falls in the ocean, it will evaporate again and return to the atmosphere. If it falls in another water body such as a lake, pond, or stream, it will flow or seep toward the ocean. It may fall on a porous or **pervious** surface like natural, uncompacted earth, where it will **percolate** down through the spaces between soil particles in a process called **infiltration**. In the soil it becomes **groundwater**, collecting in underground reservoirs called **aquifers**. If the aquifers are full, water may seep to the surface as springs, which feed rivers or streams.

Water Web Sites...
www.globe.gov
www.epa.gov
www.projectwet.org
www.siue.edu/OSME/river
More sites are listed on page 189 of the Additonal Resources section.

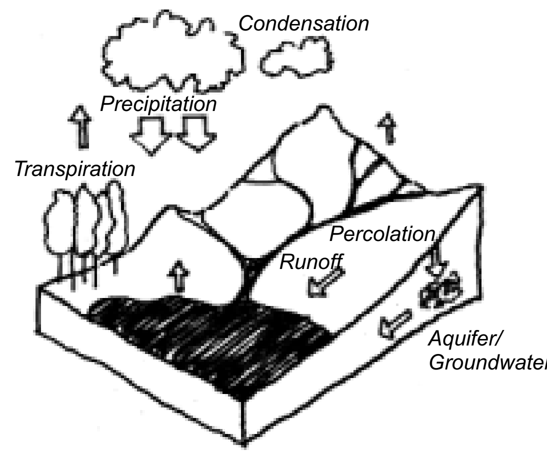
Water that stays in the soil may be soaked up by plants through their roots. This water is used by plants in the process of photosynthesis, and becomes a waste product – water vapor—that is returned to the atmosphere. This process of water moving through plants from their roots through their leaves into the air is called **transpiration**.

If precipitation falls on a hard, **impervious** surface such as concrete or asphalt streets where it cannot infiltrate or soak in, it will run across the surface as **runoff** and flow toward a creek, river, or the ocean. Runoff can also occur when the rate of precipitation exceeds the rate of infiltration. When this happens, pervious surfaces become saturated, holding so much water between soil pores that they cannot absorb any more. Water will move across the natural surface as runoff, usually toward a stream or creek before it flows to the ocean. Runoff can carry pollutants with it as it discharges into rivers or other water bodies. Some pollutants are natural and some are generated or made worse by human development. Pollution that can be traced to one source, such as an industrial plant or sewer pipe, is called **point source pollution**. Pollution that has no single source, but rather comes from a variety of surfaces is **non-point source pollution**.

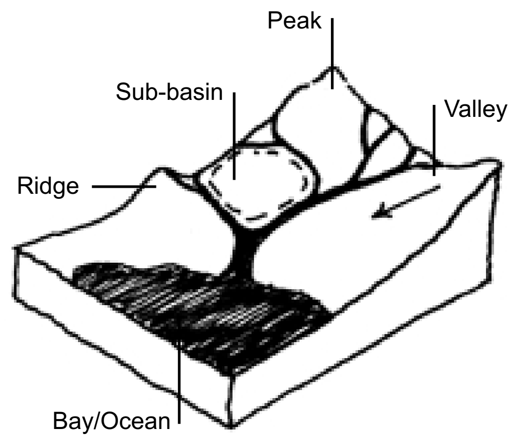
Water may pick up loose **sediment**, or soil particles, as it flows along a natural surface, carrying it along on its journey to a stream. Depending on the water's rate of flow and the soil's composition, this can cause **erosion** of the ground's surface. When sediment is deposited into the stream, this alters the natural state of the stream and in excessive quantities can be considered a form of pollution. Plant material, or **vegetation**, affects this process in a couple of very beneficial ways. Plant roots "knit" the soil together, reducing the potential for erosion. Vegetation also slows the speed of the water's flow across a surface. This reduces the amount of sediment picked up by the water and also allows water time to infiltrate into the soil.

Reading: Watersheds

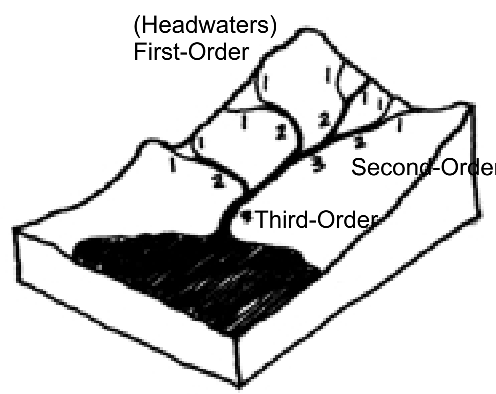
We know that the size, rate of flow, and water quality of rivers are influenced by the major components of the water cycle: evaporation, precipitation and runoff. What geographic and physical factors might influence rivers? If given the term **watershed**, what could you assume the word means by breaking it down into two parts: *water* and *shed*? We know a shed is used to house or store things. It also means to get rid of. If we apply this concept to water, the term **watershed** identifies the physical boundaries of a small-scale water cycle that sheds water from the land into a stream or lake. The watershed is also called a **drainage basin**.



Precipitation falls onto the earth's surface where it runs downhill, across forests, fields, and parking lots to streams and creeks. Several creeks and streams flow together to form a larger body of water, a river. This river then flows to the ocean or bay, where it will return to the atmosphere through evaporation and fall to earth again as precipitation.



The U.S. Environmental Protection Agency defines a watershed as "the geographic region within which water drains into a particular river, stream, or body of water." If you look on a map of your geographic area, you can identify the boundary of a watershed by looking at mountain ridges that surround your rivers. Since water doesn't run uphill, the high elevations of mountain ridges and peaks define the boundary between watersheds. Water that falls on a mountain ridge will flow down one side or another, collect with other water and flow to the ocean.

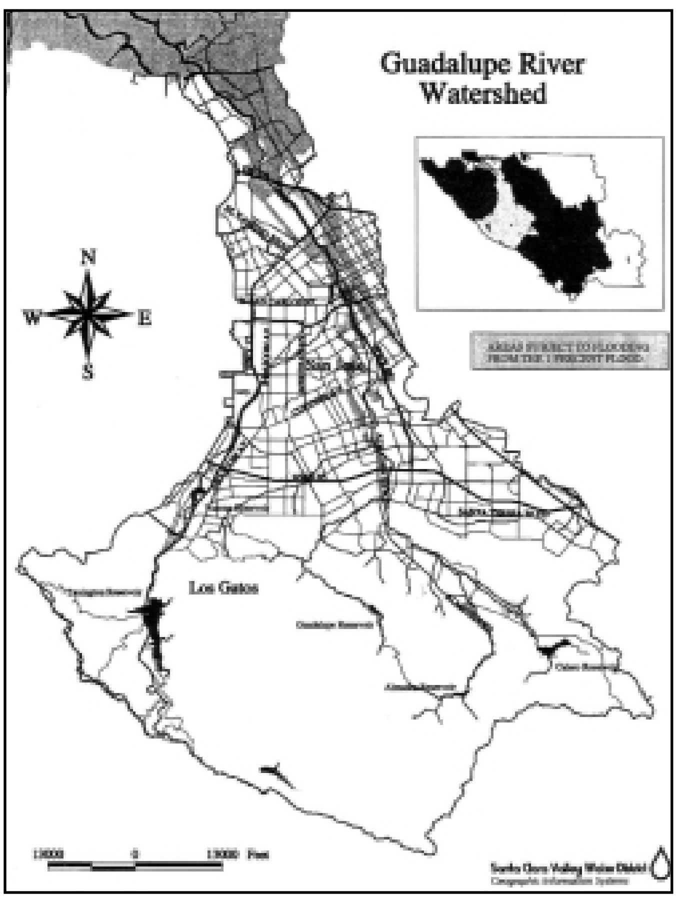


The watershed contains water in different forms – a tributary, a main channel, and a delta. A **tributary** is a small stream or creek. The watershed is made up of networks of tributaries, each of which flows into a larger stream. They are identified by **stream order**, determined by the order of other tributaries that have contributed to their flow. The start or **headwaters** of a stream, with no other streams flowing into it, is called the *first-order* stream. Two first-order streams flow together to form a *second-order* stream. Second-order streams flow into a *third-order* stream. This labeling continues until the streams deposit their water into a larger body of water, such as an ocean or a bay. Can you identify the stream order of your local creek or river?

Identifying stream order can be useful when studying water quality. What happens to tributaries affects higher-order streams. Higher-order streams can contain pollutants that originate in each of its contributing tributaries.

The tributaries of a watershed flow together to form the **main channel**. This large river carries all the tributary water to release in the bay or ocean. The size of the main channel gets increasingly bigger as tributaries join and contribute their water but physical size, soil permeability, runoff and climate all affect the channel size. The river is flanked on either side by an area of shrubs, trees and vegetation that form the **riparian zone**. Within this zone is a complex interaction of flora, fauna and aquatic organisms.

As the main channel or stream reaches the bay or ocean, it often slows down and deposits the sediment it has been carrying before the water joins the ocean. In order to move around the build up of sediment, water breaks apart into smaller streams that “fan out” into a branching pattern called a **delta**.



Unit 3: Activity 1: Watershed Map

Students learn…
- What a watershed is, how it collects and stores water;
- How the natural features of the land influence water flow through the environment;
- How water is found in many places; sometimes moving, sometimes captured; and as a result may be unavailable to living things; and
- How pollution moves within a watershed

By doing…
- Creations of their own miniature relief map;
- Plans about areas of human impact; and
- Observations of results of "rain" on their watershed

Then reflecting on…
- How the water cycle provides water to land, air, and plants;
- How natural factors affect the availability of water; and
- How humans influence the water cycle and quality of water available

Materials

For each student:
- 8.5" x 11" white paper

For each group of 3-5 students:
- Water soluble markers (green, blue, brown, red and others)
- Spray bottle (that can make a strong mist)
- Table covering (laminated map or cafeteria lunch tray)
- Rags for clean up

Getting Started

In this activity, everyone will transform a piece of plain paper into a detailed relief map. Before beginning, discuss the differences between a flat map, topographical map, and relief map.

Begin by asking what the students think the word "watershed" means. Explore ideas about "sheds" and water "holders." Ask questions to encourage students to examine what they know and what they think they know. Show students a map of the country or area in which you live, showing creeks and rivers areas; mountains and valleys. Ask students to think of names they would name the watershed in which they live.

Introduce the steps

When facilitating, be sure to make your own map as an example, demonstrating each step just before the others try it.

1. Crumple a piece of paper into a small ball first. Then gently pull apart to open, but *do not* smooth out flat.
2. Have students set their crumpled paper on a table and imagine it as a miniature range of mountains and valleys.
3. With brown or black markers trace the "ridges" of your "mountains" starting at the tallest "peaks". Give people time to trace most major ridges, then with blue markers trace the lowest points between all the ridges. This is where rivers and creeks flow. What happens at the lowest points where the creeks meet? Draw in your freshwater lakes. After most people have traced the main waterways, add tributaries. Add green to represent riparian plants – the vegetation that grows adjacent to a river or creek.
4. Give students time to work on the watersheds. As students are creating their miniature relief maps, lead a discussion to help them observe the unique features of their landscapes.

Model the steps

5. Finally, use red where people would develop land, build houses and businesses. Discuss the ideal location to build: On the lakeside? Near a creek? In the mountains? Why are different locations preferred? What might happen to water quality as a result of human presence?
6. Have students take a close look at the maps. How are the maps similar and different? Do any of them remind them of real mountain ranges? What do students think would happen if it rained on their mountain ranges? Where will the water flow? Examine the houses – are any sitting on floodplains?

7. Before making it rain on your maps, discuss the term watershed. A watershed is the entire land area around a stream from which all runoff ends up in that same stream. The boundaries of a watershed are naturally ridges. On one side of the ridge, the water ends up in one creek, and on the other side of the ridge, the runoff ends up in another creek.

8. The ridge is the boundary between the watersheds of two creeks. Point to specific spots on the students' maps and ask the group to predict where the runoff will go. Observe which stream it feeds into. The spot you pointed to is a part of that stream's watershed!

9. Now it is time to see if your predictions are correct. Place your map on a tray or laminated sheet. Before handing out water sprayers, demonstrate how to make it rain. Hold one up *well above your map and make the sprayer spray like rain, gently falling from above.* When finished with the demonstration, hand over the sprayer and let a student make it rain! It will take several spurts of water before the creeks start to flow, so remind the group to WATCH CAREFULLY! Ask students to call out when they see the first creek flowing. Have students continue with the sprayer(s) in turns.

10. On maps, use water-soluble red ink or food coloring to represent pollution. Add a few drops of red food coloring to a mountain in your watershed and watch what happens to the pollution after rain.

11. Ask students to discuss the following:
    - Did the flow of water go where they predicted? Any surprises?
    - Did pollution spread from a "dry hillside" into the water system?
    - How would this pollution affect the plants and animals in our watershed map?
    - How can we prevent pollution from spreading in our creek?

Scientific explanations

- Show a diagram of the water cycle and discuss the ways in which water flows from water to air to land and back to water.
- Write the definition of "watershed."
- Show diagrams of transpiration and discuss unique structure of leaves.
- Show composition of a water molecule and discuss unique characteristics of water.
- Introduce the term "non-point source pollution."

Journal reflection

Now that students have explored the topic of watersheds through their own creations, have students interpret their understanding of how water moves through the natural environment and what the potential results or consequences are.

Have students engage in the following bullets for journaling:

- Draw the water cycle in their journals.
- Draw their watersheds and place arrows to show the flow of water. Include labels to show riparian zones and potential sources of pollution.
- In journals, have students create pictures of three natural areas (a beach, a park, and a mountain canyon). Have students label where different steps of the water cycle occur in each area. The more detailed the picture, the more complete the water cycle!

Students make watershed maps

Unit 3: Activity 2: Locate Your Watershed

Students learn…
- Where the streams of their local watershed are located; and
- What natural features exist in their local watershed

By doing…
- Explorations of topographic maps; and
- Finding first order streams, rivers, reservoirs

Then reflecting on…
- The local water supply; and
- Environmental issues facing the watershed

Materials
For each group of 3:
- Laminated topographic maps of watershed study area (available from United States Geologic Society (USGS))
- Water-soluble markers (shades of blue)
- Small sticker “dots” to mark local landmarks
- Spray bottles and rags for clean up

Getting Started
In groups, students review a laminated topographic map of the local watershed. Ask students if they know what information a topographic map provides that is different from other maps. Give students time to explore their maps, talk about what they think different features of the map are (creeks, forest, hills, lakes) and why (how do the map symbols relate to the natural features?). Have students try to identify their favorite places on the map.

Introduce the steps
1. After initial exploration and discussion, explain topographical lines and how to interpret them.
2. Point out to students a mountain top, a body of water, a steep canyon and other topographic elements
3. Show students the path of a stream from mountain top to valley to lake or bay
4. See if students can find other examples of topographic features

Model the steps
As students are exploring their maps, encourage students to ask other questions about map features. Remind students of the watershed maps they created and explain that they will now trace the real paths of their local waterways as they can see them on these maps.

5. Pass out markers and tell students to find the uppermost end of a stream or river. This will most likely be by a ridge.
6. Tell the students (or teams) to carefully trace the path of the water from upper elevations, through valleys, through developed areas and then to lakes or bays.
7. After finding a river’s outlet to a body of water, have students see if they can follow their tracing in reverse to determine if they found all the tributaries.

Share observations
- Ask students if there are any places where the water seems to disappear and later reappear? Ask students what this may mean (*culverts underground*)?
- Ask students if they notice any pattern to the locations of reservoirs or treatment plants (*always before water enters a bay, near the mouth*).
- Challenge students to find the ridgelines, or boundaries, surrounding one watershed.

Scientific explanations
- Show diagrams of stream orders and identify tributaries.
- Show diagrams of watershed formations and other local maps (such as trail maps).
- Discuss formation of mountain ranges and identify local peaks.

Activity 2, cont'd

- Discuss different factors that influence the health of the entire watershed comparing different areas: erosion of streams to increase sediment levels at lower regions; mountain peaks with radio stations or other development that introduces contaminants at higher order streams.
- Show sample watershed survey forms (a good reference is <u>Measuring the Health of California Streams and Rivers</u> by Jim Harrington and Monique Born or the <u>Streamkeepers Field Guide</u>).

Journal reflection

Now that students have explored the topographic maps of the local watershed, have them reflect on their new knowledge and work on these bullets for journaling:

- Ask students to reflect on the ways their watershed maps were similar to real topographic maps and see if they can draw a topographic map that shows all the landforms that are included in a watershed.
- Ask students to draw different kinds of stream flows that may be found in steep canyons, rolling hills, and flat land areas like a central valley. See if students can write descriptions and make a list of features to show how these water flows may be different.
- Ask students to make a line drawing of the watershed pattern seen in undisturbed creeks on a topographic map and label headwaters, first-order streams, second-order, etc.
- In journals, have students write the name of the creek closest to their house. Have them research to find out where it begins and where it ends, and if any other creeks are close by (you can have park and trail maps on hand). Have students draw this creek system in their journals to bring back into class and share.

See www.valleywater.org for more water songs and watershed education information provided by the Santa Clara Valley Water District.

The Santa Clara Valley was called the "Heart's Delight."
Vegetation and wildlife were everywhere in sight.
The valley's changed a lot in the past two hundred years.
Running out of water is just one of our fears.
The Silicon Valley is what it's called today.
One point six million people living in the south bay.

In Santa Clara County there are many watersheds.
The mighty Guadalupe is a well-known one, it's said.
It stretches from the mountains, down through the valley floor.
San Jose and Los Gatos are its towns, there are no more.

Five reservoirs are found within this watershed.
The Guadalupe flows into a creek and riverbed.
Almaden and Calero spill in Alamitos Creek.
Lexington and Vasona are the last that you might seek.

The Guadalupe River's in this large watershed.
You've got to climb Mt. Umunhum to see the river's head.
Lots of creeks together make up the water flow.
Canoas and Los Gatos are just two that you might know.

It flows near twenty miles and often changed its bed,
Creating special places within the watershed.
Its area for drainage is very big to see,
One hundred seventy square miles in reality.

Ohlone natives used the river as a water source,
Hunting, swimming, fishing, all along its course.
They lived throughout this valley for five thousand years,
Making tule boats and eating shell fish and deer.

Anza named the river for his patron saint.
In seventeen seventy six, there wasn't one complaint.
And then the Eastern settlers all began to come,
Looking for a chance to raise a handsome sum.

San Jose was settled along the Guadalupe banks.
California's first capitol, the oldest town, it ranks!
Highway Eighty-Seven is in the river's flood plain.
That's why the highway's flooded when we get a lot of rain!

This river's now polluted. The miners didn't know.
New Almaden Quicksilver Mine adds mercury to the flow.
Can't eat the fish! Don't swim in there! It's very sad to see,
The river once so rich with life, no good for you and me.

The water in the river bed flows to Alviso slough.
Some water is diverted to a perc pond or two.
In all, the water percolates down into the ground.
The aquifer is waiting for any water that is found.

An aquifer is pebbles, mostly gravel, rocks and sand.
It takes a hold of water, and keeps it in its hand.
The aquifer that's centered throughout our valley floor
Is formed in three sub basins, don't you try to count to four.

Santa Clara and Coyote, and Llagas, that makes three.
It's not a lake or river or anything you see.
The water is just held there, until we pump it up.

Research Your Watershed

For in-depth study, students can take on research projects to learn more about their watershed and surrounding community. Students can then present to peers and local community groups to share their knowledge.

Materials
For groups
- Information on local water resources (maps, department of water publications)
- Information on local water issues (articles, pamphlets, publications)
- Information on local climate
- Topographic map(s) of local creek and regional watershed
- Articles about creek, pond, or ocean restoration/clean-up especially with students involved.

Note: See Resources section and BioSITE online for links to information.

It's not likely that you can understand everything about your river by fieldwork alone. Students explore many resources that are available for learning about a local watershed. Have students write questions they're interested in and that they want to know about their watershed. For example, "What is the average annual rainfall in your area?" How do the maximum and minimum amounts of annual rainfall in your area compare with other places in the year? What animals live near the river? What is the source of drinking water in your town? What are the most common problems for water quality in your local rivers, lakes, and water bodies?

You might decide to research specific events in the history of your community that have affected your creek. In our Santa Clara Valley Watershed, some of the events and history we have discussed include:
- Quicksilver mines
- Mount Umunum
- Environmental restoration projects

Some suggested topics that you may want to consider are listed to the right.

"I feel like I'm doing something that a lot of other people aren't...like it's a special thing... [getting to know] the environment and being involved with it and trying to help something."

– BioSITE student

Some Research Topics:
Watershed History--
How life has changed over time.

Current Issues--
What is impacting our communities.

Local Organizations--
What the community is doing to address the issues.

Projects by Students--
Action focused on public awareness and environmental health.

BIOSITE online

www.cdm.org/biosite

Unit 3: Activity 3: Pollution Soup

Students learn…

- Local watershed history; and
- Important events over time that have influenced the ecological balance of a community

By doing…

- A demonstration of how “Clear Lake” has been influenced by changes over time; and
- Discussion of the important decisions humans have made to balance the impact of development and the quality of the environment

Then reflecting on…

- How we have been able to understand the impact of our development; and
- What solutions can help move toward sustainable communities?

Materials

For each group of 3 students:

- Pre-made set of 10-12 index cards showing some major milestones of the local watershed. (See sample below)
- Large, clear plastic jar with screw top, 3/4-filled with water
- 10-15 small clear plastic vials filled with liquids and materials and labeled to represent possible pollutants introduced into the environment at the milestones shown on the deck of cards (plant waste = leaf litter; farming = coffee grounds; gold rush = gold glitter; cleansers = food coloring; oil = oil)
- 11” x 17” Activity Sheet with the letters: **S O L U T I O N** written vertically along left-hand side

Getting Started

Begin by asking the students what they think it might have been like 500 years ago. 200 years? Ask students if they have ever heard their grandparents talk about what it was like when they were children. Then tell the students they are going to participate in a puzzle to put the past in order as things occurred.

Introduce the steps

Students receive a set of index cards depicting local historical events that have impacted the development of their watershed. Cards should <u>not</u> be in correct order.

1. When students first receive the cards, ask them to find one or two they are certain occurred before anything else.
2. Have the class agree on the first couple of cards, and then have teams of students work on ordering the rest, chronologically.
3. As you walk around the room, using a key, encourage students to reorder what is not quite right and let the teams know when they do have several in the right order.
4. As teams complete the timeline correctly, have them stack the cards in order and wait for everyone to finish.
5. As every team completes the ordering of events, give each a plastic vile that is labeled with one of the events in the deck. Tell them not to open it just yet, as they will be taking part in a demonstration.

Native Americans
plant waste

Sample Index Card

The order of chronological events may go something like this:

	Event	Pollution consequence
	Native Americans	plant waste
	farming	more organic
	gold	mercury
	more people	more waste
	factories	chemicals
....	landfills	garbage
	cleansers	toxins
	large scale agriculture	nutrients
	cars	oil, copper

Activity 3, cont'd

Model the steps

6. Show the students a large jar of clear, clean water as you introduce "Clear Lake". Remind students what it may have been like before humans – that cycles in nature kept the ecological balance and sustained a maximum number of diverse species.
7. While discussing the historical events shown on the cards the students have placed in order (an overhead projector or white board work well), have teams come up to read the card and add the contents of their film canister to Clear Lake.

For example, first natural leaf litter (plant waste) is added to Clear Lake and the "lake" continues to appear clear. Then as coffee grounds (more organic waste), food coloring (chemicals), and oil (motor oil) are added, it becomes evident that Clear Lake has changed.

8. As each substance is added, share ideas about what pollutants are, what natural substances can become harmful and what natural and human factors impact the environment.
9. As Clear Lake becomes clouded, ask students if they would still canoe, swim in or drink the water. If the answer is no, ask students what could be done to improve the water quality.

Share observations

Ask students what they know about current conditions of local lakes, streams and rivers. Students can share what they learned in researching their own watershed. Discuss the challenges of keeping watersheds healthy.

- Have students create a solution chart of how Clear Lake can return to a healthier balance.
- For the letter "S" in SOLUTION, have the group decide on a statement beginning with the letter "S" that would ensure a better future for Clear Lake." Have each team come up with the other 7 "solutions" for the future.
- Have students read articles on success stories, especially ones that involve high school students. Share impressions of these articles.

Scientific explanations

- Explain in detail how things like increased populations, development, governmental policy, and the building of water pollution control plants have influenced environmental changes over time.
- Discuss environmental policy and research that are affecting the community at present.
- Invite a scientist to come into the class and present his/her research concerning current environmental impacts.
- Explore Web pages of environmental organizations and mission statements. Show sample Web pages to discuss different ways to show data.
- Study local watershed maps to locate environmental concerns, centers, human impacted areas.

Journal reflection

Now that students have explored the history of the watershed, have them record their reflections by completing these bullets for journaling:

- Have students brainstorm in groups what solutions they have come up with and write out steps towards achieving these goals.
- Have students devise a campaign that informs the community of their interests and suggests ways for the community to improve the quality of life in their watershed.
- Have teams of students create posters for the school and for public display.
- Have students research current news articles on watershed issues. In their journals have facilitators summarize some of the key points of the articles to share with their students.

Make sure facilitators have at least one positive outcome to report to their students. WE ALL CAN MAKE A DIFFERENCE!

Facilitator Field Day Planning

Each unit requires that facilitators devote time to planning field day structure and preparing to teach Activities 1 and 2 to elementary students. As the program progresses, facilitators will take on increasing responsibility for these tasks. In the beginning facilitators will require more guidance from their teacher. This guidance can lessen over time.

We suggest a framework for planning in the *Tools for Implementation* section. With this framework, facilitators review and translate terms and concepts so they are appropriate for fourth graders. They then consider learning goals and lesson organization with the members of their field team. Then the teacher summarizes and forms an agenda outlining the field day.

To begin planning Unit 3, have students consider the terms and concepts listed in the box to the right and refer to page 156 of the *Tools for Implementation* section.

Terms and concepts
With a partner, review the material learned in this unit by describing the following features of your watershed in terms that 4th grade students would understand. After each partner takes turns describing the term in his or her own words, write down your definition of the word.

Tips for Facilitators...
Here are some suggestions to keep in mind when trying to explain new vocabulary to 4th graders:

- Find out what they know (or think they know) about the word already.
- If their first definition is incorrect, don't simply correct them—soften it by complimenting them for sharing their ideas or point out some relationship between their answer and the correct one ("Great! You have part of it right!").
- Try to give examples from their own experience that will help them understand.
- Ask them to try to explain back to you the meaning so that you can find out whether or not your explanation was clear. But don't make it feel like a test. They're testing you – and your teaching skills!

Hydrologic cycle
Water cycle
Evaporation
Condensation
Precipitation
Pervious
Percolation
Infiltration
Groundwater
Aquifer
Transpiration
Impervious
Runoff
Point source pollution
Non-point source pollution
Sediment
Erosion
Vegetation
Watershed
Tributary
Stream order
Delta

EVALUATION

Debrief and reflect

At the end of this unit, after you have planned lessons and had your first field day (or few days) of facilitating, reflect on your teaching experience:

- Do you think the students learned what you intended?
- How can you tell?
- Is there any part of the new material about which you are unclear?
- In your teaching, what do you feel good about? What makes you stressed?

Activities assessment

Consider the following questions about the activities:

- What went well?
- What can be improved upon for next time?

Journal

In your journal, write down your thoughts about the above questions and issues so that you can keep a record of your teaching experience.

UNIT 4: WATER QUALITY

INTRODUCTION

Our belief in children's inherent skills for inquiry and science was what inspired the Museum to create the BioSITE program. Our grand plan was to involve students as young as nine years old in authentic research, meaning that the water quality data collected and interpreted by students would be shared with and used by local scientists. This science and teaching experiment, begun in 1993, continues to inspire us and the thousands of students and teachers who have since participated in BioSITE. We hope you recognize the unique effort that is required of teachers and students (and we certainly recognize it and commend you for it!) to take on a project like this – one which requires trying new things, reaching out to different people, and staying focused on the future. There are other groups doing projects like this (in fact, we include some in the *Resources* section and recommend you share your experiences with them), but it is unusual enough that you will find many people surprised (perhaps even yourselves) at what you are capable of.

Water quality monitoring is one of the most challenging and rewarding aspects of this program. Carefully collecting water samples and conducting the same tests week after week can become tedious. And test results will not give you all the answers you are looking for. There is no convenient, satisfying moment in water quality monitoring when you can say you are done. These are some of the challenges you will come across in your work – they are exactly the same as those faced by other scientists conducting similar research. But you may also face challenges that scientists never encounter. Despite all your hard work, some agencies may not be interested in using your data – because you are "just students, not professionals." You will also face challenges in fitting the program to school schedules, finding equipment and resources to make sure your studies are accurate, and communicating the importance of what you are doing to others in the community.

For each challenge, you will find many, many rewards. You will find that you become quite good at things that you thought were difficult at the start. You will find that scientists are amazed and inspired by your work. Your elementary students will look to you for answers, inspiration and encouragement, and you will find that you are able to give them. **This unit will give you necessary tools and information – how to use water quality test kits, to interpret the results of the tests, and to understand what the results tell you about the creek – so you can share the rewards, challenges and results of research with the rest of the BioSITE team.**

UNIT OVERVIEW

Engage	**Introduction to New Material** Reading: Water Quality
Explore	**Activities to Explore Material:** *Activity 1: Water on Earth* *Activity 2: Solar Water Purifier*
Explain and Elaborate	**Advanced Study** Research and Reading: Water Quality Monitoring *Activity 3: Water Quality Tests* Facilitator Field Day Planning
Experience	**Field Study and Teaching:** Water Quality
Evaluate	**Debrief and Reflect**

LEARNING OBJECTIVES

At the end of this unit students should be able to:

- Perform water quality tests;
- Understand how water quality tests relate to the ecosystem;
- Discuss the natural and human factors that influence water quality;
- Know how to record water quality data and understand why it is important; and
- Analyze data and interpret trends of water quality, of human impact, and riparian habitat balance

Water Quality Web Sites

www.streamkeeper.org/foundation.htm

www.bridgingthe watershed.org

www.green.org

www.rivernetwork.org

Reading: Water Quality

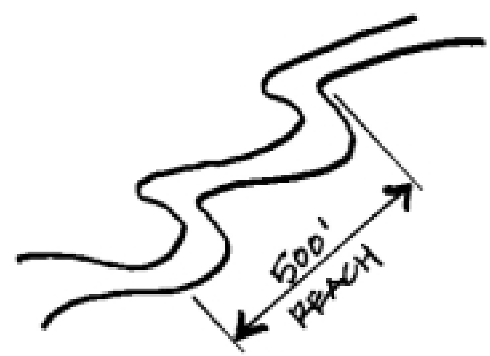
Water quality tests reveal certain qualities about the water that indicate stream health. When you begin monitoring your creek, you will be testing for these qualities. You will find out how much oxygen, sediment, and how many pollutants are in the creek, all of which affect the living organisms in the riparian ecosystem. Before going in depth about each water quality test, we will first introduce some of the physical characteristics of a stream that can greatly affect where and how the tests are performed.

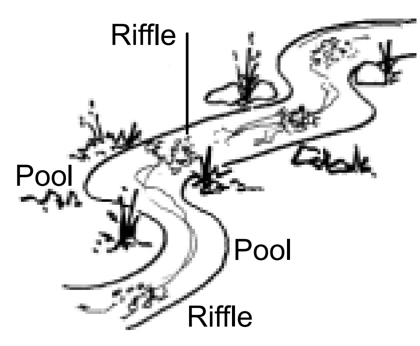
Monitoring an entire stream is nearly impossible given the constraints of time, budget, and human resources. To make projects manageable and to have enough resources to collect detailed data, your program must select a section of the stream to study. Each section of a stream is called a **reach**. The *upper reach* is the headwaters section, where water moves fast in relatively steep, straight channels. The *lower reach* is usually a delta near the stream's outfall to the ocean or major water body. Here, the water flows slowly along a wide, meandering, flat-bottomed channel. The *middle reach* flows through our communities, meandering back and forth along a moderate gradient.

Select a section of this reach that is most conveniently located to the school. If possible, avoid being near human alterations such as small dams, storm drain inlets or cemented channels. Pick a unit of measure for the length that will give you enough diversity in your data (*Streamkeeper's Field Guide* recommends 500 feet).

Within the middle reach as the river winds and bends along its course and changes in elevation and composition, the characteristics of the water change along the way. The water will flow through a series of pools and riffles. **Pools** are areas of the stream where the water is slow moving or stagnant. In pools, water is deep and holds a relatively consistent temperature. **Riffles** are shallow areas between pools where water moves rapidly over rocks and cobbles.

Typically, riffles are used as collection sites for samples so that the data is consistent and comparable with other studies. Water depth and movement influence the rate of flow, temperature, amount of oxygen in the water, and where pollutants, sediment, solids and debris collect and concentrate. Therefore, choose a collection site that consists of a series of riffles.





Basic water quality tests

Now that you know where to set up your collection site, we will discuss exactly what you will be testing for and monitoring over time. In BioSITE we conduct basic water quality tests for dissolved oxygen, rate of flow, pH, temperature, turbidity, and conductivity/dissolved solids on an ongoing basis. This next section discusses each substance/pollutant/characteristic that you will be measuring for, its natural and human sources, how to measure for it and what its presence or absence means for water quality and aquatic organisms. We will discuss measuring in general terms since each school may use a different brand of test kit. To collect precise data, make sure to follow the instructions that come with the kit you use. Also be sure to always use goggles or safety equipment when test directions recommend it.

Dissolved oxygen

What it is

Dissolved oxygen refers to the amount of oxygen in the water. The measure of dissolved oxygen is one indicator of whether the water can support a healthy population of fish and aquatic organisms, which need a minimum level to live. The lower the dissolved oxygen content, the harder it is for these organisms to breathe. If it is too low, some organisms may die.

Where it comes from

Dissolved oxygen has two primary sources: aquatic plants and water movement. Aquatic plants release oxygen into the water as a by-product of photosynthesis. As plants grow during daylight hours, dissolved oxygen levels increase. The second primary source of oxygen enters the water as air gets trapped through movement and turbulence caused by wind, waves, or running water. Low temperatures and less salinity are other sources of dissolved oxygen. There are many factors that affect dissolved oxygen such as temperature, salinity and bacteria.

What test results mean

Dissolved oxygen levels indicate whether or not conditions are good to support a healthy fish population. There could be a variety of factors that affect the measurement, depending on the source (described above). For example a low reading could be due to high levels of salinity, lack of sunlight (plants die due to lack of sun), or plant death (bacteria use oxygen and break down dead plants). Also, as temperatures rise water can hold less oxygen. A high reading could be due to plant growth (algae and aquatic plants grow, producing oxygen as a byproduct of photosynthesis). As you can see, these factors work together. Dissolved oxygen content can be improved by controlling algae growth and nutrient content or by providing more wind or water movement.

How to test for it

Like all of these tests, you will need to follow the instructions listed on the test kit that you use. Basically, to test for dissolved oxygen you will fill a bottle with water from the stream and add a series of chemical reagents that will show the amount of dissolved oxygen that is in the water, measured in parts per million (ppm). The fewer ppm found in water, the worse the water quality. Readings of less than 3-5 ppm (depending on the stream) suggest danger to fish and aquatic organisms because there is little or no oxygen available in the water (5 parts per million means there are 5 oxygen molecules for every one million water molecules). Depending on your stream conditions, a healthy reading could be anywhere between 7 and 14 ppm.

Date: 11/22/2002
Dissolved Oxygen: 16 ppm

Sample Field Data

When taking water samples for testing, consider that riffles will measure more dissolved oxygen than pools with slow or stagnant water. This means that you will want to test in riffles every time to establish the standard testing location for your study. For further study, you may do the test in a pool for comparison, but it must be in addition to your ongoing testing of the riffle – not a replacement of that day's test.

Rate of Flow

What is it

The **rate of flow** test simply measures the speed at which water in the stream is flowing. Rate of flow controls other water characteristics such as oxygen content, turbidity, and temperature. It also affects how many plants and animals live in the stream. Plants and animals have adapted to water flowing in order not to get carried away in the current. Plants have roots that anchor deeply, algae clings flat to rocks to resist the flow, and aquatic organisms have physical adaptations, such as streamlined body shape.

Where it comes from

The rate at which water moves can be dependent on a variety of factors such as the slope and gradient of the land over which it flows (water runs more quickly over a steep slope than a shallow one), or seasonal rain and snowmelt that adds water to the flow. Water flows over smooth rocks with little resistance, or can be blocked by large rocks or boulders. Additional human factors that affect the rate of flow are culverts, dams, diverting water, and dumping waste.

What test results mean

More aeration takes place when water is agitated, tumbling over rocks at a rapid rate. This increases the levels of dissolved oxygen in the water, which is required for plant and animal life. A slow rate of flow results in lower levels of oxygen. When water moves quickly with some turbulence, it evaporates more quickly than when the flow is slow. This reduces the temperature of the water. Cool water is required for the survival of many fish species.

How to test for it

Rate of flow can be measured with very low-tech tools. You will measure the amount of time a floating object takes to travel a pre-measured distance. To do this, two students hold a 10 meter tape measure along a straight run of the stream. A third student throws a buoyant object, such as a wood chip, a few feet farther upstream from the upstream student holding the tape. As soon as it passes the upstream student, start a stopwatch and measure the time it takes to pass the downstream student. Repeat this three or four times and average the results. Calculate the results in meters per second by dividing 10 meters by the number of averaged seconds. For everyone's safety, do not attempt to retrieve the object. Use something natural, like a small piece of wood, that can be thrown accurately, will be visible and won't pollute the stream.

pH

What it is

A **pH** test indicates the level of acidity or alkalinity – the number of free hydrogen ions – of the water. A neutral pH reading means there are an equal number of hydrogen and hydroxyl ions in the water. An **acidic** reading means there are more hydrogen ions; an **alkaline** (basic) reading indicates more hydroxyl ions.

Date: 11/22/2002
Rate Of Flow: .12M/sec

Date: 11/22/2002
pH: 8.0

Sample Field Data

WHERE IT COMES FROM

Sources of pH change are either natural or influenced by humans. When organic material decomposes it releases carbon dioxide that, through chemical processes, lowers the pH of the water. This occurs more in still or slow-moving water than in flowing water. Naturally occurring minerals that are bases, such as limestone, increase the water's alkalinity by buffering acids. Seawater maintains a stable pH because it contains minerals that buffer acids, but freshwater contains fewer buffering acids so it's more susceptible to changes in pH.

Industry often produces high concentrations of chemicals (carbon dioxide, sulfur dioxide, nitrogen oxides) that cannot be buffered, so the water becomes more acidic. Likewise, dumping of organic fertilizers, leaf litter, or other plant materials in gutters and neighborhood street storm drains leads to decomposition by bacteria, which produce acidic waste products.

WHAT TEST RESULTS MEAN

Though some water bodies like bogs are naturally acidic, for most water bodies a near-neutral reading indicates a balanced and optimal condition for freshwater aquatic organisms and their life processes. Imbalances or changes in this chemical composition can be detrimental, as non-toxic chemicals can change to toxic forms and non-natural changes to the water's pH can signal premature migration, mating, laying eggs, or other abnormal behaviors. Imagine, for example, what the consequences would be if an organism lived in water and suddenly the water changed to vinegar, lemon juice, battery acid (all acidic), ammonia or bleach (alkaline)?

When pH levels are highly acidic, bottom-dwelling bacteria begin to die. These bacteria serve a role decomposing organic material. When they are gone, the organic matter begins to accumulate, tying up nutrients. As a result, many fish and organisms begin to die. When pH measures too basic, chemicals such as ammonia become more harmful and most organisms cannot survive. Highly alkaline or acidic water may be damaging to organisms' gills, fins, or exoskeletons and changes in pH can make aquatic organisms susceptible to disease, toxins, and parasites.

HOW TO TEST FOR IT

To measure for pH you will take a sample of water and add pH indicator solution. The color of the water will match with a color indicating pH on a scale of 0 (most acidic) to 14 (most basic), with 7 being neutral.

Temperature

WHAT IT IS

Water molecules absorb thermal energy easily, with only slight variation in temperature change. This means that sudden temperature changes in the environment (an unusually warm day in spring or clearing of vegetation along creek banks allowing more constant sunlight to hit the water) will change the water temperature.

Date: 11/22/2002

Temperature: 17 °C

Sample Field Data

Where it comes from

Environmental factors that influence temperature include sun and shade, time of day, season, weather, and waste heat from decomposing plant matter or industrial waste pollution. Stream characteristics that influence temperature are size, depth, flow, color, and **turbidity** (particles suspended in the water).

Water temperature is influenced by both natural and human factors. Naturally, the water's source affects its temperature. If the stream starts from snow pack or underground, the water temperature will be cooler than if the source is a seasonal pond or hot spring. External influencing factors include the stream's latitude and location, the season, air temperature, and time of day. Shade and sunlight also determine the temperature. Overhanging vegetation may shade the water and keep temperatures cooler.

The size, depth, and velocity of the water are also factors. A large body of water like an ocean or large lake with significant volume holds its temperature longer than a pond or stream. The deeper the water is, the more difficult it is for sunlight to penetrate to the deep waters so they stay cool. Rapidly flowing water, like a stream, maintains lower temperatures.

Particles in the water affect its temperature. Particles of soil or other solids affect the water's color and turbidity (clarity) and absorb thermal energy. Just like darker clothing absorbs more heat in the sun than white clothing, these particles absorb and pass heat to the water and warm the water. Some of the human factors that increase water temperatures are discharge into streams from industrial cooling processes and storm water runoff warmed by the sun as it flows over warm surfaces such as roads, sidewalks, or roofs. Additionally, when trees and vegetation are removed from riverbanks, both temperatures and turbidity (through soil erosion) increase.

What test results mean

Aquatic organisms generally have evolved to survive in constant water temperatures. Extreme or rapid changes of more than 1 or 2 degrees can injure, shock, or kill aquatic organisms. Seasonal temperature changes are less dangerous, as they affect the water more slowly. The amount of average heat in water varies per stream, but generally, temperatures above 24 to 27 degrees Celsius (75.2 to 80.6 degrees Fahrenheit) are dangerous for living aquatic organisms.

Increased temperatures affect an aquatic ecosystem in many complicated ways. Warmer temperatures lower the capacity for dissolved oxygen and increase the rates of photosynthesis and the metabolism of aquatic organisms. Warm temperatures also encourage plant growth and stimulate movement of aquatic organisms, but temperatures that are too high can cause damage to juvenile organisms or eggs. As organisms become more active, they consume more dissolved oxygen, reducing the amount available to others. Parasites, toxic bacteria, and diseases thrive in warmer temperatures making organisms more susceptible to disease and more sensitive to pollution.

Celcius/Farenheit conversion

$$^{\circ}C = \frac{(^{\circ}F - 32.0)}{1.80}$$

$$^{\circ}F = (^{\circ}C \times 180) + 32$$

How to test for it

Measurements should be taken at regular intervals (weekly, monthly) in the same location and at the same time of day. Take the measurement in a place where the thermometer touches water only (in the middle of the water column), as contact with the bottom of the creek or any other substance could influence the measurement. If possible, record temperature measurements in both Celsius and Fahrenheit. To convert either reading, use the formulas in the sidebar. By measuring temperature at multiple points along the river you can investigate the reasons for any changes you record from the different locations (such as the amount of sunlight reaching the water, stream depth and rate of flow, or storm drain inlets).

Turbidity

What it is

Turbidity measures how clear or cloudy the water is. High turbidity readings indicate a lack of clarity that can be caused by suspended solids/particles in the water. Suspended solids (as opposed to dissolved solids, which are not visible) can reduce the penetration of sunlight through the water. Solids such as clay, silt, and algae will also affect turbidity.

Where it comes from

Runoff sediment and solids come from soil erosion. Weather can be a source of turbidity as winds can create currents and heavy rains and stormwater runoff enter the stream and stir up sediment. Bottom feeding animals (such as carp) also stir up sediment. Waste discharge and soil erosion increase the levels of solids and sediment. Algae growth can change the color and turbidity of the water.

What test results mean

When turbidity is high (high level of suspended solids), the solids absorb light and heat, thus raising the water temperature. Higher water temperature lowers the level of dissolved oxygen. Photosynthesis decreases due to low light penetration; less photosynthesis means even less oxygen. Lower light, warmer water, and less oxygen support fewer different species of animals resulting in less diversity. Also, suspended solids can clog animals' gills, slow growth rates, and bury microhabitats. Eggs laid in gravel beds and small aquatic insects living there may get buried by settling particles and suffocate.

When turbidity is low (clearer water), there is good light penetration resulting in a high rate of photosynthesis (in the presence of plants), lower temperature (than a similar stream with turbid water) and higher levels of oxygen (the result of photosynthesis and colder water).

How to test for it

Different test kits are available for measuring turbidity. For shallow, fast-moving streams an electronic meter that measures the amount of light scattered in the water can be used. Scattered light will be more intense the greater the amount of suspended particles in the water. For deep and slow-moving water such as lakes and wetlands a Secchi disc can be used. A Secchi disk is a white disk that is lowered into the water until it disappears from sight. BioSITE measures turbidity by comparing turbid water with clear tap or bottled water. First, turbidity tubes are filled with both types of water and compared for cloudiness. Then, a reagent is added to the clear water until the water in both tubes is equally cloudy. The measure of the amount of turbidity reagent added indicates the amount of turbidity in the water. The amount in milliliters is converted to a special unit used for measuring turbidity called Jackson Turbidity Units (JTU).

Conductivity/Total Dissolved Solids

What is it

Dissolved solids are particles present in water that are so small they pass through a filter (unlike the particles examined in turbidity). The particles are various minerals and salts such as calcium, bicarbonate, nitrogen, phosphorus, iron, sulphur, and other ions. **Conductivity** is a measure of the water's ability to conduct an electrical current, which is influenced by the number of ions in the water that come from the dissolved minerals. Thus, we can use a total dissolved solids (TDS) or conductivity test to measure the quantity of dissolved solids.

Where it comes from

The minerals and salts found will vary with each stream because they come naturally from the surrounding geology. Soil erosion and streambed composition influence conductivity as the minerals dissolve in water. Human factors can also affect the natural balance of solids. Runoff from roads can contain copper, lead, and other particles. Runoff from agricultural and landscaping areas can contribute nitrogen and phosphorous. Wastewater from treatment plants also can add nitrogen, phosphorous and organic matter. While one can't say for sure what the healthy range of these solids should be, regular testing can establish an average reading for a stream so that any sudden impact on the creek's natural status can be detected.

What test results mean

Organisms need a minimum level of minerals, salts, and ions for their metabolic processes, but too much can be toxic. Extremely high levels of dissolved solids can lower water quality, causing problems for organisms living there. They can also make drinking water undrinkable. Extremely low measures of dissolved solids can also be a problem because of a lack of nutrients or materials needed for the growth of aquatic life.

Changes in TDS or conductivity can indicate a change in the aquatic ecosystem, such as soil erosion or human impact like industrial dumping. When testing, there is no 'healthy range' of numbers to look for because each river's conductivity will depend on what kinds of minerals and other inorganic solids are naturally found in the ground surrounding the stream. Each stream has a characteristic TDS or conductivity measure. To find this, create your own baseline data or contact your local water resources department.

How to test for it

Total Dissolved Solids is measured with a conductivity or total dissolved solids meter. To test for a reading, an electrode is held in the water and a gauge indicates results. When measuring, we are comparing results with baseline data and looking for a sudden change that might indicate changes upstream due to flooding, construction, or runoff from city streets. Industrial dumping might also be caught by this measurement. The TDS measure will be high if dissolved metals or ions are present. When measuring, note that results may be especially high the first few hours after rainfall when runoff from roads and homes carries solids into the stream. It may measure low after water from a treatment plant is discharged.

Date: 11/22/2002
Total Dissolved Solids: 231 ppm

The Big Picture

As you have seen, all of the factors involved in each water quality test relate to each other. Conducting each of the tests on a regular basis gives you an understanding of a stream's character over time. Combined with your exploration of plants and animals you can see how water, flora and fauna interact with each other to form the riparian ecosystem.

What's exciting is that you are able to be scientists and do real tests. As a result, you will have very valuable research to share about the health and needs of your environment. You will be making a scientific contribution as well as a contribution by sharing the experience with younger kids to educate and inspire them.

2004 National Youth Service Learning Conference; Orlando, FL

Unit 4: Activity 1: Water on Earth

Students learn…
- The percentage and distribution of water on Earth;
- The water cycle; and
- The importance of water conservation

By doing…
- Investigations into the locations where water is found;
- Drawings and diagrams of the water cycle; and
- Demonstrations of the amount of fresh water available to drink

Then reflecting on…
- The importance of each step of the water cycle;
- Where water is trapped on earth; and
- Where accessible water needs to be conserved and quality preserved

Materials

For the whole group:
- 100-foot measuring tape or length of rope, marked with 100 units (100’ measuring tapes may be hard to find – landscapers or groundskeepers may have one)

Getting Started

Begin by asking students why the Earth is sometimes called “the Blue Planet.” Ask students what they think is most important about having available water on our planet. Then ask what kinds of “water” we have on our planet and where these different forms of water may be found.
Then begin the demonstration:

Introduce the steps
1. Show students the full length of the 100 units of rope by stretching it around the four walls of the room, across the floor, or have students hold both ends.
2. Ask students, “If this entire length represents 100% of the water on our planet, how much of this length do you think represents salt water?” This is a good time to ask students to picture a globe.
3. Slowly walk the length of the measuring tape or rope. Ask students to say “stop” when they see you reach the proportion they think represents salt water. They will most likely have you stop too soon. Let them know there is more saltwater than that, and continue walking. Have them keep guessing and stopping you until you reach 97 units. The actual amount of saltwater on our planet is 97 percent of total units (feet, meters, or liters).

Explain that there is and always has been one fixed amount of $H^{2}O$ molecules, or water, on Earth. This fixed amount sustains life on the planet. 97% of this water is saltwater and the remaining 3% is either freshwater (both above and below ground) or frozen.

Model the steps

4. Ask students how much of the remaining 3 units of water (freshwater) are frozen, underground, and above ground in the following order.
5. Continue walking along the measuring tape or rope, starting first with the frozen water and continuing as follows:
   - Frozen: of the 3 units of freshwater, 2.15 units are trapped in glaciers and polar ice caps.
   - Underground: of the 3 units of freshwater, 0.31 units are trapped underground (groundwater supply).
   - Available: of the 3 units of freshwater, 0.34 is available for animal and plant life (available, but not necessarily drinkable).
6. To complete the demonstration, write out that .00003 units of the available freshwater on our planet represent the clean, fresh, drinking-water available to humans.

Tips for facilitators…

Your students may take a few wild guesses, but brainstorm with your group about what they know of our water supply on earth, and how they know this information. (By seeing a picture of earth, they would know that much of the Earth is covered with salty ocean water).

Share observations

- Have students share what information from the demonstration came as a surprise to them.
- Review the different steps of the water cycle and ask students how the environment affects the cycle (where is water trapped, where is it plentiful, or scarce, etc.).
- Ask students how these proportions may have changed in the past (ice age) and how things may be affected in the future (poor water quality/clean water shortages).

Scientific explanations

- Show students a diagram of the water cycle and discuss the importance and process of each step in the cycle.
- Provide information on groundwater supplies in the local watershed.
- Show students a diagram of possible surface water contaminants in a developed area.
- Show students a diagram of the different methods of recycling water.

Journal reflection

Now that students have realized the importance of taking care of water (especially because so little of it is available as drinking water), have students think of ways communities can ensure a clean water supply for the future. Have them reflect through these bullets for journaling:

- Have students depict the proportions of Earth's water supply in a diagram or visual. (Graphs, modern art, colors, all proportioned relative to percentage of water on Earth).
- Have students diagram the way water is recycled in a water treatment plant.
- Have students create a neighborhood flyer informing the public of ways to conserve water (and common water-waste problems) and why it is important.
- In journals have the students write a water conservation plan for their household. Have each family member commit to one way to save water around the house. Keep a record for several weeks and have each student report on their families water conservation project.

Unit 4: Activity 2: Solar Water Purifier

Students learn...
- How to build a model of the water cycle;
- How the process of the water cycle cleanses our water supply; and
- The connection between natural cycles and a healthy ecosystem

By doing...
- Investigations on the water cycle using a model;
- Comparisons of water quality within a water cycle model; and
- Experiments to improve or harm the natural cleansing of a water supply

Then reflecting on...
- What natural factors affect water quality;
- What human factors affect the quality of our water supply; and
- The importance of monitoring water quality to ensure a healthy water supply

Note: This activity is quick to set up but it may take several days for results to develop depending on the amount of sunshine.

Materials
For each group of 6 students
- Large glass jar or plastic bucket
- Small, clear plastic cup
- Plastic wrap
- Small rock or weight
- Water
- Salt
- Weight in cup (something clean, since it will sit in water)
- Large rubber bands or tape

Getting Started
Begin by asking students what they know about water. "Why do we need water and what things do we use water for?" Try to encourage a long list so students will begin to realize how essential water is. Our Blue Planet is alive because of the fact that water is present and available to living things.

Identify with students the many places we find water. Discuss the unique characteristics of a water molecule that enable water to be found in different states in our environment. Emphasize that the amount of water, as we learned in the last activity, is and has essentially remained the same since the dinosaurs roamed our planet. Our task is to learn how to maintain the quality of the existing available water supply, so we may continue to have clean water! We can do that by monitoring our watersheds and learning how to control the factors that affect our water supply!

Introduce the steps
1. Show students a diagram of a water molecule and discuss the simple basic chemistry of this unique bond.
2. Ask students if they can explain what happens when water changes from a solid to a liquid to a vapor. Can students give examples?
3. Ask students to list the many places that a water molecule could end up…our bodies, an iceberg, a tree, groundwater supply, a cloud. Discuss these "water stops" and have students explain what may happen to the molecule at this part of the water cycle. "Could the molecule get trapped?" "Could the water supply become polluted?" "Could the water supply become purified?"

Model the steps
4. Ask students to list examples of water changing from one state to another (making ice cubes, rain) and have them explain what change of state is taking place. Explain to students that you are going to create a model of water changing from a liquid, to a vapor, and condensing back to a liquid again. From ocean to clouds to rain!
5. Place an empty clear plastic cup inside the clear jar or bucket right in the center, on the bottom. Add one to two cups of well-salted water to the jar but leave the clear plastic cup <u>empty</u> (you may need to put weight in the cup at this point to keep it from floating and falling over). Cover the jar with plastic wrap and place a small rock on the plastic wrap so the weight of the rock pushes the plastic into a point directly above the empty cup.

Tightly seal the plastic on the jar with rubber band or tape. Place your “water cycle jar” in the sun and see what happens!

6. Ask students to predict what they think they will. Changes could take place in an hour in the heat, or a day or two in cooler temperatures.
7. Ask students what role the sun plays in the experiment?
8. Ask students what they think will happen to the salt water.
9. Ask students if they will be able to drink “fresh water” if the water in the jar is recycled: how and why?

Share observations

- Have students record observations in their journals for the time you are able to watch your “water cycle.”
- Ask students what evidence they have produced to show water changing states.
- Ask students to explain their observations and what they think happened in the jar.
- Ask student groups to create diagrams to show how their model depicts natural events that take place in the water cycle.
- Have student groups design a presentation about water and the water cycle.

Scientific explanations

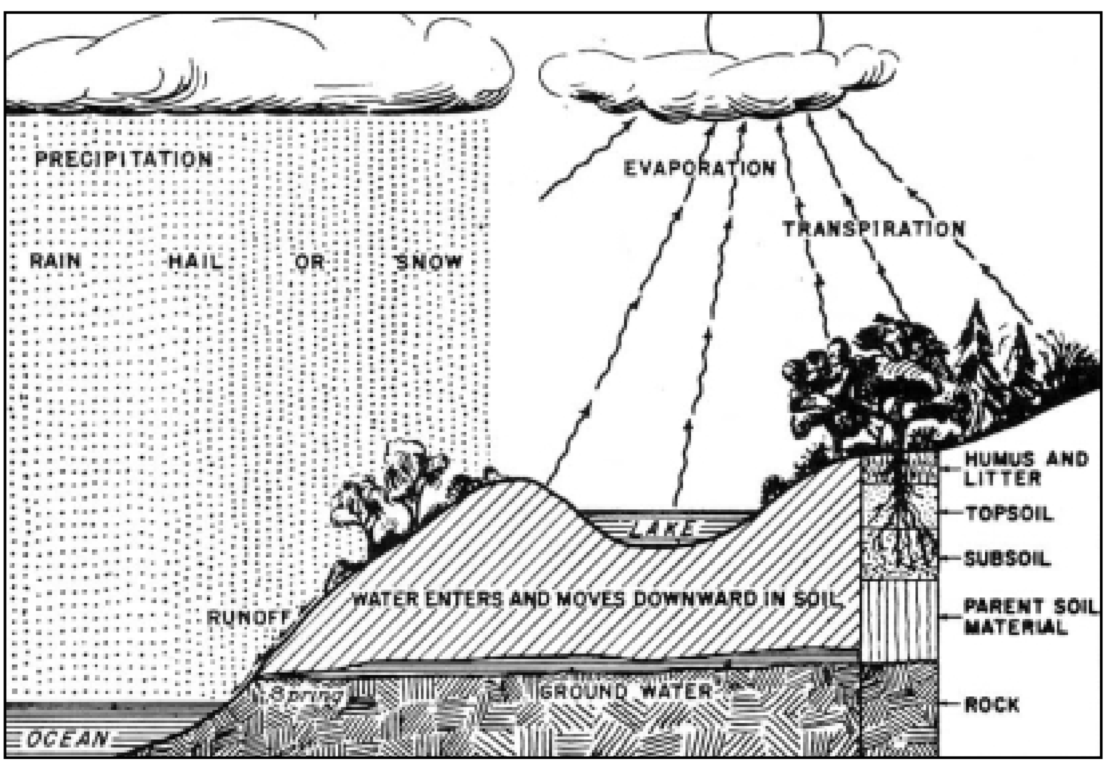
- Show students diagrams of water cycles that depict particular climate patterns, like living in a rain shadow or desert conditions.
- Introduce students to natural processes that connect with the water cycle such as transpiration and photosynthesis.
- Have students research and present watershed restoration projects that are using natural environments to improve the conditions of watersheds.

Journal reflection

Now that students have learned more about the importance of each aspect of the water cycle, have them propose ways to maintain high water quality standards in different community settings.

Use these bullets for journaling as a guide:

- Have one group of students design a water management plan for a farming community.
- A second group of students can design a plan for a rural mountain community.
- And a third group can design a plan for an urban community.



The Water Cycle

Tip for teachers...
Try adding different things to the salt water, such as food coloring or oil.

Research and Reading: Water Quality Index

Adapted from information in Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools, Mark K. Mitchell and William B. Stapp

There are a few recognized ways to measure water quality: the Water Quality Index (WQI) and the Pollution Tolerance Index (PTI). The National Sanitation Foundation established the WQI in 1970 so rivers nationally could be measured and compared according to the same index. Nine tests comprise the WQI: dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, temperature, total phosphate, nitrates, turbidity and total solids. Each test is an independent test or kit and is taken in a particular part of the stream. The results are charted and weighted to determine how water quality ranks on a scale of 0 (Very Bad) to 100 (Excellent).

An alternative to studying the chemical contents of the water as a means of determining stream health, the Pollution Tolerance Index looks at what species survive in the water. To assess water quality with PTI, scientists count the number of macroinvertebrates found in a stream reach and chart them according to their tolerance for pollution. The results are tabulated according to a scale and indicate how well the stream supports aquatic organisms. PTI Scale ranges from 0-10 (bad) to 30+ (excellent) (More information and testing for PTI is covered in Unit 8: Macroinvertebrates.)

In BioSITE, we conduct WQI and PTI on a limited basis only (one to two times per year), limiting our ongoing water quality tests to those described earlier on page 77-83. The Water Quality Index requires four additional tests: fecal coliform, nitrates, total phosphate, and biochemical oxygen demand.

Fecal Coliform (FC)

The fecal coliform, test measures the quantity of naturally occurring bacteria that is from the feces of humans and other warm-blooded animals. The bacteria are non-pathogenic (they do not cause disease), but if an individual is infected, pathogenic organisms, such as viruses and parasites, may be found along with the fecal coliform. Thus, high counts of fecal coliform may be a sign of the presence of pathogenic organisms.

Fecal coliform comes mainly from human waste. Waste is conveyed in underground sewer systems, of which there are two types: storm sewers and sanitary sewers. Sanitary sewers carry wastewater from toilets, sinks, showers, and washing machines. This water is treated before discharging into streams or other water bodies. Storm sewers carry rain and snowmelt, and discharge untreated water into the stream. This untreated water would also include waste runoff from animals.

In balanced conditions the presence of pathogenic organisms is scarce. This is why measuring fecal coliform counts for changes, or increased levels, is a good way to measure pathogenic organisms. In high counts, such as 200 FC (200 colonies/100 ml), swimming or immersing in water can be unsafe for people. Fecal Coliform in drinking water typically measures 0.1colony / 100 ml.

To test, you will take a water sample *below the surface* of the water, within the current (use a rod extender if you need to reach extra length). The surface contains higher numbers of FC. *Take note of the weather on your testing day—heavy rains that produce more runoff could result in a higher count.* You will need to follow the instructions on the testing kit. An easy, reliable kit called ColiQuant EZ can be purchased from LaMotte Science Education Products. (www.lamotte.com)

Nitrates

The test for nitrates measures this specific form of nitrogen. Living plants and animals use nitrogen to make protein. Blue-green algae take nitrogen up from the roots of plants and converts it into ammonia and nitrate, two forms of nitrogen that plants require for growth. Animals eat aquatic plants and convert the plant protein into animal protein. As plants and animals die, bacteria break down their protein into ammonia, which is combined with oxygen to form nitrates. When organisms, such as water birds and aquatic organisms excrete, nitrogen is released.

Nitrates originate from runoff containing fertilizer from lawns and agriculture, sewage that is not properly treated before discharging into rivers, and runoff from areas with high concentrations of animals, such as dairies and cattle feedlots.

Being a form of nitrogen, nitrates promote plant growth. Sometimes this can cause **eutrophication**, or extensive growth of algae. With this growth also comes the breaking down of algae, which increases the demand for oxygen (this will be discussed further in the description of the B.O.D. test).

The type of test you use will vary depending on whether the water you are sampling is fresh or brackish. Be sure to follow the directions on your test kit. Generally, you will place the sample of water in a color-viewing tube, add reagent powder and shake the tube. Observing carefully, you will see the color change to red if nitrate is present.

Total Phosphate

The test for total phosphate measures phosphorous in the form in which it is found in water – phosphate. Phosphorous is an essential element required for plant and animal growth and metabolic reactions. Organic phosphates are present in water in low concentrations because they tend to attach to soil particles and organic matter.

Phosphates are naturally occurring, but human practices similar to those you've read about before – animal, industrial, or human waste; soil erosion; or excess fertilizers – can add more phosphates to the water creating an unbalanced condition.

Algae requires very little phosphate to grow, so excess quantities can cause extensive growth called eutrophication. If extensive growth is not prevented, eutrophication can result in a river or lake filling with aquatic vegetation. Because there is so much demand for oxygen under these conditions, it creates an anaerobic environment in which all of the oxygen is depleted and you will observe an increase in pollution-tolerant species.

In this test, a sample of water is treated with various chemical solutions such as sodium hydroxide, sulfuric acid, potassium persulfate, and phosphate reagent. It is boiled and mixed, and evaluated against a color comparator to determine the level of phosphorous (the water will turn blue-violet if it does).

Biochemical Oxygen Demand (BOD)
Biochemical oxygen demand measures the amount of oxygen consumed by organic matter and microorganisms. One instance, for example, is when aerobic bacteria decompose aquatic plants. As this organic material breaks down it oxidizes, or combines with oxygen, using some of the total amount available in the water. Another is when nutrients, such as nitrates and phosphates, are released as by-products of aerobic bacteria feeding on organic material. These nutrients stimulate plant growth, which ultimately produces more decay and more demand for oxygen.

Sources of organic material can be both natural and human. Natural sources include primarily leaf fall, but include other natural elements like wood and vegetation that come to rivers from upstream water bodies such as swamps and bogs. Human sources of organic material are identified either as point or non-point sources. A **point** source is a single point of discharge such as a wastewater treatment plant, food-processing factory, or paper mill. The waste products of these point sources add organic matter to the stream and increase BOD. **Non-point** refers to a number of sources that you can't pinpoint to a specific location rather; combined sources add organic matter to streams. Examples of non-point sources from urban runoff are pet waste, lawn fertilizers, grass clippings, and loose paper.

All of these elements, when added to streams, increase the biological oxygen demand as aerobic bacteria that decompose this organic matter consume the available dissolved oxygen. If the amount of organic matter is out of balance, some organisms may not get the oxygen that they need to survive. Only those that are pollution-tolerant will survive, diminishing the diverse and complex ecology of an ecosystem that once had an abundance of oxygen.

The test method for BOD is similar to that of dissolved oxygen. The main difference is that two samples are taken and one is incubated for a period of time, during which bacteria and microorganisms consume oxygen. The sample is then measured for what the oxygen demand on that sample was during that period of time.

To perform the test, use 2 dissolved oxygen bottles – one clear and one black (or covered with electrical tape so that no light shines through). Hold bottles in the river between the surface and the bottom, for 2 to 3 minutes. Prepare the clear bottle sample according to the dissolved oxygen test instructions. Cap the black bottle and incubate in the dark for 5 days at room temperature. After 5 days, measure the dissolved oxygen level according to the standard test. Subtract the measurement from the black bottle from that of the clear bottle to determine the amount of oxygen consumed in 5 days.

Original Sample After Incubation	**=**	**Amount of O^2 consumed by organic matter and microorganisms after 5 days**

Testing kits can be ordered from:

HACH Company
(www.hach.com)
HACH Company
PO Box 389
Loveland CO 80539-0389

La Motte
(www.lamotte.com)
La Motte Company
PO Box 329
Chestertown MD 21620

GREEN
Global Rivers Environmental Education Network
(www.green.org)
Earth Force
1980 Mt. Vernon Ave.
Alexandria VA 22301

See page 163 for ordering information on test kits we use.

Unit 4: Activity 3: Water Quality Index Tests

Now that you know about each of the elements we study when monitoring water quality, it's time to practice the tests. Review the instructions and components of each test kit and practice using it. Journal pages with basic test information are provided in the *Tools for Implementation* section.

We all know how valuable it is to learn by doing. In some cases that is the only way a learner can obtain a true understanding of a difficult concept. In some instances we reach a single "aha!" moment where the understanding we have searched for becomes clear on our own terms. In other cases, practicing tasks by repeating the same steps over and over again leads us to a deeper understanding of patterns and explanations underlying scientific concepts. BioSITE students experience both of these learning patterns throughout the program, but for water quality research, practicing and studying water quality tests and results over an extended period of time are especially helpful in understanding the relationships and complexities within the watershed. By repeating tests, students also learn skills and methods that help them to collect more accurate data sets over their year of study. Below are some of the things we have learned, as well as some of the protocols for water quality testing that we found we had to emphasize, so your students can learn from our experiences.

- **Stream observations** over an extended period of time reveal patterns of change that support water quality data analysis. Students keeping detailed journal entries are able to correlate physical changes in their study site with the chemical data of their water quality tests.

- **Water quality test data** is affected by several variables of stream conditions and testing procedures, so carefully following protocol for taking water samples for all tests is very important. Water samples for water testing should be taken in the same location every field day so comparisons can be justified. Samples should be taken mid-stream width and mid-depth with open end of sample bottle facing downstream. Different tests may have other protocol to keep in mind as well.

- **Dissolved oxygen** samples should be taken in the riffle of the stream. Air bubbles should be carefully avoided so data reflects just the oxygen in the water sample.

- **Rate of flow** should be taken at several sites and averaged, carefully following the same procedure for each test.

- **pH** should be consistent throughout your stream study and careful measurements of reagent should be practiced so results will not reflect human error. Drops of reagent should be formed with the dropper in a vertical position and with consistent pressure for each drop added.

- **Temperature** should be recorded at several sites, both sunny and shaded. Location should be accurately recorded and included with degrees.

- **Turbidity** tests should be completed upstream of any disturbance and careful sampling protocol should be followed so that the results are not affected by the sampling procedure. Any slight disturbance in the water can affect the turbidity measurement.

- **Total Dissolved Solids (TDS)** meters are sensitive and should be handled carefully. Keep extra batteries on hand, be sure to turn your meters off after each use, and make sure to store them in a dry location. To record the TDS measurement, wait until the reading has stopped fluctuating and record.

Facilitator Field Day Planning

Facilitators determine how to go about teaching students. To structure the lesson planning process, refer to the *Team Lesson Plan Worksheet* (Template 1) in the *Tools for Implementation* section.

Based on the lesson planning discussion, the high school teacher reviews and summarizes facilitator suggestions and develops an overall lesson plan to give to the entire group for the field day (see *Field Day Agenda* (Template 2) in *Tools for Implementation*).

Have students consider the following:

Terms and Concepts
With a partner, review the material learned in this unit by describing the following features of water quality in terms that 4th grade students would understand. For the words that refer to water quality tests be sure to describe what it measures and the consequences of different levels. After each partner takes turns describing the term in his or her own words, write down your definition of the word.

Water quality
Monitoring
Reach
Pools
Riffles
Dissolved
Oxygen
Rate of flow
pH
Acidic
Alkaline
Temperature
Turbidity
Dissolved solids
Conductivity

Ten Water Quality Questions
Write ten questions about water quality tests that you think an elementary student might ask. Your questions can be about how the tests identify problems in the watershed, how to perform the tests, what the test means, etc.

After writing ten water quality questions, write the answers to each of those questions. You should write the answers in language that an elementary student can understand. This will give you practice anticipating questions and thinking about how you would respond.

Tips for Facilitators...
Here are some suggestions to keep in mind when trying to explain new vocabulary to 4th graders:

- Find out what they know (or think they know) about the word already.
- If their first definition is incorrect, don't simply correct them—soften it by complimenting them for sharing their ideas or point out some relationship between their answer and the correct one ("Great! You have part of it right!").
- Try to give examples from their own experience that will help them understand.
- Ask them to try to explain back to you the meaning so that you can find out whether or not your explanation was clear. But don't make it feel like a test. They're testing you – and your teaching skills!

EVALUATION

Debrief and reflect

Reflect on your field day teaching:

- Do you think the students learned what you intended?
- How can you tell?
- Is there any part of the new material about which you are unclear?

Activities assessment

Consider the following questions about the activities:

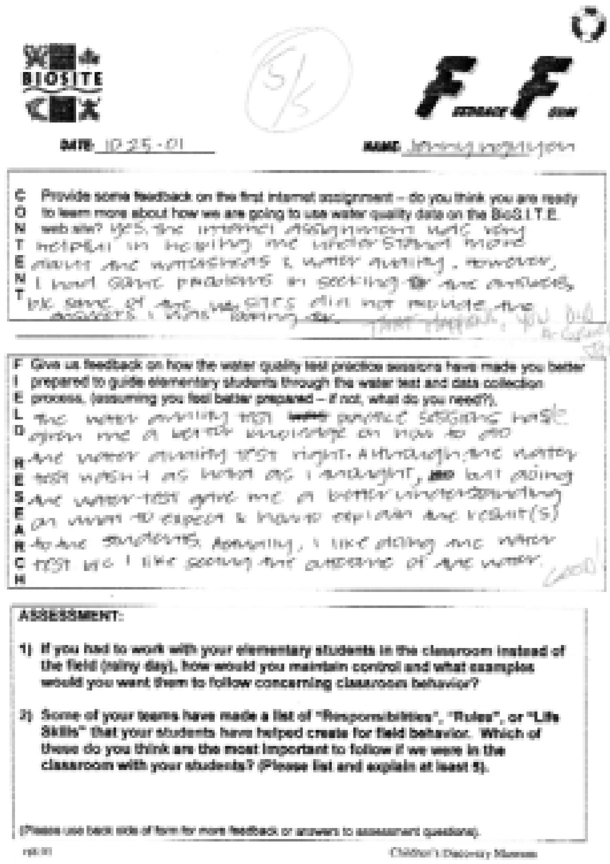
- What went well?
- What can be improved upon for next time?

Journal reflection

Now that students have practiced water quality testing procedures, they will examine their process through writing in their journal.

Have them use these bullets for journaling as a guide:

- In the journal, have facilitators write down thoughts about the above questions and issues so that they can keep a record of the teaching experience.
- Have facilitators write in their journals a list of steps for each of the water quality tests they will be doing. For each of the steps, have facilitators write one comment or question they will share with their students to help them understand what they are doing and the importance of monitoring water quality.



BIOSITE

DATE: 10-25-01

NAME: [illegible]

CONTENT: Provide some feedback on the first internet assignment – do you think you are ready to learn more about how we are going to use water quality data on the BioS.I.T.E. web site? [illegible]

FIELD RESEARCH: Give us feedback on how the water quality test practice sessions have made you better prepared to guide elementary students through the water test and data collection process, (assuming you feel better prepared – if not, what do you need?). [illegible]

ASSESSMENT:

1) If you had to work with your elementary students in the classroom instead of the field (rainy day), how would you maintain control and what examples would you want them to follow concerning classroom behavior?

2) Some of your teams have made a list of "Responsibilities", "Rules", or "Life Skills" that your students have helped create for field behavior. Which of these do you think are the most important to follow if we were in the classroom with your students? (Please list and explain at least 5).

(Please use back side of form for more feedback or answers to assessment questions).

Children's Discovery Museum

Sample Facilitator Feedback Form

UNIT 5: RIPARIAN COMMUNITIES

INTRODUCTION

In studies of the environment, animals often have the starring role, however, there are some plants that impress us with their unusual adaptations—such as the carnivorous venus fly trap or dreaded poison oak. But most of the time, the plant kingdom seems to serve as mere background for more glamorous animals. **This unit challenges you to put plants at the forefront of your studies and to look closely at the role of plants, particularly riparian plants.**

The most important and often overlooked role of plants is as producers of all food on the planet! Trace any animal's food source and you will find it ultimately goes back to plants. The owl eats the bird who eats the insect who eats the plant. Without the plant, there wouldn't be any owl. Because all energy on earth comes from the sun, and plants can take that energy and convert it through photosynthesis into plant material, they are the primary building block for animals up the food chain.

But that's not the only reason plants deserve the spotlight. Plants are vital not only as food for animals, but also as habitat. They provide shelter for countless species, from bacteria to insects to large arboreal animals, such as primates. In your field studies, you will find many ways that the plants and trees at your field study site serve as important habitat. Plants also play a role in your research. In water quality monitoring, we carefully examine the water temperature, dissolved oxygen, turbidity, and other tests. There are direct relationships between those tests and the plants along the stream, as well! We hope that after this unit, you'll appreciate these connections and the unique role of plants in your watershed.

UNIT OVERVIEW	
Engage	**Introduction to New Material** *Introductory Activity: Lost in the Forest* Reading: Riparian Communities
Explore	**Activities to Explore Material** *Activity 1: Treeific Trees* *Activity 1 Extension: Photosynthesis Pencil* *Activity 2: Eroding Landscapes*
Explain and Elaborate	**Advanced Study** Research and further reading: Riparian Trees *Activity 3: Tree Survey* Facilitator Field Day Planning
Experience **Evaluate**	**Field Study and Teaching:** Riparian Communities **Debrief and Reflect**

LEARNING OBJECTIVES

At the end of this unit students should be able to:

- Illustrate the concept of food webs;
- Understand nutrient cycles, how nutrients work through the system and assess what nutrients are needed in the system;
- Describe the role plants play in the riparian ecosystem;
- Identify characteristics of riparian plants – specific adaptations that allow them to live along the creek;
- Describe the importance of riparian plants to the health of the creek in terms of habitat, niche, adaptation;
- Illustrate the formula for and process of photosynthesis;
- Perform various measurements for trees; and
- Complete a map showing trees along a creek section

INTRODUCTORY ACTIVITY: LOST IN THE FOREST

This game is designed as a sensory awareness activity and trust-building exercise, as well as a fun way to be introduced to the basic structure of a tree.

Materials
For each pair of students:
• Blindfold

Procedure

Begin by telling students that you are going to test your observation skills without using your eyes. Ask what other ways you use your senses to observe your environment (hearing, smell, sense of touch and temperature, and taste). Students will need to work in pairs.

Note: *Decide beforehand how you want to pair students up—this could be according to who works well together or to help them get to know someone they don't usually spend time with or you could do it randomly.*

Once they are in pairs, explain that one of them will serve as the guide for the other student who will be blindfolded. The guide will lock arms with the blindfolded student at all times to keep them from tripping or bumping into anything on the ground or in the air.

The guide will slowly take the blindfolded person to a tree. Imagine this tree is the "home" of the blindfolded student. Without taking off the blindfold, the student should try to memorize everything about the "home" tree – the texture of its bark, its size and branches, the roots and ground at the base, any leaves, etc. Then the guide will lead the blindfolded student away from the tree, using a winding, confusing path to get them "lost in the forest."

The "lost" student is now free to take off the blindfold. The challenge is to find the home tree. The student may try to retrace the path walked using the sounds heard and things felt underfoot, or the student may simply go from tree to tree to recognize the home tree by feeling it.

After finding the tree, students switch places and repeat the activity.

Note: *As the leader, you may need to place time limits on the time they are being led blindfolded to and from their tree to be sure that everyone has enough time to switch and finish the second round.*

Reflection

Ask students what senses were most important to them as they did this activity. How did they help them? Did they notice things about their environment that they had not noticed before they were blindfolded?

What was the most difficult part of this activity? Most likely, some students will say the hardest part was trusting their "guide" as they were walking. Ask them to compare how they felt about this at the beginning of their walk and at the end.

Let students know this activity is a fun way to introduce the basic structure of a tree and to find out how much students already know about trees. Talk about the parts they discovered on their trees and look at other trees nearby for comparison. Do people know the names of all the parts? What do they know about their functions? Does anyone know the common names of any of the trees you see?

Reading: Riparian Communities

The streams you will study do not operate in isolation; they are part of a larger riparian environment. The word **riparian** comes from the Latin word *ripa*, which means “river.”

The riparian environment is composed of the stream channel, stream banks and all of the biotic and abiotic components. **Biotic** means living things, such as plants, animals, bacteria and fungi, and the **abiotic** components are non-living, physical features, such as climate, temperature, water chemistry, water quality, precipitation, and soil. Both biotic and abiotic factors contribute to the success of individual species. When one factor determines success over others, such as dissolved oxygen or temperature requirements for fish, it is called the **limiting factor**. This means that as characteristics of the environment change, the limiting factors will affect what species can survive there.

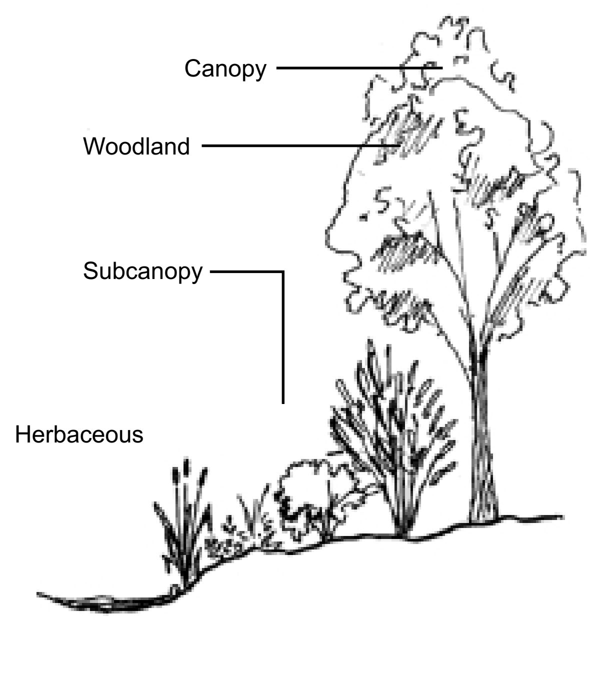
The space an organism inhabits along with its associated characteristics, such as food and shelter, is called a **habitat**. A **niche** is the organism’s functional role in its surroundings – everything that affects the organism and everything that is affected by it. Interacting groups of organisms form an **ecosystem**, or **community**. This is a self-regulating unit with constant input of energy in the form of sunlight. Here, each organism has a niche or a role to play and the absence affects all others in the community.

Riparian ecology, the interrelationships between organisms in the community can be studied at different levels of complexity. You will first look from the perspective that you would typically see when approaching your creek study site.

The **riparian zone** is the corridor of habitat on either side of the stream. This zone serves as protection and filters pollutants from the developed area. Trees and shrubs stabilize the stream bank and overhanging vegetation cools the water and provides nutrients. The zone provides food and nesting habitat, and serves as a protected travel corridor for a variety of animals.

Vegetation found at the edge of this zone is the mature **woodland**—large trees such as willow, alder, and oak. Under this canopy is the **subcanopy**, with woody plants and shrubs such as poison oak and snowberry. Under this and near the stream you will find **herbaceous** plants, such as grasses, rushes, and wildflowers.

Typical animals are deer, raccoon, opossum, river otter, skunk, coyote, mice and gophers. Birds come in all shapes and sizes. Egrets, herons, warblers and songbirds, hawks and owls are found in a variety of niches. Reptiles and amphibians, such as lizards, salamanders and frogs, are found throughout the community and macroinvertebrates, such as crayfish and aquatic insects, live in various places within the stream.



Building Blocks

The relationships between organisms in the riparian community can be understood by studying the food webs and nutrient cycles that serve as the basic building blocks of the ecosystem. These cycles are based on the use and return of carbon, nitrogen, phosphorus, and water by organisms.

The sun is the main source of energy and plants absorb this energy directly. Animals absorb this energy by eating the plants or other animals that have eaten plants. Plants are referred to as **producers** because they use energy from the sun to make new organic matter to contribute to the ecosystem. Other organisms consume energy to build their bodies. These are called **consumers**.

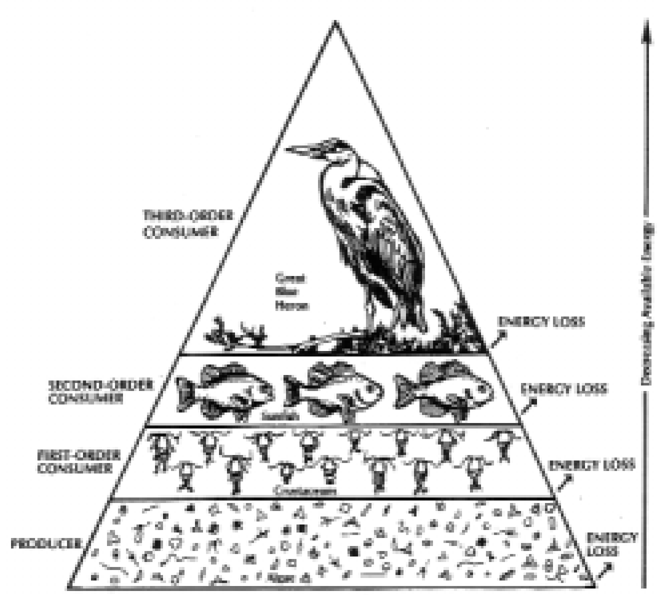
Primary consumers eat plants only (**herbivores**). Secondary consumers eat other animals that have eaten plants (**carnivores**). Some animals eat a mixed diet of plants and animals (**omnivores**). **Decomposers**, such as fungi, eat non-living organic matter.

Energy flows through the ecosystem in steps, called **trophic levels**. Producers, such as grasses, would be level 1; herbivores, such as mice, that gain energy by eating producers would be level 2; carnivores, such as snakes, that eat herbivores would be level 3, etc. Each animal gains the energy and nutrients from what it eats. The link between these levels is called the **food chain**. Often, these food chains overlap, forming **food webs** and complex connections of predators and prey.

Nutrient Cycles

Organisms within an ecosystem transfer and cycle the nutrient atoms required for life. Three essential nutrients: carbon, nitrogen and phosphorus have their own cycle. In the **carbon cycle**, plants take carbon from carbon dioxide through the process of photosynthesis and pass it on to animals that eat plants. Organic waste is consumed and decaying organisms return the atoms to the environment. One of the limiting factors to plant growth is the amount of nitrogen available. In the **nitrogen cycle**, nitrogen-fixing bacteria convert nitrogen from the atmosphere into a form that plants can use. Phosphorus is cycled like carbon and nitrogen. In the **phosphorus cycle**, phosphorus is released by erosion from its source in rocks. Phosphorus levels can be impacted by agriculture use. Since phosphorus comes from a specific object rather than from a chemical process it must be replaced if removed. This is often the case when used for agricultural purposes.

An Energy Pyramid for a Pond Food Chain



One Pond Food Chain

Unit 5: Activity 1: “Treeific” Trees

Students Learn…

- How plants store and transport water;
- The importance of producers in the water cycle and to living things; and
- The importance of native vegetation to overall riparian health, for erosion control, and as habitat for stream organisms

By doing...

- Observations of the different types of stream vegetation.
- Explorations of leaf types, characteristics, and adaptations of different riparian plants; and
- Experiments to observe how plants transpire

Then reflecting on…

- Where plants get water;
- The importance of transpiration to the water cycle; and
- How plants have adapted to conserve available water for survival in different habitats

Materials

For groups of 3:

- Gallon-sized clear plastic bags with twist-ties (not ziplock)
- Permanent markers for labeling

Getting Started

Begin by asking students what they remember about the steps of the water cycle. Imagine the path of a single drop and list the places where this drop may end up. Brainstorm the different ways in which living things hold and use water (humans, plants, cell processes).

Introduce the steps

1. Take students outside (near a creek if possible) and demonstrate how to set up for the experiment.
2. Advise students to choose a plant that is in full sun, with large leaves.
3. Label a bag with student name or team number.
4. Place the bag over a cluster of leaves so that as many leaves as possible fit inside while still leaving room between the leaves and the bag.
5. Make sure tie is secure at base of bag to trap surrounding air around leaf cluster.
6. Write down the tree or plant size, leaf size, color, texture, and describe surroundings.
7. If possible, complete set up for a second plant to compare a variable, such as leaf shape or size, or amount of direct sun.
8. Leave set up for at least 30 minutes. Check back frequently to record how many minutes it takes before condensation appears on the bag.

As leaves are doing the work, have students complete an observational study of other leaves found along the stream or in the study area.

Collect as many leaves as possible to use in the next activity. Help students to sort selection of leaves by leaf characteristics: shape, texture, colors, etc.

Brainstorm with the group how the different characteristics of the leaves collected represent adaptations that allow many different types of plants to survive in a specific habitat.

Have students number each leaf so they do not need to know the name of the plant. Next, help students create a dichotomous key for their leaf collection (see BioSITE online for examples).

Model the steps

9. Share with students samples of dichotomous keys for leaves and trees. Explain how dichotomous keys are used to identify groups of living things.
10. Have teams of students describe the process they completed to be able to sort their leaf collection.
11. Have students ask each other to identify what characteristic is key for each group of leaves.
12. Have students create a dichotomous key for their collection of leaves.

After 30 minutes have passed ask students what they expect to see when they return to their bags. Ask students if they can explain why leaves have so many different shapes and sizes.

As students return to their bags, do not undo tie until students have a chance to discuss and record observations.

Students should see moisture collecting on the inside of the plastic bags. Ask questions about the water in the bag, such as:

Where did the water come from?
Where would it end up if the bag hadn't been there?
Do you think different leaves would produce a different amount of moisture?
What might be different about leaves in sun or shade?

Share observations

- Have students exchange leaf collections and keys to practice further keying out the plants. For many of the leaves that have been collected and numbered, students may be able to identify them using field guides or tree finders.
- Discuss the different characteristics most commonly found among the plants in your study area.
- Ask students why they think scientists have created dichotomous keys.
- Share with students more complicated dichotomous keys, such as keys for macroinvertebrates or wildflowers.

Scientific explanations

- Have students study a diagram of the process of photosynthesis and review the importance of producers, carbon cycle, oxygen cycle, and water cycle to living things.
- Share information with students on specific riparian plants and their adaptations and importance to the stream environment.

Journal reflection

Now that students have observed what happened inside the bags, have students record their observations and complete these bullets for journaling:

- Have students draw out the process of photosynthesis.
- Have students explain in their own words two adaptations of leaves and their relationship to plant habitat.
- Have students invent a plant, describe its unique characteristics, and the specific habitat where you would find this plant.
- In journals have the students write a desription of a plant they would invent to live: by a creek, in the desert, on a sand dune, and in a lake. Have students make drawings that show the specific adaptations of their newly created plants, and what kinds of critters are dependent upon these plants upon these plants for food or shelter. Have students include water cycle arrows in their drawing.

Photosynthesis Formula

6CO2 + 6H2O = C6H1206 + 602

sunlight trapped by chlorophyll plus Carbon Dioxide plus water = glucose sugar plus oxygen

Tips for facilitators…

Create a skit showing the steps of photosynthesis and have your students play the roles of sugar, oxygen, water, chlorophyll, tree, etc.

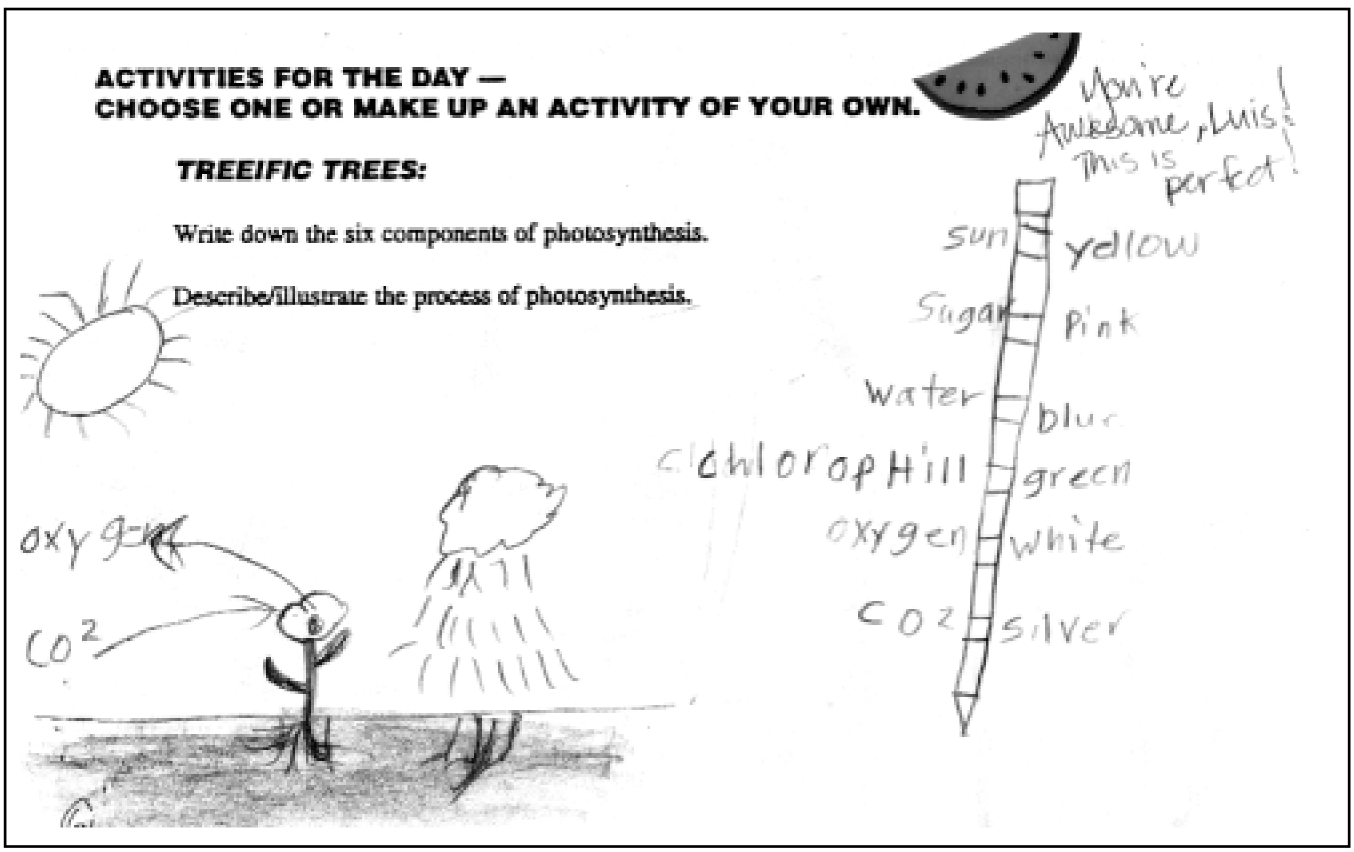
Unit 5: Activity 1 Extension: Photosynthesis Pencil

One favorite make-and-take activity to do while studying photosynthesis is our **Photosynthesis Pencil**. After students have drawn out the formula for photosynthesis in their journals and discussed the importance of plants in the watershed, students make a formula pencil to take home. Our local water district donates the pencils and we supply colored sticker material. The students each can take home a pencil and re-teach a photosynthesis lesson to their family members, reinforcing their understanding of this complex process. Each student uses small colored strips of sticker to decorate their pencils in a way that represents elements in photosynthesis.

You can also do the same activity with different colored beads and small safety pins that students can pin on their backpacks as a reminder that they are part of their environment and have a responsibility towards it. Our students take their river guardian job very seriously!

Tips for Teachers...
Using creative art materials in field teaching allows students to enhance their understanding of abstract science concepts in a fun way, and they can take simple projects home to share with family!

- **Blue = Water**
- **Yellow = Sun**
- **Green = Chlorophyll**
- **Brown = CO2**
- **White = O2**
- **Pink = Sugar**



Student journal entry describes the photosynthesis pencil project

Unit 5: Activity 2: Eroding Landscapes

Students learn…

- How to evaluate the health of a riparian community by observing habitat conditions along the sides of the creek;
- How a lack of plants can cause the stream to become unhealthy and unsuitable for plants and animals; and
- How flora and fauna are dependent upon each other to maintain a healthy and sustainable community

By doing…

- Explorations of creekside habitat;
- Experiments alongside the creek to determine importance of vegetation; and
- Water quality measurements and data analysis to understand the relationships of riparian vegetation and water quality

Then reflecting on…

- The importance of habitat preservation and restoration;
- The impact humans have had on riparian corridors through development; and
- Water quality monitoring in relation to ensuring and maintaining a healthy riparian corridor habitats

Materials

For groups of 5 (building classroom models)

- 8 x 8 pan with 2” sides
- Gallon sized ziplock bag
- 3-4 cups of diatomaceous earth (available at garden or hardware stores)
- Water, sticks, leaves, moss, plastic, wooden blocks, etc.
- Spray bottle
- Plastic wrap

For groups of 5 (in the field)

- Mapping paper
- Journals
- Erosion study materials:
  - Containers for water
  - Soup or coffee cans that have top and bottoms cut away, and edges smoothed for safety
  - Spray bottles
  - Timers

Stream Erosion Model

Making the Model: Fill half of a low container with dough made from equal parts diatomaceous earth and water. Mold dough to different shapes and slopes, to serve as the imaginary landscape of a riparian corridor. Add props to the model to represent human development and natural communities.

Getting Started

Using the model and materials above, have students use spray bottles to investigate the effect of “rain” on exposed areas with no vegetation, on areas of steep grade or barren surfaces, or areas of overdevelopment (use plastic wrap on the model to represent impervious surfaces to show how runoff affects the flow of a stream).

Introduce the steps

1. Begin by asking students what they noticed while they were experimenting with the Stream Erosion model.
2. Brainstorm with the class how problem erosion areas might affect riparian communities and make a list of possible threats to creeks in your area.
3. Ask students if they can describe different areas of the study site – how the water flow is affecting the banks.
4. Ask students to describe areas of the creek that seem to be healthy (shaded/vegetated) and also areas that may be of concern (bank has been cut away).

Taking students into the field to make detailed observations on the conditions of their stream site will help them apply lessons learned in the erosion demonstration

Safety Note:

Diatomaceous earth when dry is hazardous to breathe. In ziplock bag, carefully mix equal parts dry powder with water to make a “dough” before giving to the students.

Model the steps:

5. At a central location of the study site, gather students to review the erosion discussion.
6. Ask students to recall the specific areas they described in class and point them out on site.
7. Brainstorm with the group other areas to be investigated.
8. Divide the groups into teams and provide erosion experiment materials.
9. Explain to students that they can use a variety of techniques to explore the landscape of the creek site (such as those described below).

As students work alongside the creek encourage teams to explore conditions of vegetation in a variety of ways:

Overview Map: Have students map out a large area of the creek as an overview of the riparian corridor. Have them mark on the map the number and location of trees. Add to the map the approximate number and location of shrub areas. And finally add the areas of green grasses and low growing vegetation.

Tree Canopy Map: Have students mark out an area of stream reach that they can walk along. Have students start at the downstream end, and walking upstream stop every 10 paces to write out observations. Have students count the number of trees providing shade over the water. Have students note the kinds of plants alongside the banks. Note if there is any vegetation falling into the water including leaves, logs, and branches. And have students describe the aquatic vegetation found at each point.

Soil Erosion Study: Have students pick eight different spots of ground to compare to each other. Encourage students to find spots of different slope, location, vegetation, etc. At each spot, students will use an opened can, water, and a timer to measure how fast water infiltrates into the ground. Using the same size can and same amount of water, have students time how long it takes for the water to soak into the ground and compare this infiltration speed for each of the eight spots. If possible, have students take a soil sample to test.

Streamside Evaporation Study: Have students pick out eight different locations to compare to each other. Encourage students to pick locations of different sun exposure, leaf characteristics, distance to the water, and density of vegetation. Using a spray bottle, have students time how long it takes for water to evaporate from different surfaces. Note times and observations for each spot.

Share observations

- Have student teams report methods of study to whole group.
- Have students present findings to class using poster maps and drawings.
- Have student teams supply explanations supported by evidence from their experiments and identify habitat conditions of study site.
- Have teams supply recommendations for areas of concern.

Scientific explanations

- Show students data on erosion, sedimentation of waterways, riparian habitat loss.
- Compare data to urban development in areas of erosion, sedimentation of waterways and riparian habitat loss.
- Share information about local creek restoration projects and provide opportunity for students to get involved.
- Compare creek site data for turbidity measurements to rainfall amounts.

Journal reflection

Now that students have taken a closer look at the habitat conditions of their creek site, allow time for students to make suggestions for possible solutions to problems they have identified.

Explore these journal bullets:

- Have students identify areas within their study site to monitor closely and continue studying.
- Have students draw final maps and include data, observations, and recommendations.
- Have students create a future plan of action to correct a problem they have identified.
- In journals, have students make a list of the many factors that have impacted the health of our riparian corridors.
- Have students list strategies that could help improve the health of your creeks.

Reading: Riparian Trees

This would be a good time to invite a visiting scientist to the classroom. A botanist or a member of the Native Plant Society will be able to talk about trees that are specific to your study site and your community.

Think for a moment about some of the key factors that you know influence water quality (for example temperature, nutrients, sediment, and oxygen). Now consider how trees within the riparian ecosystem might directly contribute to those factors – trees near a stream can provide shade to cool water temperatures; add nutrients to the water as they drop their leaves; knit soil together with their roots to minimize erosion; and add oxygen to the air during photosynthesis. Can you see how trees contribute to stream health?

In a riparian ecosystem, you will find trees that are adapted to a variety of niches – from in or near the water like willows, to higher up on the dry banks, like walnuts. A tree's roots seek and gather water. Diverting a stream or extracting groundwater can be detrimental to a tree's chance of survival. Some riparian trees, like alders, need to have their roots wet most of the time. Others, like oaks, can survive long periods of drought as long as they get periodic flooding. Some trees, such as the buckeye, have developed alternative strategies such as losing their leaves in the summer if they don't have enough water.

Riparian trees provide food and shelter for birds, insects, mammals, and other plants. Acorns, nuts and fruit are a great source of nutrients, and high branches can be an optimal roost for birds. They also provide food and shelter for aquatic organisms and fish. Their leaf canopies shade the water and drop leaves, or food. When branches drop in the stream they slow the flow and create pools for fish, and a tree's shadow provides camouflage for small fish to hide from predators. Trees provide useful materials to humans, especially early settlers who used the tree's wood for lumber and fuel; acorns and fruits for food; and bark, needles, and sap for boats, baskets, and medicinal purposes.

Some information on riparian trees:

Black Walnut – (150 feet) Big hardy shade tree. High branched tree with round crown. Furrowed blackish brown bark. Leaves have 15-23 leaflets.

Buckeye – (20- 30 feet) Divided trunk growth pattern. Showy tree with masses of creamy-white flowers. Large green leaves drop in late summer to reduce dehydration. Ohlone Indians used ground up seeds as fish poison.

Big Leaf Maple – (30-95 feet) Large tree. Lives on upper stream banks. Provides food and canopy for riparian habitat.

Western Sycamore – (50-100 feet) Fast growth. Roots must reach the water table for healthy growth. Main trunk often divides into spreading second trunk. Smooth branches gracefully twisted and contorted. Beautiful, patchy, buff colored bark. Large yellow green leaves to 18 inches across, deeply lobed.

Coast Live Oak – (50-70 feet) Evergreen Oak. Relatively fast growing. Broadly rounded crown and with age can develop a massive trunk and branches. Oak trees form the basis of an elaborate food web.

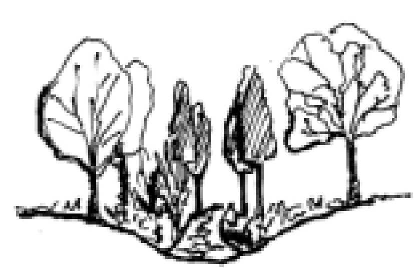
Valley Oak – (70-90 feet) Deciduous Oak. Deeply furrowed bark. Lobed leaves.

Red or White Alder – (50-90 feet) Moisture loving and very fast growing. Up to 40 foot spread of top branches often with downward tip at ends. Coarsly toothed 2-4 inch leaves, dark green above and pale green beneath.

Bay Laurel – (50-70 feet) Evergreen. Found in many plant communities. Leaves are used as spice.

Willow – (35 feet) Grow as small trees or shrubs. Leaves with pale undersides. Important to birds as a source of shelter, food and nesting material.

Cottonwood – (50-100 feet) Fast growing but short lived. Grows in low areas of riparian community.



Unit 5: Activity 3: Tree Survey

Students learn…
- How to take tree measurements at their site study;
- Techniques for identifying tree species; and
- How to record data and compile a tree inventory

By doing…
- Measurements along a belt transect to survey tree populations;
- Observations of riparian tree characteristics; and
- Research on adaptations of specific trees typically present in riparian corridors;

Then reflecting on…
- The importance of trees to the health of the riparian corridor;
- The impacts humans have had on riparian habitat; and
- Strategies to help preserve and restore riparian habitat

Materials

For each group of 3 students:
- Yellow caution tape or markers for transects
- Directional compass
- 100-meter rope marked in meters
- Centimeter rulers
- Meter measuring tape
- Tree height gauge
- Densiometer

Getting Started

Ask students to close their eyes and imagine sitting alongside the banks of a mountain stream. Have students share what images, sounds, and feelings come to mind. Take time to enjoy these thoughts and encourage students to share their imaginary stories (for example, "I went hiking up to Mt. Willow and it was quiet and I saw a deer…").

Introduce the steps

Select an area with a variety of trees of different sizes and close to the creek. Group students together to take an overview look at the study area.

1. Explain to students that they will be conducting a **tree transect survey** to study the different types of trees near the creek. Reassure them that they do not need to identify the types of trees they measure, although they may end up learning this after some research. The purpose of the survey is to take tree measurements that will help to determine the general health of the creek habitat.
2. Have students split into teams and pick one spot along the creek bank to begin the transect.
3. Have students use a marker to identify the spot and write overall conditions of the creek in that area. As student teams mark out their starts, map the location of all the study teams.
4. Number each team and mark their starting point on the map with that number.
5. Make sure each team has a variety of trees to measure along a line approximately perpendicular to the creek.

Model the steps

6. Have teams mark off every 10 meters from the start marker and in a designated line until they reach at least 50 meters from the start marker.
7. Using a compass have teams note the direction of the transect by standing at the start and looking at the end marker.
8. Now teams can start taking measurments of individual trees intersecting the transect. Make sure teams understand how to take the measurements and record the data.

Circumference at breast height

Have students measure the circumference of the tree at adult breast height (approximately 1.2 meters high). Record in centimeters. Diameter can be determined using the circumference measurement.

Tree Height

Students can estimate the height of tree by standing next to it so that their shadow falls alongside the tree's shadow. Then after measuring their shadow, their height, and the tree's shadow, they will be able to determine the approximate height of the tree. (person's height/person's shadow = tree height/tree shadow) Record in meters.

Leaf Comparison Study

Have students measure leaves of vegetation found along the transect line and describe in detail. If possible, include labeled drawings in journal, leaf prints, sun prints and rubbings. See leaf charts at BioSITE online.

Percentage of Shade Cover

Have students use densiometers to measure the percentage of shade cover provided by trees along the transect. Starting at the creek bank with the student facing the water and toes right at the edge, hold the densiometer level at his\her chest, look at the densiometer to see if his\her head is reflected in the small box. Count the number of dots that overlap with a reflection of the trees above. Double the number (50 dots on a densiometer) to determine the percentage of shade cover at the creek. For single trees not along the creek, but along the transect, have students take a measurement by standing at the drip line (farthest imaginary line where water would fall off the outermost leaves of the tree) and facing the tree, take a percentage of shade measurement using the densiometer.

Share observations

- Have student teams present their findings to the group. Encourage students to use drawings, charts and diagrams whenever possible.
- Have students chart the results of the entire group.
- Have students research riparian tree species and common vegetation found alongside creeks.

Scientific explanations

- Show pictures, slides and prints of common creek trees.
- Share tree guides with students and take a tree walk or survey with a visiting scientist.
- Do calculations with the class to determine DBH (Diameter at Breast Height)
- Do calculations with the class to determine height of trees found at the study site.

Journal reflection

Now that students have had a chance to do several kinds of measurements, allow time for students to practice identifying trees within the study site. Simple tree guides may describe trees in terms of average height and leaf characteristics.

Explore these bullets for journaling:

- Challenge student teams to identify four different trees found within their study area.
- Have students create a leaf chart for the leaves found within their study area. Ask students to explain why certain leaves are uniquely adapted to benefit riparian trees.
- Have students make tree drawing with only pencil or black pen to show different types of growth patterns.
- Have facilitators research the many issues of wildlife habitat decline the world over. Have facilitators create posters to show success stories of habitat restoration and wildlife re-population projects. If possible, plan a field trip to see a local area that has been a part of a recent success story.

Facilitator Field Day Planning

Facilitators determine how to go about teaching students. To structure the lesson planning process, refer to *Template 1* on page 157 of the *Tools for Implementation* section.

Based on the lesson planning discussion, the high school teacher reviews and summarizes facilitator suggestions and develops an overall agenda to give to the entire group for the field day (see *Template 2* on page 158 of the *Tools for Implementation* section).

Have students consider the following:

Terms and Concepts

With a partner, review the material learned in this unit by describing the following features of riparian ecosystems in terms that 4th grade students would understand. After each partner takes turns describing the term in his or her own words, write down your definition of the word.

Riparian
Biotic
Abiotic
Limiting factor
Habitat
Niche
Ecosystem
Community
Ecology
Woodland
Subcanopy
Herbaceous
Producers
Consumers
Herbivore
Omnivore
Decomposer
Trophic level
Food chain
Food web
Nutrient cycle

Tips for Facilitators...

Here are some suggestions to keep in mind when trying to explain new vocabulary to 4th graders:

- Find out what they know (or think they know) about the word already.
- If their first definition is incorrect, don't simply correct them—soften it by complimenting them for sharing their ideas or point out some relationship between their answer and the correct one ("Great! You have part of it right!").
- Try to give examples from their own experience that will help them understand.
- Ask them to try to explain back to you the meaning so that you can find out whether or not your explanation was clear. But don't make it feel like a test. They're testing you – and your teaching skills!

EVALUATION

Reflect on your field day teaching:

- Do you think the students learned what you intended?
- How can you tell?
- Is there any part of the new material about which you are unclear?

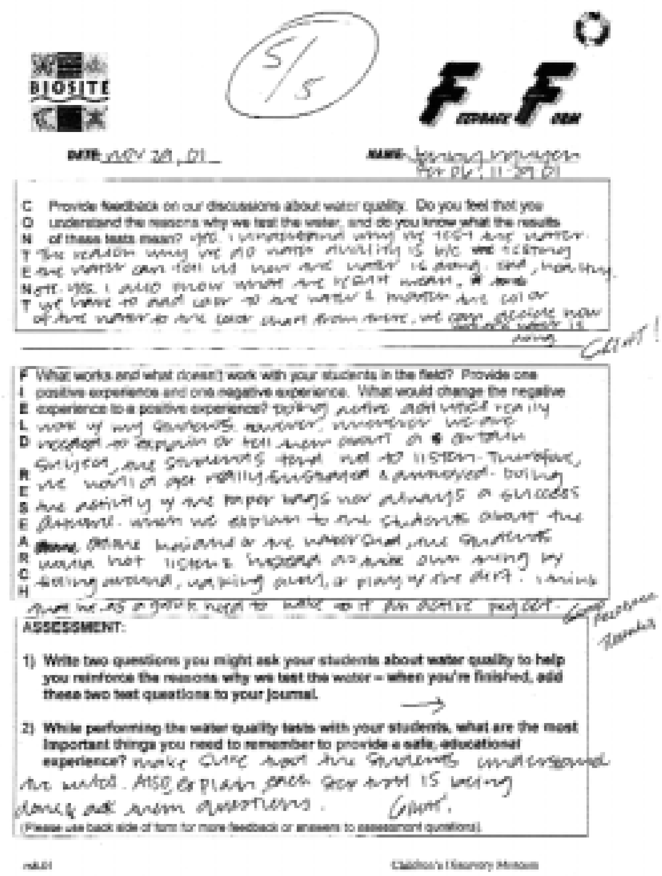
Activities assessment

Consider the following questions about the activities:

- What went well?
- What can be improved upon for next time?

Journal

In your journal, write down your thoughts about the above questions and issues so that you can keep a record of your teaching experience.



BIOSITE

5/5

DATE: NOV 29, 01

NAME:

CONTENT — Provide feedback on our discussions about water quality. Do you feel that you understand the reasons why we test the water, and do you know what the results of these tests mean?

Great!

FIELD RESEARCH — What works and what doesn't work with your students in the field? Provide one positive experience and one negative experience. What would change the negative experience to a positive experience?

ASSESSMENT:

1) Write two questions you might ask your students about water quality to help you reinforce the reasons why we test the water – when you're finished, add these two test questions to your journal.

2) While performing the water quality tests with your students, what are the most important things you need to remember to provide a safe, educational experience?

Great.

(Please use back side of form for more feedback or answers to assessment questions.)

Sample Facilitator Feedback Form

UNIT 6: BIRDS

INTRODUCTION

When you go in search of wildlife at your field study site, the animals you most likely will succeed in finding on a regular basis will be birds. Because a river or creek serves as a reliable source of water and vegetation, it draws birds in search of food, nesting sites, and protection from predators. Some birds live in the same area year round while others travel thousands of miles on annual migrations, using rivers as places to rest and refuel. As you return to your field site and become more familiar with its features, you will also begin to recognize many of the birds.

Bird watching is a fascinating and satisfying activity for people of all ages. Even though you may not be able to identify by name the birds you see, **you will discover in this unit that you can predict much about birds simply from their habits and anatomy**. For example, you will learn that from the shape of a bird's beak, you can often tell what kinds of food it eats. Knowing how to identify the food preferred by different birds is useful, because it can help you to discover more about your field site. If you regularly discover fish-eating ducks at your site, you can predict that there is a good food supply of small fish for these predators – a good indicator that the site has a diverse group of animals and plants further down in the food chain.

Remember, by now you probably know more about your field site than anyone else in the community. You've noticed several birds during your studies, but this is your chance to understand the role of these important animals along the creek that they call home. Observing birds will teach you many things about the environment, and in turn you can bring your knowledge and stories to other people in the community. In this way, you can encourage the broader community to join in observing and learning with you.

UNIT OVERVIEW	
Engage	**Introduction to New Material**
	Reading: Biology through Birds
Explore	**Activities to Explore Material**
	Activity 1: Feather Dissection
	Activity 2: Owl Pellet Exploration
Explain and Elaborate	**Advanced Study**
	Reading: Riparian Birds
	Activity 3: Bird Transect and Bird Presentations
	Facilitator Field Day Planning
Experience	**Field Study and Teaching:** Birds
Evaluate	**Debrief and Reflect**

LEARNING OBJECTIVES

In this unit students will be able to:

- Describe different adaptations and explain how they are suited to their niche in the community;
- Refine observation skills and follow the steps needed to identify birds in the field;
- Illustrate bird anatomy and explain form and function by describing the relationships between the parts of a bird (e.g., feather and flight);
- Gain practice in field study methods through establishing and conducting a bird transect;
- Present knowledge in graphic form by creating a custom bird guide for elementary students showing the birds identified at the creek site;
- Explain why birds are indicators of balance within the community;
- Use binoculars, spotting scope and magnifier tools; and
- Identify bird families by shape.

Reading: Biology through Birds

How are birds an indicator of stream health? What role do birds play in the riparian ecosystem? How do birds fit in with the food web, pollination, and other important activities?

We study these creatures because water quality is just one variable in monitoring the health of a riparian ecosystem; other variables, such as species diversity among populations of birds and macroinvertebrates are also good indicators of ecosystem health. Birds are also an essential part of the food web and the riparian ecosystem. They eat insects and are eaten by larger animals, such as coyotes. They support riparian vegetation by eating and excreting seeds. Riparian habitats are important sources of food, cover, and nesting habitat for birds. Because of this they host a more diverse and productive population of birds than some other habitats with fewer resources. However, the proximity of riparian habitats to human habitats poses a danger to this diversity. Human impacts and degradation, such as polluted runoff, erosion, and urban construction, threaten these environments, resulting in loss of habitat, poisoned food sources, and disrupted migratory and breeding practices.

These animals that play such an important role in our environment offer many opportunities for investigation. All plants and animals are classified, or organized, by scientists into different **classifications**. Members of each classification are related to each other biologically. Birds are members of the family order **aves** (within this order there are further classifications of **family**, **genus** and **species**). Members of the order **aves** are warm-blooded, egg-laying, feathered vertebrates (other vertebrates are reptiles, amphibians, fish and mammals). Observing a bird, you might guess that millions of years ago birds evolved from ancient reptiles because they both lay eggs and share similar outer characteristics, including scales. The bird's scales evolved into feathers and its forelimbs into wings.

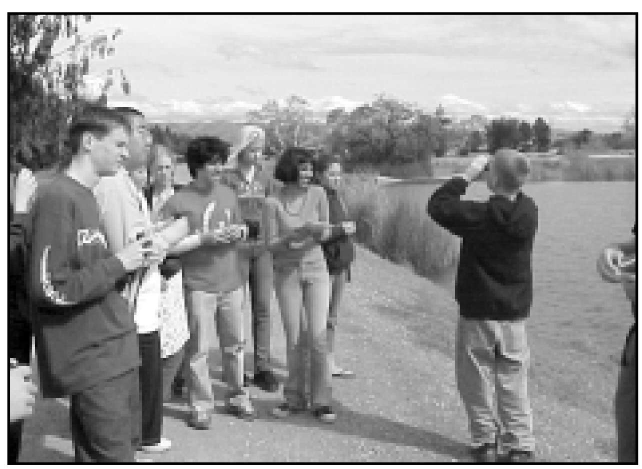
Adaptations

Though not all birds fly, birds are the most adapted of all vertebrates for flight. What **adaptations** do birds have that make them particularly suited for this physical activity? Along with wings and feathers, birds' bodies are tailored to make them strong and light. The wing muscle is attached to the sternum (breastbone); air sacs are located throughout the bird's body and within its bones to decrease its weight; and bones are modified to strengthen and streamline the body.

As a class, birds also have behavioral and morphological adaptations to take advantage of a wide variety of food types. **Specialists** eat a single type of food, like insects. **Generalists** eat several types of food and take advantage of seasonal and local abundance. The shape and size of the beak determine what type of food birds eat.

Beaks

Bird beaks are specialized to serve as efficient tools for a specific food source. Birds use their beaks for probing in the mud, eating insects, tearing flesh, scooping, grasping, straining, and fishing. Small birds are typically vegetarian, insectivorous, or a combination. Larger birds and predators like raptors may eat rodents or small birds. A bird's beak shape and size is



adapted to the type of food it eats, and where it has to look for the food. Since birds have no teeth, food goes into the stomach where it is broken down with strong acids and digestive enzymes. Anything that is not digested in the stomach (such as fur, bones, and feathers) goes to the gizzard where it is stored and regurgitated later in the form of pellets.

Feathers

Feathers distinguish birds from other vertebrates. Feathers provide insulation, waterproofing, and a smooth body surface that reduce friction for flight. Different types of feathers serve different purposes. The large flight feathers that cover most of the body, the wing and tail, and the tiny feathers on the face are called contour feathers. They are strong, flexible, lightweight, and waterproof. They have a single shaft of keratin (the same material as our fingernails and reptile scales) running down the center and thin, interlocking barbs on either side that form the vane and can be recombed into place if disarranged. Down feathers have little or no shaft but provide insulation. Filoplumes are hairlike feathers that perform sensory functions. Bristles are stiff shafts with little or no vane. These are often eyelashes or filters over the nostrils.

Birds manufacture their own color pigments (brown, black, red and green) in their feathers. However, blue and iridescent colors are part of the internal structure of the feather. Red, orange, and yellow pigments are derived from food that the birds eat. Colors are adaptations that birds use for camouflage, displays of courtship, and warning signs to other birds or animals.

Wings

The shape and size of wings are directly related to the type of flying a bird does. In general, wings are curved convex on top and concave underneath to assist with lift. The outer ends, or wing tips, serve as a propeller and rudder. The tail also provides steering power. Birds that are fast flyers or that spend much of the time flying, like falcons and swifts, have long pointed wings. Birds that live in forests, like owls and songbirds, have short broad wings to allow them to fly in and out of dense vegetation. Eagles, vultures and other large birds have long broad wings for soaring.

Feet

Birds' feet are shaped for different purposes. Birds use their feet for swimming, wading, perching, and grasping or capturing prey. Birds, such as raptors, have sharp **talons** and are able to spread their toes wide to catch prey. Owls, which hunt at night, have feathers that cover their legs and feet to silence their approach to prey as they hunt.

Senses

Birds have excellent vision and color perception. Their large eyes have acute resolution and are located on the side of the head. Each eye can focus independently so birds can either see binocular, when looking straight ahead, or monocular by looking at two different images at the same time. Binocular vision allows birds to judge distances, while monocular vision gives them a wide field of view. Birds have sensitive hearing, especially nocturnal birds, but generally poor smell and taste.

Behavior

Birds use their calls to attract mates, defend their territory, signal alarm, or announce a food source. Young birds call to stimulate their parents to feed them.

Unit 6: Activity 1: Feather Dissection

Students learn…

- About the different adaptations of birds;
- How a feather is constructed; and
- Why the biodiversity of birds and wildlife is important

By doing…

- Exploration of different birds and their adaptations;
- A classification of bird families; and
- A study of feathers and their unique structure

Then reflecting on…

- Biodiversity;
- Importance of birds to specific habitats; and
- Form and function of feathers

Materials

For groups of 5:

- Several different bird feathers
- Magnifiers
- Toothpicks
- Spray bottle
- Chart paper with feather diagrams

Getting Started

Explore the word “animal” with the class. What is an animal? What is a mammal? Most people think of mammals when they hear the word animal, but **animal** is a large group (kingdom) of living things that are grouped into smaller and smaller groups. Only one of these smaller groups is the group (class) of **mammals** (warm blooded vertebrates that produce milk for young). The kingdom of animals actually includes living things such as insects and fish, as well as mammals.

- After students understand what a large group the animal kingdom is, ask students to list as many animals as they can on a piece of paper in three minutes.
- During this time make a chart on the board, listing the following classes in columns across the top: crustaceans, insects, arachnids, fish, birds, reptiles, amphibians, and mammals.
- Ask students to tell what animals they listed, and write them on the board in the column of the correct class.

Brainstorm with students the amazing diversity of living things, reminding students of plants and fungi – two other kingdoms of living things.

- Ask the students to talk about some special “talents” of animals that they know, such as spider and snake venom, the speed of a peregrine falcon or cheetah, the song of a whale, etc.
- See if students can explain these talents as adaptations.
- Divide the group into teams and have them list bird adaptations.

Introduce the steps

1. Have teams share one bird adaptation with the group.
2. List birds and adaptations on the board.
3. Have the class make a list of birds they know and group them into families.
4. Discuss characteristics of each family and special adaptations for specific birds.

As students explore what birds they know, pass out bird books and guides to help add to the list. Review birds that students are likely to see at the study site. Explain to students that one simple way to understand the uniqueness of birds is to examine the special structure of a feather.

Model the steps

5. Pass out feathers to each student. Supply teams of students with magnifiers, water, and toothpicks.
6. Have students make a detailed drawing of what they see using the magnifiers.

7. If microscopes are available, have students examine feathers under more powerful magnification.
8. Have students draw details of specific areas of a feather to later be used when identifying and labeling parts of a feather.

Share observations

- Have students describe different kinds of feathers they explored.
- Have students present identifying characteristics including tail feathers, crown feathers, and primary flight feathers of birds that students may see in the field.

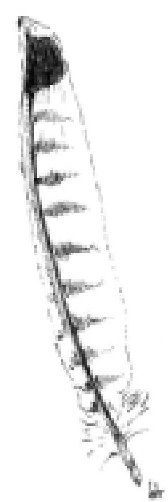
Scientific explanations

- Discuss a detailed drawing of a feather, showing barbs, barbules, and the feather shaft.
- Make a chart with the class of specific birds, their field markings, and adaptations.

Journal reflection

Now that students have taken a closer look at birds, have students write in their journals about what they have learned, using these bullets as a guide:

- Have students write observations about birds they have seen in the field.
- Have students make a plan in their journal to study the behavior of a bird or group of birds for a longer period of time.
- Have students make a paper airplane and analyze the form and function of the parts of the airplane in comparison to the form and function of the parts of a bird.
- Have students draw and label a diagram of a feather.
- In journals, have the students create a picture of a bird they have invented after learning about the unique adaptations of birds. Have them report the natural history of their bird to the class, where it lives, what it eats, and how it raises its young.



Unit 6: Activity 2: Owl Pellet Exploration

Students learn...
- About owl adaptations;
- About local riparian food chains; and
- Dissection procedure

By doing…
- Drawings of owls and details of specific adaptations;
- Charts of food chains; and
- Owl pellet dissection

Then reflecting on…
- The relationship of birds to their food web and habitat; and
- The adaptations of predator and prey in a particular habitat

Materials

In groups of 5:
- Owl pellets (one per student or pair of students)
- Small dissection trays
- Toothpicks
- Tweezers
- Magnifiers
- Sorting chart of owl pellet contents (see BioSITE Online)
- Owl info chart and diagrams

Getting Started

Begin by asking what kinds of birds students know about. How are birds different from one another? How are owls different from other birds? Lead a discussion to bring out some details of owls and their unique adaptations.

Introduce the steps

1. Draw out the talons of an owl or facial disc and explain the adaptations that allow the owl to be an efficient hunter.
2. Have students chart a simple food chain that includes the owl and list some of the things it may capture as prey.
3. Tell students that they are going to find out more about what owls eat by dissecting an owl pellet.
4. Before passing out pellets, show students a sterilized owl pellet and explain how it is formed and treated for scientific study.
5. Demonstrate how to unwrap and study the outside of the pellet to look for clues, and review how the pellet is formed inside the owl's body. Explain how to dissect slowly and gently so evidence of the owl's diet stays intact. Show students how to match one bone to the owl pellet chart and how to compare other bones of similar shape.
6. Pass out materials, key, and pellet to each student and have students record as they find each bone. Point out that each pellet may have different types of bones and after the dissection the whole group will tally up a total for the kinds of bones found.

As students begin the dissection on their own, encourage students to take their time and be careful as they open up the pellet. If students are reluctant to begin, they can watch a partner and help to key out what kinds of bones he/she finds. Give students plenty of time and help to key out what kinds of bones and materials they find.

Model the steps

7. Once students begin finding bones, have them identify the kind of animal they are from by using the key.
8. List all the kinds of bones found by the entire class and tally the numbers of each kind.
9. Have students make a detailed sketch of a favorite bone, labeling observations on color and texture, shape and measurements.

Tips for Teachers...
We've found that owl pellet dissection works best individually or in pairs. The students get more engaged and it is an activity that really develops a student's sense of self as scientist.

Share observations

- Have students share with other teams their results and drawings
- Have group tally results of dissection: the total number of pellets dissected and types of animals, bones and insect pieces.
- Brainstorm with group the importance of predator prey relationships in balancing energy flow in a community.

Scientific explanations

- Share diagrams of owl anatomy, form and function with students. Have students practice creating scientific drawings and detailing information on a drawing.
- Show students keys to owl pellets and pellet contents, and have the class practice with sample bones to figure out how to match bones to bodies to animal species.
- Share diagrams of food chains and food webs that include owls and birds of prey.

Journal reflection

Now that students have completed their dissection, have students continue to draw what bones they have found. Examine and respond to the following bullets for journaling:

- Ask students to draw and label two to three bones that belong to the same animal.
- Have students draw a food web that includes the owl, the prey, and other living things in a particular habitat.
- Have students list important adaptations of predators and prey in a particular habitat.
- In journals, have students make a list of the many different kinds of birds found near their homes. Have students create a food web that shows at least three kinds of birds, what they eat, and who preys upon them. Have students complete the food web with plants and humans connecting to the energy flow

Tips for facilitators…
With this activity, it may take a few minutes for some students to get comfortable. You can encourage them through praise for their observation skills and efforts and especialy by showing your own enthusiasm for the activity. Most likely they will become engaged as others around them do so.

Here's a tip from a high school facilitator...
"A challenge for me was trying to get all the girls involved with the owl pellet. Danny and I tried to explain that it wasn't poop or puke, just a hairball. But it didn't work so we just had them identify each bone. I tried to show them I wasn't afraid as a girl, and touched it too."

"Today I found many different bones. I might have had enough to make a whole skeleton. I found ribs, leg bones, a skull, and lots more bones."
– Elementary student journal entry

Reading: Riparian Birds

Ecosystems have a collection of species that are generally found in one ecosystem. By nature, a stream environment should have a certain population of birds. While the particular species varies by region, there will be species that live in trees and hunt rodents and reptiles and others that live near the stream and eat insects.

Birds inhabit a diverse range of **niches** within the riparian ecosystem and use every part of the habitat for food, territory and nesting. Some birds choose low shrubs, such as blackberry and willows, located near the stream channel. Others select the tree **canopy** or **snags** (standing dead trees). A diverse composition of vegetation is required to support bird diversity. Raptors (hawks, owls) and songbirds (warblers, sparrows) are found in trees. Woodpeckers live in snags. Small birds and shore birds live near the water (towhee, flycatcher, sandpiper). Some species you will likely find near the stream include raptors (hawk, kestrel, vulture, and turkey vulture, kingfisher) and waterbirds (duck, egret, heron, red-winged blackbird).

This description of birds and their niches is a good example of **biodiversity**—having a variety of organisms, such as birds, their insect and small mammal prey, and the vegetation they live in and eat from, represented within an ecosystem. This mixture and abundance of species help preserve genetic diversity and diverse habitats. They also illustrate how species are interrelated with each other. Biodiversity is lost when a habitat is destroyed or made smaller in the process of construction, logging, or natural disasters. You have no doubt heard of the controversies surrounding rainforest destruction and logging. If a habitat is destroyed, and a bird has evolved over many years to adapt to that particular habitat, then the bird either has nowhere to go or it has to force another bird to leave its habitat. Consider that habitats are also food sources, such as the fruits, nuts, and berries from trees or insects that live in tree bark. If a bird is forced to move, they have to adapt to another type of food.

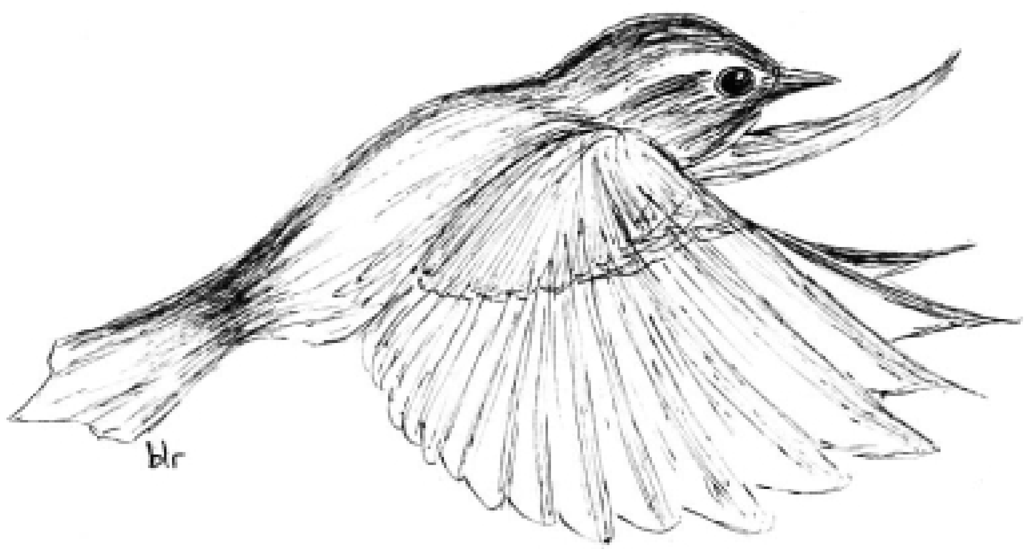
To increase their chances for survival, some birds take advantage of their ability to fly to respond to seasonal changes in temperature, habitat, and food sources. These birds **migrate**, or move back and forth on a seasonal basis. Species fly as far as from the Arctic to Antarctic, or from North America to South America, making the trip every year. Birds know when it is time to migrate. Environmental cues, such as temperature changes or changes in day length, stimulate their migration.

A killdeer makes its nest on top of rocks in a dry area of the streambed.

Studying bird population is helpful for keeping track of biodiversity. Because birds are so well adapted to a particular niche and because they are able to cover great territory, they are good indicators of environmental stability or instability. Scientists and field biologists keep track of birds over time by **tagging** or studying migration patterns. Tagging is done by placing a small metal band around a bird's leg and monitoring that individual's location at various times of the year. **Migration** study is done by observing and recording birds at particular times of year.

Both types of study offer volunteer opportunities. For example, the National Audubon Society has coordinated a Christmas Bird Count every year since 1900. It has evolved over time from a non-scientific study where people went out into their backyards and neighborhoods on Christmas day to count all the birds they heard or observed, to an organized count with unified standards and methods that involve over 45,000 people around the world. Just like in BioSITE, volunteers collect and record data, submitting it to the organization to be compiled and published. Now volunteers count birds within a 15-mile radius on one specific day within two weeks of Christmas. Once the data is collected and compiled, the organization analyzes population trends and patterns, such as geographic and winter distribution. While the data may not be completely accurate, it gives a general sense of the patterns and can be very helpful in noticing trends.

A student uses plants for cover as he tries to focus in on some birds.



Unit 6: Activity 3: Bird Transect and Bird Presentations

Students learn…
- Which birds are commonly seen at their study site;
- To apply the classification system to birds
- Specific characteristics and adaptations for different families of birds; and
- Field Identification skills to identify birds in the field

By doing…
- Research on field birds common to their field site;
- Classification charts of bird families and their characteristics; and
- Presentations to the entire class on different species of birds

Then reflecting on…
- How birds are adapted to the riparian habitat;
- The importance of using bird monitoring to study stream health; and
- How the diversity and population of birds affects the health of a stream corridor

Materials

For groups of 5:
- Field Guides of birds
- Bird information via links on Web and other resources
- Presentation materials for pairs of students: transparencies, colored markers, poster board

Getting Started

If possible, take students on a bird walk prior to introducing this project. On the walk students should use observation and recording skills to study birds.

Begin by asking students what types of birds they have seen in the field. Ask them to describe what the birds were doing, where they were seen, and any field marks they remember. Ask students to talk about the birds they have seen at other places, such as the zoo or even on television nature shows. Brainstorm with the class some of the unique adaptations of birds.

Introduce the steps

1. Review the classification system of living things and discuss how the class of birds is related to other animals.
2. Have students draw a simple chart of living things and discuss the grouping order. (kingdom, phyla, class, order, family, genus, and species).
3. Show (or have students research on the Web) a list of common birds most likely to be seen in their study area (your local Audubon Chapter can supply this).
4. Supply students with bird information, Web access, or bird guides. Have students work in pairs on one specific bird for their presentation.

As students begin researching about the birds of their area, give them an outline of presentation requirements and discuss any questions they may have. Allow students to be creative in their presentations, using audio visuals or props if they wish.

Model the steps

5. Have students make a poster showing the family to which their bird belongs and its characteristics.
6. Have students create a transparency of their bird that shows field markings.
7. Have students share information with the class on genus and species of the bird, natural history and related birds. Have students describe special adaptations and unique behavioral characteristics of their bird.
8. Encourage students to include information they have collected on field days, photos from outside sources and information about their bird from wildlife magazines.

Share observations

- Have students take notes during presentations to create a bird guide with field ID notes and special behavioral information.
- Have students take a second bird walk with an experienced birder to help lead the walk and identify the birds they researched.

Scientific explanations

- Share classification of family of birds and their characteristics.
- Show students system of classification of living things.
- Show students diagram of bird and label parts of the bird used in field identification.
- Show students silhouettes of birds for further help in field ID.

Journal reflection

Now that students have researched and heard presentations from their classmates, allow time for students to become successful birders and field naturalists. Have them reflect, using the following bullets as a guide for journaling:

- Allow time for students to record behavioral information about the birds they watch at their study site.
- Have students create a species account in their journals to compile information on the number of times they see specific species of birds and notes on where, what they were doing, etc.
- Have students draw their own imaginary bird, complete with habitat descriptions, drawings, food chain, and unique adaptations.
- Have facilitators research endangered birds of the world. Have the facilitators write a summary on one of these birds to share with their students. Have facilitators report to the class on how wildlife biologists are trying to re-establish certain populations of endangered birds (California Condor, Cranes, Peregrine Falcon).

Facilitator Field Day Planning

Facilitators determine how to go about teaching students. To structure the lesson planning process, refer to *Template 1* on page 157 in the *Tools for Implementation* section.

Based on the lesson planning discussion, the high school teacher reviews and summarizes facilitator suggestions and develops an overall agenda to give to the entire group for the field day (see *Template 2* on page 158 in *Tools for Implementation*).

Have students consider the following:

Terms and Concepts

With a partner, facilitators review the material learned in this unit by describing the following features of birds in terms that 4th grade students would understand. After each partner takes turns describing the term in his or her own words, facilitators write down their own definitions of the word.

Evolution
Classification
Aves
Genus
Species
Adaptation
Specialist
Generalist
Predator
Feathers
Talons
Niche
Biodiversity
Migration

Tips for Facilitators...

Here are some suggestions to keep in mind when trying to explain new vocabulary to 4th graders:

- Find out what they know (or think they know) about the word already.
- If their first definition is incorrect, don't simply correct them—soften it by complimenting them for sharing their ideas or point out some relationship between their answer and the correct one ("Great! You have part of it right!").
- Try to give examples from their own experience that will help them understand.
- Ask them to try to explain back to you the meaning so that you can find out whether or not your explanation was clear. But don't make it feel like a test. They're testing you – and your teaching skills!

EVALUATION

Reflect on your field day teaching

- Do you think the students learned what you intended?
- How can you tell?
- Is there any part of the new material about which you are unclear?

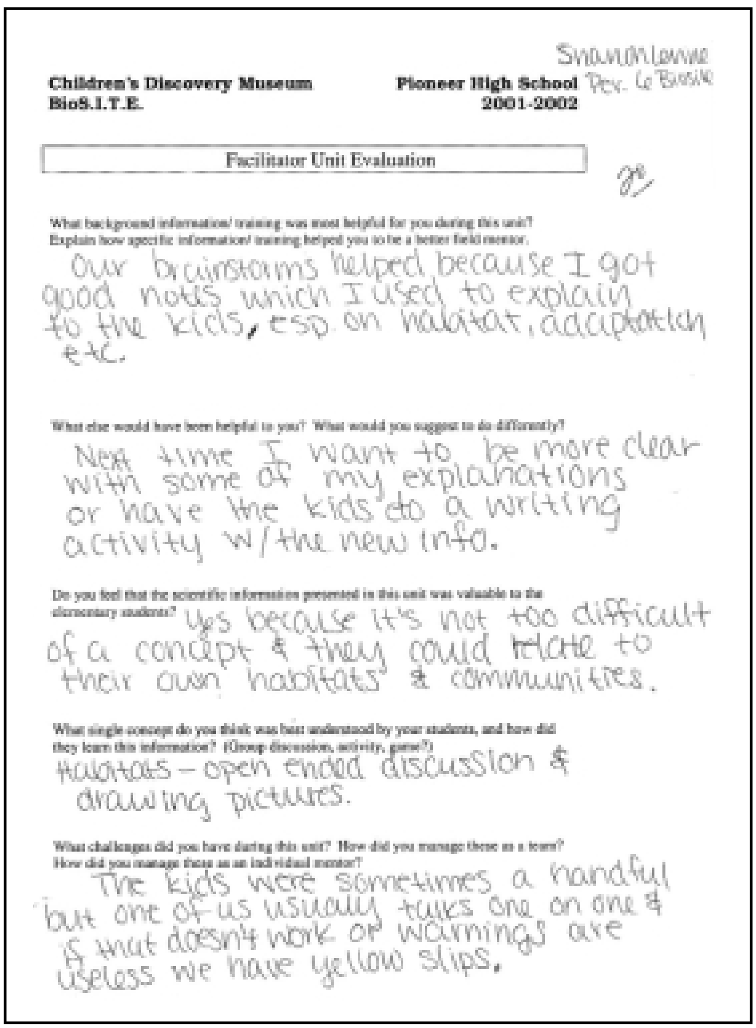
Activities Assessment

Consider the following questions about the activities:

- What went well?
- What can be improved upon for next time?

Journal

In your journal, write down your thoughts about the above questions and issues so that you can keep a record of your teaching experience.



Shannon Lewine
Per. 6 BioSITE

Children's Discovery Museum
BioS.I.T.E.

Pioneer High School
2001-2002

Facilitator Unit Evaluation

What background information/ training was most helpful for you during this unit? Explain how specific information/ training helped you to be a better field mentor.

Our brainstorms helped because I got good notes which I used to explain to the kids, esp. on habitat, adaptation etc.

What else would have been helpful to you? What would you suggest to do differently?

Next time I want to be more clear with some of my explanations or have the kids do a writing activity w/the new info.

Do you feel that the scientific information presented in this unit was valuable to the elementary students?

Yes because it's not too difficult of a concept & they could relate to their own habitats & communities.

What single concept do you think was best understood by your students, and how did they learn this information? (Group discussion, activity, game?)

Habitats – open ended discussion & drawing pictures.

What challenges did you have during this unit? How did you manage these as a team? How did you manage these as an individual mentor?

The kids were sometimes a handful but one of us usually talks one on one & if that doesn't work or warnings are useless we have yellow slips.

Example of student feedback form

UNIT 7: FISH

INTRODUCTION

There are many animals—some large and impressive, some small and well hidden—that serve as important indicators for the health of their environment. In this unit, we have chosen to focus on fish in this way. Our studies of salmon began when our students spotted them swimming up the Guadalupe River. They were over three feet long and so large that their backs pushed up out of the water as they swam through the shallower riffles. We spent most of several study sessions watching them, noting where they were and what they were doing. At some point, the 4th graders and their facilitators recorded some video of one fish that seemed to be cleaning the gravel in preparation to spawn.

In the end, it was only by showing the video footage that we were able to convince people that the salmon were really there and they were that big. People had just assumed that our shrunken little river, running through the urban center of one of California's largest cities, could not possibly support many fish, let alone the mighty salmon. Thank goodness our students were there!

Ours is not the only story like this. There are students in Washington state who removed barriers from their creeks and waited, with hope and patience, to see if salmon would return to their old spawning grounds. They were not disappointed. There are students who adopted their native endangered freshwater shrimp and found them living in the little irrigation canals of nearby dairy farms. Who knows what you may find?

Unit 7 will introduce you to the salmon, an important fish for study because its success or decline in a stream often reflects the overall health of the watershed. You will certainly want to learn what you can about the fish that live in your waterway, and then what you learn about fish may also apply to the other animals you encounter.

UNIT OVERVIEW	
Engage	**Introduction to New Material** Reading: Fish Facts
Explore	**Activities to Explore Material** *Activity 1: Fish Anatomy* *Activity 2: Life Cycle*
Explain and Elaborate	**Advanced Study** Reading: Fish Hatcheries vs. Wild Populations *Activity 3: Natural Selection vs. Hatchery* Facilitator Field Day Planning
Experience	**Field Study and Teaching:** Fish
Evaluate	**Debrief and Reflect**

LEARNING OBJECTIVES

At the end of this unit students should be able to:

- Describe the form and function of fish anatomy; identify and draw different parts of the fish;
- Diagram and explain the various stages of the fish's life cycle;
- Analyze specific dangers to different fish species during different parts of their life cycle;
- Explain how fish are adapted to their environment;
- Understand how water quality and a stream's physical features contribute to the life cycle of the salmon;
- Understand why fish are an indicator species for water quality and stream health; and
- Predict how habitat restoration (planting, erosion control) contributes to improving stream habitat

READING: Fish Facts

Fish play an important role in the riparian ecosystem. Like birds, they are considered an **indicator species** for stream health. This means that fish of certain species or numbers of fish indicate whether water is healthy in terms of balanced pH, temperature, dissolved oxygen content, turbidity, etc. They also are an integral part of the food chain, being both predators of insects and prey of larger fish, birds, and small animals. Most fish are adapted to live in either fresh or salt water, not both. Some fish are **anadromous**—they are born and begin life in freshwater streams and rivers, then migrate to the ocean, and finally return to the stream in which they were born in order to breed. For these species (such as salmon) and others, the stream's health and physical characteristics are a vital part of the life cycle and contribute to their chances of survival. First you will study the anatomy of fish. Then, you will look at its life cycle. Lastly, you will look at its habitat needs and how that relates to stream health and human impact.

Form and Function

Senses

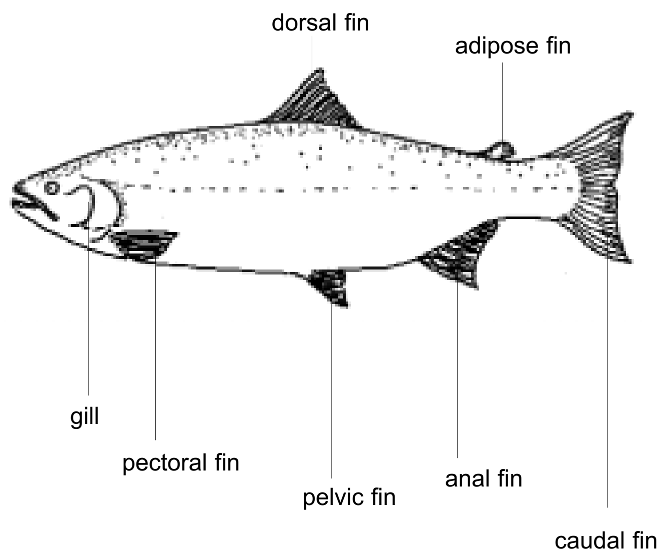
Fish have an excellent sense of smell that helps them avoid predators and locate homes for spawning (laying eggs). Fish use their nostrils only to smell, not to breathe. Fish don't hear like humans do, so they don't have ears. Rather, they have a series of small holes along each side of their body, called **lateral lines**. These holes are connected to the nervous system and detect low-frequency sounds through the water. Fish see with their eyes, but their eyes are adapted to constant bathing in water—they don't have eyelids or tears.

Breathing

Fish breathe using their mouth and gills. They take in water, which contains oxygen, through the mouth and release it along with carbon dioxide through the **gills**. The gills are protective cover for blood vessels that absorb oxygen directly from the water.

Movement

Most fish are coated with a protective cover of **scales**. The scales are coated with slime that helps fish move through the water and protects them from disease. Also assisting in movement are the different muscles (required for each movement) that lie underneath the skin and fins. Wild fish such as salmonids have several **fins**: pectoral, dorsal, caudal, anal, pelvic and adipose. Hatchery fish may be missing the adipose fin, and other native fish species may have different fin configurations. The anal and dorsal, on the back and underneath, are used for balance. The caudal (the fin at the end of the tail) is used along with muscles for propulsion through the water. Fish also have two sets of paired fins: pectoral and pelvic (on the sides) to help them balance in the water. The adipose fin on salmon is a small fleshy fin on the fish's back that serves no known purpose.



Life Cycle

We will look at the life cycle of the Coho–a stream and river fish. It begins life when females lay approximately 3,000 pink **eggs** in the crevices between gravel at the bottom of the streambed. Here, the eggs are protected from sunlight. Between late winter and spring, after about 1 month of incubation, the eggs hatch. The hatchlings live and grow in the gravel for 2 to 3 weeks in a form called **alevin**. At this stage they are vulnerable to both predators and light. They get oxygen from the water and food from a yolk sac that hangs from their bellies. This sac contains a diet of protein, carbohydrates, vitamins and minerals. By late spring to summer, the yolk sac has been completely absorbed and alevin become free-swimming fish, called **fry**. At this stage they are easy prey and require a steady food source. They live in the streamside cover, where shelter, protection and insects are found. Fry spend 1 to 3 years in streams growing and feeding on small insects and plankton. They then migrate to sea, at which point they are called **smolt** and are approximately 10 to 15 cm long. During this stage they undergo physical changes that prepare them for living in saltwater. Once they enter the ocean they are called **salmonids**. They spend 3 to 6 months in the ocean where they prey on plankton and smaller fish and try to avoid their predators: larger fish, seals, whales, and humans. Then the **spawning salmon** head back to their native stream to reproduce.

Stream Health and Human Impact

Maintaining stream health is important for species survival. From the original 3,000 eggs laid by one Coho salmon, only 2 to 4 adult salmonids succeed in returning to spawn.

A healthy stream habitat must have a good gravel bed for laying eggs and sturdy side banks for protection. The water quality tests that you are monitoring are directly related to fish life. For example, fish require stable, cool temperatures. Fish breathe oxygen, so high dissolved oxygen content is desirable. Sediment and silt in the water can bury fish eggs, damage gills, and impair sight so low levels of turbidity are an advantage. A good rate of flow keeps sediment in the water from settling to the creek bottom. If water is stagnant, sediment can coat incubating eggs, preventing oxygen from reaching them. Sediment can also settle between gravel in the spaces where Coho lay their eggs. Also, insects pass by fish in the current when water is moving, making the food source readily available.

Habitat Restoration

Streams are easily damaged by urban runoff, erosion and siltation – all results of human development, pollution, and poor agricultural and logging practices. These streams are vital sources of life for fish. If they are degraded or destroyed, fish won't be able to survive. Fish are sources of food for birds and mammals, and they prey on insects, which maintains a healthy population balance for many animals beyond the creek.

What can we do to improve fish habitat? Stream bank restoration projects reconstruct eroding banks and eliminate streamside pools. Revegetation projects also combat erosion, increase the amount of oxygen in the water if the projects include aquatic plants (plants create oxygen during photosynthesis), and create a habitat for insects (fish food). The quality of storm water that flows into creeks can be improved by not dumping pollutants into the storm drain, by adopting careful development practices (locating buildings away from creeks, by practicing erosion control during construction) and by fishing only in regulated areas with permits.

Students in BioSITE contribute to habitat restoration projects by participating in creek clean ups, sharing water quality data with other organizations and incubating fish eggs to release in the wild.

Unit 7: Activity 1: Fish Anatomy

Students learn...
- The form and function of specific fish adaptations; and
- Important water quality standards necessary to maintain populations

By doing…
- Detailed drawings of fish anatomy; and
- Observation of live fish and creation of field guides

Then reflecting on…
- How the physical features of living things are related to their purpose;
- How fish are one type of indicator for monitoring watershed health; and
- Environmental conditions that affect the status of salmon species

Getting Started

Begin by asking students to draw a fish from memory. Give students enough time to include as many details as possible. Students may be able to draw a few different kinds of fish.

> **Materials**
>
> *Per team of 2:*
> - Journal drawing paper
> - Goldfish in a small clear bowl or cup
> - Diagrams of Steelhead trout and salmon
> - Water quality data
> - Simple salmon outline on 11” x 17” paper

Share drawings with the class to identify common understandings about fish anatomy. Then give students a second chance to do a drawing by observing a live fish, such as fish in cups, or in a classroom aquarium, or at a natural history center.

After students have drawn the live fish, lead the class in a step-by-step drawing of a Steelhead trout, identifying physical features as you go along.

Introduce the steps
1. Have students begin by identifying the dorsal, ventral, anterior and posterior of a fish.
2. Have students label all the fins on their drawing and explain what they are used for.
3. Identify head features and gill location. Discuss the form and function of gills.
4. Finally draw in lateral lines as the unique feature of fish species and compare some field identification marks for different fish families (catfish, sunfish, trout).

As students are continuing to practice drawing fish species, allow enough time for students to explore the many different kinds of fish. Students may want to draw some unique ocean fish and compare different physical features.

If possible, you can have students make presentations on different fish species – native and local species as well as endangered or threatened.

Model the steps
5. Have students study different drawings of fish and discuss why fish are shaped differently, what features and adaptations are unique to certain species, and general characteristics that make fish different from other living things.
6. Have students create a “fish field guide” that summarizes some of what they have learned. A “fish field guide” can be created by enlarging a simple drawing of a salmonid species from an 8.5” x 11” size to an 11” x 17” size. This will give you an elongated outline to work with.
7. Have students label the drawing for form and function.
8. Have students divide the guide into 4 sections.
9. On the back, have students write in four water quality tests (one in each section) that are most important when studying fish habitat such as: temperature, rate of flow, dissolved oxygen, and turbidity.
10. Where students have labeled each water quality test, have students fill in data for each test and an explanation of why monitoring this data is important for healthy fish habitat (temperature needs to be cool enough, rate of flow needs to be fast enough, DO needs to supply oxygen to fish, and turbidity needs to allow gills to function, etc.).

Share observations

- Have students review water quality data and discuss seasonal changes that may affect fish species.
- Have students share explanations of important minimum and maximum readings of water quality variables in relation to survival of salmon species.
- Include discussions of other riparian features that affect the health of fish populations (vegetation, stream substrate).

Scientific explanations

- Show labeled diagrams of fish species. Discuss form and function.
- Show comparison of different field species, noting field identification and seasonal changes for male and female.
- Show charts and graphs on species numbers in native habitats.
- Share charts on water quality monitoring standards for healthy fish habitat.

Journal reflection

Now that students have explored the biology and natural history of fish, allow time for students to write and draw about what they have learned.

Use these bullets as a guide for journaling :

- Have students draw a detailed picture of their favorite native fish showing anatomy features, field identification marks, and special adaptations.
- Have students create their own imaginary species, writing a complete natural history for their species.
- Have students create a creek plan of action, both short term and long term, to improve fish habitat.
- If possible, have students present their short term creek plan to the local water district.
- In their journals, have the students list the conditions needed for cold water fish species to survive. Have students place the conditions in order of importance and explain how each condition needs to be monitored for the fish populations to be able to succeed.

Tips for facilitators…

If at all possible, it is very intriguing to elementary students to be able to make a drawing from a live fish but you need to be very careful to model care and concern for fish and keep captive fish comfortable and safe. *Under no circumstances should aquarium fish be released into a creek!*

Tip for teachers...

The *Salmon and Trout Education Program* (STEP) is an excellent companion curriculum! Being able to raise Steelhead eggs for your local watershed brings lessons to life. For more information on STEP, visit: www.steponline.info

Unit 7: Activity 2: Life Cycle

Students learn…
- What an anadromous species is;
- The life cycle of salmon and Steelhead; and
- The importance of healthy habitat and conditions in fish species' ability to complete a full life cycle

By doing…
- A complete drawing of the life cycle stages of anadromous species; and
- STEP activities to understand more about threatened fish species and necessary habitat conditions

Then reflecting on…
- Environmental issues affecting different species of salmon at different stages of their life cycle; and
- How community efforts can make a positive impact using examples such as the Monterey Bay Salmon and Trout Education Program (STEP) which incubates steelhead eggs

Materials
- Paper
- Markers
- Activities from STEP programs
  --Salmon Survival Game
  --Homing Game
  (found at www.mbstp.org and www.steponline.info)

Getting Started

Begin by asking students the importance of maintaining a variety of fish species in different environments.

Discuss biodiversity in general and share with students some other issues surrounding the disappearance of species.

Discuss with the class the process of adding species to the threatened and endangered lists and explain the current status of these species (refer to the Department of Fish and Game).

Let students know there are several issues affecting the diversity of species on earth, and many are being studied and conditions improved though the work of scientists as well as informed communities.

Share with students the background and mission of the Monterey Bay Salmon and Trout Education Program. Explain that they will be doing a few activities from this program (see website: www.mbstp.org).

Introduce the steps

1. Have students create a project (poster, mobile, or card display) depicting the salmonid life cycle. The project should identify the life cycle stages as well as habitat needs and conditions of each stage.
2. Be sure to allow time and encourage students to focus on their drawing skills, including small details. Have students work through a draft and then create a final project that can be set up for display.
3. As students work on their life cycle study, allow time for Internet research on the STEP Program and related fish sites (an amazing list of Web links focused on programs such as STEP and other water quality and volunteer monitoring programs can be found at STEPonline (www.steponline.info). Have groups report on their findings. Have the class discuss the conditions of fish species in the Pacific, Atlantic, and Alaskan waters. Have the class discuss the issues surrounding the fishing industry.

Model the steps

4. Have students research current conditions of local fish species and report on findings.
5. Have the class play the Salmon Survival Game (STEP) and discuss the challenges at each step of the game.
6. Have students make suggestions as to which organization or type of scientist they would like to have visit the class to learn more about what is happening in their area.
7. If possible, plan a field trip or invite the scientist to visit the class.

Share observations

- Have student projects displayed for public viewing for Earth Day.
- Have students plan a water celebration day in honor of water creatures.
- Contact local water district to see if they are interested in display as well.

Scientific explanations

- Show students diagrams of the salmonid life cycle.
- Share pictures of fish species and chart field identification markings for different native species.
- Give students fish guides to explore and use in their own drawings.
- Show students a chart of habitat use for salmonid species at different life cycle stages.
- Have students play the Homing Game (STEP) to appreciate the amazing accomplishment of fish migration and the return to a home stream.

Journal reflection

Now that students have studied the life cycle of salmonid species, challenge students to expand on what they understand. Complete these bullets for journaling:

- Have students draw the life cycle of a different species of animal, and include a presentation comparing and contrasting the life cycles of fish and other species.
- In their journals, have students write a life story as a salmon from an egg in the redd bed to an adult spawner. Have students list the chapters as life cycle stages and have students describe what it felt like to meet new challenges.

Tips for facilitators…

Games from the STEP program are mentioned, but facilitators can also create their own games using the life cycle information to have students better understand the concepts and environmental concerns surrounding fish species.

Tips for facilitators…

Favorite activities of our BioSITE students can be found at the STEP Web site: www.steponline.info/lessons.html and soon the new curriculum will be available, so check the bulletin board at this site!

Another great game link can be found on the teacher's page of the *Run, Salmon, Run!* Program: www.mcn.org/ed/cur/cw/Salmon/Resources.html

Reading: Fish Hatcheries vs. Wild Populations

This is a great opportunity to invite a visiting scientist such as a fisheries biologist to come in and discuss the challenges of domestic vs. wild populations, introduction of new species, and conservation.

For many years, humans have created conservation and breeding programs to maintain endangered populations of animals. Pacific Salmon, which are fished for food, are one of these populations. In 1872, the United States Fish Commission established the first fish hatchery in California to breed salmon. Since that time, over 400 hatcheries have been constructed from Alaska to California.

Hatcheries do help increase the number of fish in a protected environment; however, breeding fish to be released into the wild raises controversy among scientists, fisheries biologists, ecologists, and government agencies. What happens when a domesticated animal is released in the wild? Does it have the same chances for survival? You have read about the very delicate life cycle that salmon go through. Consider what might be different if these fish were bred in captivity and then released.

Some examples of differences are:

- Fish populations have developed adaptations that allow them to live in specific waters. When humans raise and incubate eggs they can ship them anywhere in the world, removing the fish from its natural habitat.

- Raising fish in a hatchery can affect the natural gene pool. If a small number of fish are introduced and primarily responsible for breeding, they yield less diversity than would occur in a natural environment.

- Growing up in a hatchery, fish can develop behaviors that are different from those needed for survival in the wild. For example, hatchery fish are fed pellets that are tossed into the water, like the fish food you might feed fish in your aquarium. To eat, fish must feed from the top levels of the water. This is contrary to how they would feed in the wild, where on the surface of the water they are more likely to be prey for birds or large mammals.

This dilemma of increasing fish populations while preserving diversity and natural evolutionary conditions is an exciting challenge for science and engineering. In this next activity, you will have a chance to “take on” the challenge.

NOTE: See BioSITE online at www.cdm.org/biosite for information on visiting scientists and a power point presentation on Fish Hatcheries vs. Wild Populations.

Unit 7: Activity 3: Natural Selection vs. Hatchery

Students learn...

- Current issues related to fish populations, fish migration, and local habitat conditions;
- The difference between hatchery-selected adults and native adults;
- The habitat conditions that produce the strongest adult population of fish species;
- How scientists are working to increase fish populations; and
- How to get involved with community projects

By doing…

- A study of hatchery fish versus wild salmon characteristics;
- An activity with a visiting scientist that focuses on current field research; and
- A design of a fish hatchery that would facilitate a successful fish-rearing program to ensure compatible cohabitation of farm-raised species with wild species

Then reflecting on…

- Current habitat conditions of wild species;
- Consumer responsibilities to sustain wild fish populations; and
- How fishing industry policies are designed to accommodate different populations

Getting Started

Explain to students that a visiting scientist not only presents information on current research, but also gives students an opportunity to learn more about career possibilities in the field of environmental science. Current research in the field of fish and the environment includes many areas of focus, one of which is management of fish populations through controlled hatcheries.

Ask students if they have ever been to a hatchery. If possible, have a fisheries biologist present information on a local hatchery (see guidelines to help scientists prepare for a visit on pages 160-161 of the *Tools for Implementation* section) or show a video on fish hatcheries and management.

Have students list the conditions under which these hatchery fish are raised.

Introduce the steps

1. Ask students to make a chart of conditions required to meet the needs of the hatchery-raised fish.
2. Ask students to look for answers to the following basic questions:
   - Where are fish located at each different phase of the life cycle?
   - What conditions make up the habitat for these fish at each location?
   - How do these fish find food?
   - How do these fish find shelter?

As students take notes and explore these questions, allow open discussions and class questions to be addressed. If time allows, students may research more on the conditions of hatchery fish.

Model the steps

3. After a time, have students add to their charts additional information on native fish that follows the same line of questioning.

Share observations

- Have a class discussion and compile complete information for the students.
- Team up students (or set up as a debate) and ask each team to explain the behavioral differences that may result in the different situations of hatchery fish and wild species.
- Discuss as a class this comparison. Ask how these behavioral differences may affect the breeding pairs that cohabitate in the wild.

Scientific explanations

- Show videos of fish being raised in hatcheries.
- Show videos of fish in the wild.
- Share statistics of numbers raised in hatcheries and compare to wild populations.
- Share statistics of population numbers of fish farmed for the seafood industry.

Journal reflection

Now that students have explored and debated the issues related to hatchery fish versus wild species, allow time for students to research further and explore these bullets for journaling:

- Challenge students to design a hatchery that would support behaviors more compatible to wild fish.
- Ask students to analyze the cost issues of building and maintaining their designed hatchery as compared to a traditional hatchery.
- Have facilitators research current fish hatchery projects and salmon populations. Have facilitators summarize in their journals to share information with their students.

Tips for teachers...
Contacts for visiting scientists can be found through the Department of Fish and Game (www.dfg.ca.gov), local water districts, City Environmental Services Departments, or colleges and universities.

Facilitator Field Day Planning

Facilitators determine how to go about teaching students. To structure the lesson planning process, refer to the *Team Lesson Plan Worksheet* (Template 1) on page 157 of the *Tools for Implementation* section.

Based on the lesson planning discussion, the high school teacher reviews and summarizes facilitator suggestions and develops an overall agenda to give to the entire group for the field day (see *Field Day Agenda* (Template 2) on page 158 of the *Tools for Implementation* section.

Have students consider the following:

Terms and Concepts
With a partner, review the material learned in this unit by describing the following fish terms in words that 4th grade students would understand. After each partner takes turns describing the term in his or her own words, write down a definition of the word.

Indicator species
Anadromous
Spawn
Gills
Scales
Fins
Eggs
Alevin
Fry
Smolt
Salmonids

EVALUATION

Reflect on your field day teaching:

- Do you think the students learned what you intended?
- How can you tell?
- Is there any part of the new material about which you are unclear?

Activities Assessment

Consider the following questions about the activities:

- What went well?
- What can be improved upon for next time?

Journal

In your journal, write down your thoughts about the above questions and issues so that you can keep a record of your teaching experience.

UNIT 8: Macroinvertebrates

INTRODUCTION

Most likely this is the first time you've heard the term "macroinvertebrates" and we wouldn't be surprised if you don't think they sound like much fun. If so, think again! **This unit is BioSITE's most popular and memorable. You will discover that hidden under the water, among the rocks and plants in any healthy stream, is a tiny universe of critters, including macroinvertebrates.**

For every dragonfly you see above a pond or creek, there are dragonfly nymphs, fearsome hunters living underneath the water. Just as a frog hatches from an egg and begins its life as a tadpole under water, many of the insects you see flying near a waterway spend an early stage of their life cycle in the stream. Some may even spend years living in the water, only to live as a mature flying insect for a few weeks or months.

The number of macroinvertebrates you can find living in the gravel beds of a stream is truly astonishing. Because of the competition for food and shelter from predators, macroinvertebrates are highly adapted to live in specific niches of the underwater environment. They specialize in eating different things and living in different locations. You will see tiny claws for clinging to rocks in fast moving water, special jaws for shredding plants, tiny houses built of pebbles and insect "glue," and more.

You will find that, just as with birds and fish, observing macroinvertebrates teaches us many things. You will learn how to conduct a form of water quality testing using macroinvertebrates instead of test kits. Examples of camouflage and adaptations will be brought to life right in front of your eyes. And, perhaps most importantly, you will find that a crowded "city," full of residents, homes and roads, can fit right under your foot. So watch your step!

UNIT OVERVIEW	
Engage	**Introduction to New Material** Reading: Introduction to Macroinvertebrates
Explore	**Activities to Explore Material** *Activity 1: Who Am I?* *Activity 2: Critter Catch*
Explain and Elaborate	**Advanced Study** Reading and Research: Pollution Tolerance Index *Activity 3: Pollution Tolerance Index* Facilitator Field Day Planning
Experience	**Field Study and Teaching:** Macroinvertebrates
Evaluate	**Debrief and Reflect**

LEARNING OBJECTIVES

At the end of this unit students should be able to:

- Explain the ecological concepts of camouflage, adaptation and species;
- Identify and classify various creek organisms;
- Observe and record adaptations;
- Review the microenvironments within the stream (riffle, pool) and understand their relationship to macroinvertebrate habitat;
- Learn how to identify the macroinvertebrates of the study site using a dichotomous key; and
- Compare the information they gather to the pollution tolerance index.

Reading: Introduction to Macroinvertebrates

On land in the riparian ecosystem it's easy to see interesting things among the larger animals. Hawks catch field mice, fish jump out of the water to catch an insect in midair, and Snowy Egrets and herons stand patiently waiting to spear their prey when it swims beneath. Life in the water can be just as remarkable. The smallest living organisms can be seen only by microscope. The largest, like fish and amphibians, are easily seen with the human eye.

Macroinvertebrates are animals that can be seen without a microscope, but they differ from fish and amphibians because they have no backbone; they are **invertebrates** protected by an exoskeleton. Among these creatures we find small organisms that live underwater but breathe air through a snorkel-like tube that pokes through the water surface. We also find beetles that carry around air bubbles to help keep them afloat and serve as their personal source of oxygen when they dive below the water surface. Some bugs have a beak with which they pierce their prey and suck out the juices. Others have wax on their feet so they can skate on the surface of the water.

Each of the many different types of macroinvertebrates has interesting physical adaptations and a unique level of tolerance to water pollution. Many have a life cycle that is specific to a **metamorphosis**, or change, from the **larval** to adult stage. Others, like leeches or planaria, do not metamorphose.

Like birds and fish, macroinvertebrates are indicators of water quality. In fact, they can even be used to "test" or measure the quality of water by using a Pollution Tolerance Index, which calculates the number and species of macroinvertebrates found in the water. Macroinvertebrates are first grouped by their ability to tolerate pollution and then counted. The types of organisms found reflect the level of pollution in the water.

One reason macroinvertebrates are considered a good indicator of water quality is because they are relatively limited in their mobility. They tend to stay in one general area, so if a species disappears this can serve as a warning signal that the water quality has declined. For example, if many species that cannot tolerate pollution were found, you could deduce that the water quality is good. If a sample taken revealed only pollution-tolerant species, this would suggest the water was polluted. The test doesn't explain the cause of pollution—it only identifies the symptom. The macroinvertebrate organisms are classified and taxonomically grouped according to their pollution tolerance: most intolerant, moderately intolerant, fairly tolerant, and most tolerant of pollution.

It is important to note that finding "fairly tolerant" or "tolerant" critters does not automatically indicate a polluted stream. Even clean streams have tolerant macroinvertebrates, but they are located alongside intolerant species.

Pollution Tolerance Classification

You will notice that macroinvertebrates are basically grouped in a range according to their tolerance for varying levels of oxygen and nutrient pollution in the water. The following describes their tolerance and physical adaptations that allow them to survive in those conditions.

Group I: Pollution Intolerant

These organisms are considered “pollution sensitive.” They are intolerant of nutrient pollution (from sources such as sewage and fertilizer) and of decreased oxygen levels. If pollution increases, macroinvertebrates in Group 1 will die. In their ideal habitat – cold, clear streams with high oxygen levels – you would find a diverse and abundant group of stoneflies, alderflies, dobsonflies, and snipeflies. They feed on naturally available food sources such as decaying leaves.

Group II: Moderately Intolerant

Organisms in this group have a higher tolerance for nutrient pollution, but are still mainly intolerant of decreased levels of oxygen. This group contains a diverse number of species, such as mayfly nymphs, caddisflies, riffle beetles and water penny beetles. They can be found in different areas within the stream. Cranefly larva and crayfish live in riffles; dragonfly and damselfly nymphs live in pooling water. Mussels and clams don’t move – they are found on the bottom, clinging to rocks.

Group III: Fairly Tolerant

This group can tolerate low levels of oxygen and high levels of nutrient pollution. They tend to be bottom dwellers – scavengers and omnivores like aquatic sowbugs and scuds that feed on decomposing organic matter. Midge larva and gill-breathing or right-hand snails feed on a variety of plant and animal food sources. Blackfly larvae thrive in the nutrient-filled water of sewage treatment plants.

Group IV: Pollution Tolerant

As the name of the group suggests, these macroinvertebrates can tolerate severe nutrient pollution and low levels of oxygen. They often have adaptations to get their oxygen from the surface of the water. Aquatic worms and leeches tolerate stressed, low oxygen environments. Left-hand snails have special air-breathing adaptations and bloodworms (midge larva) have special blood that helps move oxygen through the body.

Types of Macroinvertebrates

Macroinvertebrates can also be categorized by what they eat. In riparian habitats, organic matter such as leaves and needles, twigs, flowers and fruit from nearby trees and vegetation, falls into the stream and eventually sinks to the bottom to decompose. As it falls and sinks, bacterial and fungi **decomposers** begin to consume it. This coarse organic matter is then stripped and shredded into smaller, finer particles by macroinvertebrate **shredders**. The shredders feed on the leaves but get most of their nutrition from the decomposers that attached to the leaf. In small, vegetated streams shredders are the dominant class. **Detritivores** then feed on the decomposed leaf, which now includes the bacteria and fungi along with shredder feces. Further down, the stream opens up and becomes wider. With less vegetation shading the water and more sunlight getting through, more algae grows. In these waters, **scrapers** are dominant. These macroinvertebrates scrape the algae off rocks for consumption.

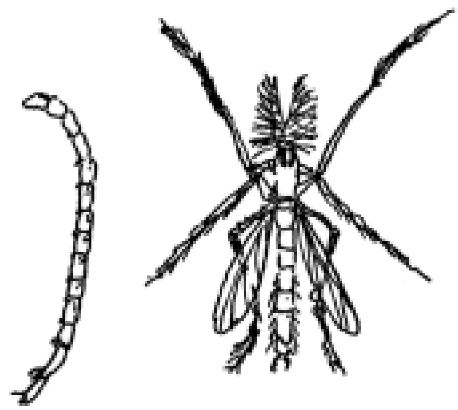
Looking for Macroinvertebrates and Adaptations

The different physical characteristics of streams determine where macroinvertebrates are found. The organisms are adapted to the levels of oxygen and nutrients found in riffles, runs and pools (for example, riffles have more dissolved oxygen than pools). When you take samples, reflect on what you know about natural cycles, about water quality and about stream composition. You will be more successful finding macroinvertebrates if you consider the following:

- Look during the appropriate season and weather conditions. Heavy rains or flooding may wash critters away. Droughts may kill aquatic critters.
- The water you look in should have at least a moderate rate of flow. If it is stagnant, limited oxygen may reduce their chances for survival.
- Since aquatic critters need oxygen, look for them in places in the stream where you know this is most likely – in riffles. You'll want to look in other parts of the stream, too – near vegetated banks and under rocks.
- You may have more luck finding critters if the streambed is rocky as opposed to silted or sandy. Rocky stream bottoms allow for air pockets and safe places for macroinvertebrates to live.
- Critters need to eat. Look for them in areas that have vegetation along streambanks, as leaves drop in the water providing food when they decompose.

Adaptations and Metamorphosis

In their immature form, macroinvertebrates are either **larva** or **nymphs**. Both go through a process of physical change called **metamorphosis** to become an adult. In the larval stage the organism is generally a soft, wormlike body. Nymphs are further developed than larva and have limited adult features like legs and wing pads. During metamorphosis the larva or nymph hardens, changes shape and transforms: wings and legs develop and the insect becomes sexually active. When larva transform they undergo **complete metamorphosis**. Nymphs undergo **incomplete metamorphosis**. Species that have a larval form include flies, mosquitoes, beetles, crane flies, caddisflies and midges. Species that have a nymph form include stoneflies, mayflies, and true bugs.



Midge fly larva and adult

Unit 8: Activity 1: Who Am I?

Students learn…
- Life cycle stages of common aquatic macroinvertebrate families;
- Specific adaptations of common macroinvertebrates; and
- How surveying macroinvertebrates can serve as an indicator of pollutants

By doing…
- An introductory game to find matching life-cycle stages of creek animals;
- Detailed drawings of creek macroinvertebrates; and
- Exploration of dichotomous keys and field guides

Then reflecting on…
- The importance of macroinvertebrates in the energy flow of a creek environment;
- The form and function of macroinvertebrate adaptations; and
- The needs of aquatic macroinvertebrates, their relationship to the overall health of the stream and the creatures that live in and near it.

Materials

For groups of 5:
- Pre-made deck of "Who Am I?" cards. These are 4" x 6" index cards folded in half with microinvertebrate information as detailed below. The deck can include as many sets as needed. Each set includes 2 folded cards
- Macroinvertebrate field guides

Getting Started

1. Pass out macroinvertebrate cards and tell everyone that each card is to remain sealed until you instruct everyone that they can break the seal (the sets are scotch taped closed to play the game).
2. When you say go, have everyone move around the room, asking questions and comparing pictures to see if they can decide who may have their match. NO PEEKING!

Introduce the steps
1. Pass out macroinvertebrate cards. The outside of the card just has a picture of one stage of one macroinvertebrate. The inside of the card shows the other stage that makes the match, and gives information on the species including the common name.
2. Students are given a short amount of time to find who they think their partner should be. They can only use the picture on the front of the card - No Peeking inside!!
3. When all students have found a partner, have students share with the class why they think they might match.
4. Time for reality check! Have partners look inside the cards to see if their educated guess is correct.
5. Allow time for students to find their correct match if their guess was not right.
6. As students gather with their matches have pairs brainstorm the advantages of different life stages. Students should discuss: What other creek critters need the presence of this macroinvertebrate in some way? When and how does it manage habitat differences due to seasonal changes?

Mayfly Set:

<u>Card 1</u>
- Inside top half with photocopied picture of **mayfly nymph**
- Inside bottom half with species name and life cycle facts
- Outside front with photocopied picture of **mayfly adult**
- Outside back with hints for ID (since outside front is adult - hints tell facts about the nymph)

<u>Card 2</u>
- Inside top half with photocopied picture of **mayfly adult**
- Inside bottom half with species name and life cycle facts
- Outside front with photocopied picture of **mayfly nymph**
- Outside back with hints for ID (since outside front is nymph – hints tell facts about the adult)

Inside bottom half is the same for each card. Players with adults on the outside try to find the larvae or nymph to match. Players with a larvae on the outside try to find an adult. Follow same pattern for each set: Stonefly, Riffle Beetle, Blackfly, Damselfly, Dragonfly, etc.

Model the steps

7. Have pairs make a list of critter needs.
8. Have pairs use field guides to list related macroinvertebrates.
9. Have pairs list adaptations of their critter family: the type of feeding, place they are found in the creek, special anatomy, etc.
10. Have students give a brief presentation on their macroinvertebrate to the entire class.

Share observations

- Have full group discuss findings. Have students draw posters of their critter to share with class.
- Present special adaptations of macroinvertebrates. Create a chart to share that includes "Did you know?" facts.
- Discuss different families of common macroinvertebrates.

Scientific explanations

- Show students a diagram of the system of classification of living things.
- Show students different macroinvertebrate charts and drawings.
- Show students life cycle stages of macroinvertebrates.
- Explore dichotomous keys and field guides to be used later for identifying macroinvertebrates in the field.

Journal reflection

Now that students have gathered information on different types of macroinvertebrates, have students practice keying out creek critters. Also have them explore these bullets for journaling:

- Have students draw their macroinvertebrate from the matching activity.
- Have students invent a critter – writing specific adaptations and describing specific habitat
- In their journals have the students draw out a food chain that would exist at their creek site. Have students use actual critters that are found at your creek site and see if the can build a food web from one or two food chains they can draw.

Tips for facilitators…

Help students make scientific drawings that include details, labels and several views of same object. Draw with students, taking time to look closely and get help from the key.

Bring your own drawings, charts and posters to use while teaching.

Unit 8: Activity 2: Critter Catch

There are many guides for surveying macroinvertebrates that are available for reference. This activity can be done as a training at the creek or with critters brought in from a creek. If you bring critters in, be careful to keep them in cold stream water by placing the container of critters in stream water inside a larger container that contains ice water.

Students learn…
- How to find critters in a creek;
- How to observe carefully and return critters to the creek; and
- How to identify macroinvertebrate families

By doing…
- Creek exploration and observations of macroinvertebrate habitat;
- Live macroinvertebrate collecting; and
- Field study and identification of macroinvertebrates

Then reflecting on…
- The importance of a healthy stream environment for macroinvertebrates and the critters that feed on them;
- Adaptations of macroinvertebrates; and
- Macroinvertebrate survey numbers that indicate the state of the health of the creek

Materials
- Creek water samples including macroinvertebrates, rocks and vegetation
- Magnifiers (aquatic viewers are best)
- Field guides
- Wading boots (for the creek)
- Collecting nets (mesh aquarium nets are ok)
- Small collecting tubs (i.e. yogurt containers)
- Large holding tubs (i.e. plastic dishpans
- Ice cube trays for sorting

Getting Started

Begin by explaining to students that this activity is very hard on the environment. It is important to survey the critters in the creek, but to do so impacts their habitat. The impact can be minimal if activity guidelines are followed and the study is done carefully.

It is important to remind students throughout the training to work slowly and carefully. This will be a challenge when students are mentoring their elementary students at the creek as well.

Plan a thorough in-class training to introduce the procedure for collecting critters before students actually do the survey at the creek. Ask elementary teacher to prepare students as much as possible.

Introduce the steps
1. Pass out field guides that show the families of macroinvertebrates students are most likely to find.
2. Review the life cycle of macroinvertebrate species and explain where they may be found. (riffle, pools, on rocks)
3. Have all the field equipment in class to show as you explain the critter catch procedure. *See steps for collecting on page 144.*
4. Have a sample of creek water, aquatic vegetation, and macroinvertebrates available for in class training.

As students are exploring and reviewing the information they have already been given, ask students if they have ever searched for aquatic animals in a creek before. Allow students to share stories.

Ask students to think about how having a large number of people even walking carefully through a creek may have an effect on the creek environment. Explain to students that one goal of this activity is to gather information with a minimum negative effect on the stream.

Ask students to suggest how this may be accomplished. Make a chart of goals for the entire class. Remind the students that if they follow the guidelines while keeping their goals in mind they will have a fun and exciting exploration of creek critters! While introducing the steps for this creek survey in the classroom, students will become familiar with ways to carefully observe macroinvertebrates, and then be ready to follow the survey procedures at the creek.

Model the steps in the class

5. Have pairs of students explore a small amount of water collected from the creek. Each pair of students should have access to a field guide, magnifiers and viewers, and smaller containers to help sort the living things they find.
6. Have students draw what they find as well as use guides to identify macroinvertebrates.
7. Encourage students to look for very small things that they may only see by looking in the water for different kinds of movements.
8. Have students keep track of the critters they have identified.

Share observations

- Have the class share information on the kinds of critters they found, how they discovered them, and what challenges they encountered.
- Have volunteers share their drawings.
- Help the class make one detailed scientific drawing that provides information on the characteristics of a specific macroinvertebrate and make special notes on its ecological importance.

Model the steps at the creek

9. Have groups of students explore a small amount of creek. Each group of students should have access to a field guide, magnifiers and viewers, smaller containers to help sort the living things they find, and one larger container to hold collections of creek water,rocks, vegetation and resting critters.
10. Have groups divide into pairs for specific jobs during the exploration. They will rotate through each job before the training is completed.
11. One pair of students will have the job of putting on boots, going in the creek and exploring under rocks, in vegetation, and in sediment using nets, and carefully taking samples off of the underside of rocks. See step by step collecting methods on page 144. They will then give their discoveries to team partners on the side. Students in the creek are working carefully to not disturb the creek environment any more than necessary to collect critters.
12. Another pair of students is receiving samples from the creek and taking them to a large holding tub with fresh cold water. These students are using magnifiers and viewers to observe critters that have been collected. These students are drawing what they observe and carefully labeling their observations.
13. A final pair of students is identifying critters they have found using field guides and dichotomous keys. These students are keeping a tally of the critters and drawing in their journals from guide drawings. These students are also returning critters to the creek by bringing them back to the students in the creek.

Sampling method

Students engaged in macroinvertebrate sampling

Tip for Teachers...
Plan this unit with weather and presence of macroinvertebrates in mind. We prefer late Spring.

Scientific explanations

- Share diagrams and posters of macroinvertebrates.
- Show students creek habitat drawings and areas to be explored when searching for macroinvertebrates.
- Help the class through steps of identifying macroinvertebrates by using a dichotomous key and field guides.
- Show students a chart of macroinvertebrate characteristics, adaptations, and family classifications.

Journal reflection

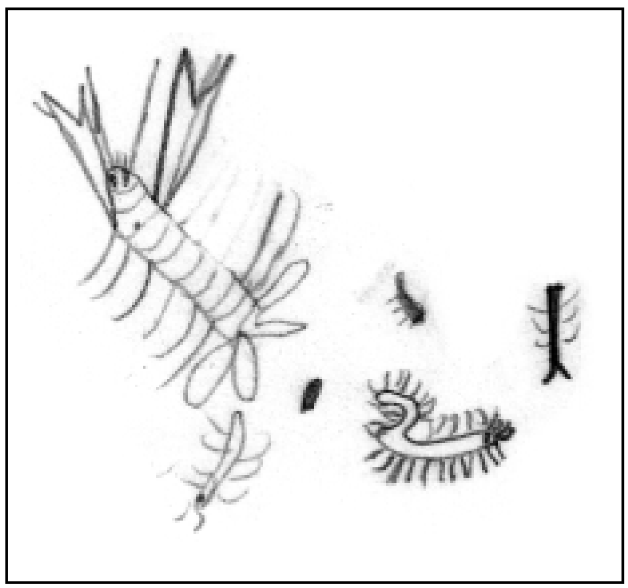
Now that students have explored creek critters, allow time for students to work on their scientific drawings. Use these bullets as a guide for journaling:

- Have students pick out their favorite macroinvertebrates and make larger scientific drawings to share with the class.
- Have students research online to find out more about macroinvertebrates, creek studies, and macroinvertebrate survey statistics.
- Have teams of students make presentations of macroinvertebrate families and their characteristics (a skit idea?).
- Have students write tips to help with correct identification of macroinvertebrates.
- Chart adaptations and their functions.
- In their journals, have students make a chart that shows different macroinvertebrates found in their stream. The chart should show name of macroinvertebrate, drawing of immature stage, drawing of adult, classification order, type of feeder, and tolerance level.

Tip for facilitators…

This activity is always a favorite!! Planning ahead, keeping organized, and having clear goals will protect the creek and provide a great field exploration for your students.

When using dichotomous keys, avoid the temptation to identify macroinvertebrates by comparing with the pictures in the guide. Some critters look very similar and only through following step by step identification methods in the key can you be sure of correct identification.



Elementary Student Journal

Steps to collecting macroinvertebrates:

Demonstrate the following steps before allowing any student to enter the water.

1. Set up a "holding tank" of river water in a white dish tub or bucket (in the shade if possible).
2. You will need a fine mesh net and wading boots before you enter the water.
3. Hold hands with someone on the bank when you first step into the water (in case it is slippery)
4. Always look before you step.
5. Move slowly to be safe and to protect as many
6. Look for critters in the following areas if possible:
   - Among rocks in the fastest water in the riffles
   - Hanging on plants submerged in water at stream's edge
   - Crawling along the bottom in slower moving water
7. Position your net immediately downstream of the area you want to search.
8. Slowly bend over and "dust" off the rock or plants that are upstream of the net.
9. Replace the rock and bring the net out of the water.
10. As quickly as possible turn the net inside out into the "holding tank" or any container of water.
11. You should be able to see anything you caught swimming around in the "holding tank."
12. To get a closer look, use a small container to catch the critters and look at them under a magnifier.

When finished for the day, carefully lower the holding tank into the water and rinse it and all nets and smaller containers in the stream until no more critters can be found. Have another person look in the containers to see if you missed any before packing up.

If you don't have enough nets and boots, you can also try picking up rocks near the stream edge. Look closely for anything tiny moving on the rock or for debris attached to rocks—these could be eggs or shelters built by critters. Rocks with critters on them can be brought to the "holding tank" for better viewing.

Reading and Research: Pollution Tolerance Index

The study of macroinvertebrates and the activities in this unit tie in with many aspects of science and water quality monitoring. In the critter catch activity we practice observing, recording data, and using a field journal. When we look for critters in the creek, we use our knowledge of physical stream characteristics, such as pools and riffles, and of water quality—where the stream has the most oxygen, to find where aquatic organisms thrive. Then, we pool our data and observations and together compile it to analyze the creek's water quality with the Pollution Tolerance Index (PTI).

In Activity 3 you will prepare a Pollution Tolerance Index. At the beginning of this unit we described that scientists group macroinvertebrates into four taxonomic groups of different species, according to their tolerance for pollution:

- Group I: Pollution-Intolerant organisms
- Group II: Moderately Intolerant organisms
- Group III: Fairly Tolerant organisms
- Group IV: Pollution-Tolerant organisms

Once you search for, collect, identify, and release these macroinvertebrate critters, you will tally the number of critters you find in each group according to a special formula. When done properly, the group in which you find the most number of critters will reflect the pollution level of the water. This does not mean that if you find one pollution-tolerant organism the stream is polluted (even clean streams will have these organisms living along with pollution-intolerant organisms), rather it means that you are likely to find organisms that the conditions of the habitat support. So if the water quality is very good, critters that are very sensitive to pollution will be able to survive. But if the water quality is very polluted, they will not survive and you won't likely find them.

Look for macroinvertebrates in these areas:

Caddisfly: in still ponds or flowing areas of the stream where the current is not strong. They are adapted for either low or high dissolved oxygen. They are easily recognized with their case. Out of their case they look worm-like.

Mayfly: in fresh, running water; under or on submerged rocks. They often have a flat body shape so water can run smoothly over them. Mayflies are quick, undulating swimmers.

Dragonfly/damselfly: in marshes or ponds, along lakeshores, possibly in slow-moving parts of the stream and in submerged vegetation. Dragonflies are slow walkers and tend to swim sideways.

Beetles: in water; on the surface. Different species are adapted to various parts of the water. Some become terrestrial adults.

Mosquito: in still or stagnant water like ponds, marshes, or swamps. They hang just below the suface when breathing.

Stoneflies: in icy cold streams and under small water falls – places where there are high levels of dissolved oxygen. They cling strongly to rocks in very fast water. They look like mayflies but have no gills on abdomen.

Waterstrider: on the water surface.

Giant Waterbug: on the water surface.

Dobson flies, fish flies, alder flies: on and among rocks in unpolluted sstreams.

Flies (black flies, etc.): in cool headwaters of stream, cool flowing water with high dissolved oxygen. They are attached to rocks in clusters that almost look furry.

Rat-tail maggot and horse fly: ponds, stream edge.

Midge (including bloodworms): lakes, ponds, streams

Crustaceans/crayfish: streams, bottom

Scud: pond, lake, stream, spring.

Aquatic Sowbug: in water, under stones.

Once you've identified the critters, you'll be using the PTI survey form to calculate your pollution tolerance index. The process will be something like this:

Taxonomic Group I (3 points each)	**Taxonomic Group II** (2 points each)	**Taxonomic III** (1 point each)
Intolerant of Pollution	Moderately Tolerant of Pollution	Fairly Tolerant of Pollution
❑ Stonefly	❑ Crayfish	❑ Midgefly
❑ Alderfly	❑ Clam/mussel	❑ Black fly
❑ Dobsonfly	❑ Damselfly	❑ Scud
❑ Snipefly	❑ Caddisfly	❑ Sowbug
	❑ Mayfly	
	❑ Cranefly	
	❑ Dragonfly	
	❑ Water penny	
	❑ Riffle beetle	

- **Count the critters you find by checking off the organisms in each taxa.**
- **Don't count the quantity you find, just count that you found it.**
- **Then multiply by the number of points and get the total.**
- **For example, a recent BioSITE class recorded the following:**

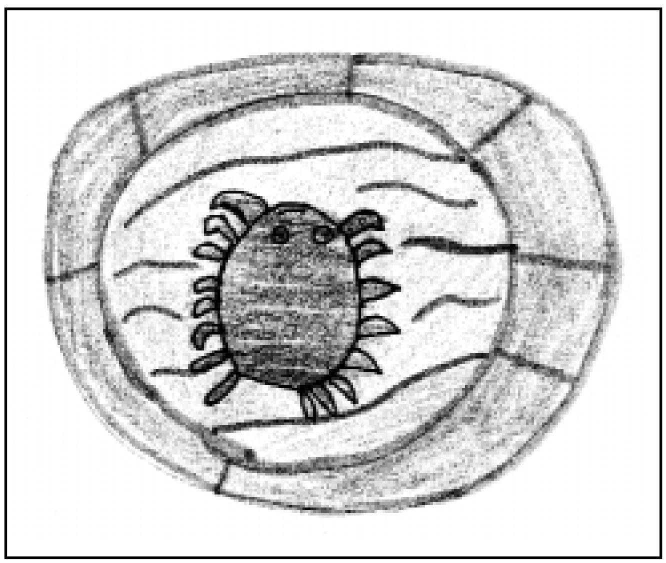
Taxa I: 3 different critters found x 3 points each = 9;

Taxa II: 5 different critters found x 2 points each = 10;

Taxa III: 2 different critters found x 1 point each = 2.

The total number of points is 21, which according to the following table rates "good" water quality.

>23 = excellent
17-22 = good
11-16 = fair
<10 = poor



Elementary Student drawing in journal

Unit 8: Activity 3: Pollution Tolerance Index

This is an important activity to do a few times a year. The first time, you learn how to do it. The second time you practice what you learned the first time. And the third time allows you to have data to compare and analyze over a period of time.

Students learn…
- How macroinvertebrate surveys are completed to provide a pollution tolerance index;
- How macroinvertebrate studies are important in monitoring water quality; and
- How to study macroinvertebrate populations and use data collected over time

By doing…
- A macroinvertebrate survey following guidelines for determining a pollution tolerance index; and
- Research on macroinvertebrates

Then reflecting on…
- The importance of macroinvertebrate populations in the creek ecosystem;
- The importance of long-range studies in understanding creek restoration and habitat protection; and
- Differences between PTI and chemical water quality testing

Materials
- Critter catch materials
- Pollution Tolerance Index Guide from *BioSITE online* (www.cdm.org/biosite)

Getting Started

Begin by reviewing macroinvertebrate information. Ask students to explain the importance of these creatures in the creek ecosystem. Ask students to share how they think studying macroinvertebrates could help scientists monitor the health of the riparian corridor.

If possible, invite a visiting scientist to come and share their research about macroinvertebrates (see pages 160-161 for guidelines to help scientists prepare for a visit). In addition, have students conduct research on macroinvertebrate studies. Explain to students that one way to understand the importance of macroinvertebrates to overall creek health is to complete a Pollution Tolerance Index (PTI).

Introduce the steps
1. Have students review the kinds of macroinvertebrate families they identified in their critter catch.
2. Introduce students to the PTI method by explaining that the presence of families of macroinvertebrates in a creek can be used to indicate levels of pollution.
3. Have students brainstorm which families they think may be present in polluted areas (they may know of leeches) and which may be found only in very clean creeks (stonefly).

As students are reviewing macroinvertebrates and the critter catch procedure, generate a list of which creatures they believe may be found in polluted and clean waters and why. Could it be related to behavioral characteristics, adaptations, or predator/prey interdependence?

After students have explored their own ideas, supply a PTI survey form. Tell the students that they will be doing this survey very carefully to protect the creek habitat as well as to collect accurate and precise data.

Model the steps at the creek

4. Each group of students should have a PTI guide and materials for critter catch.
5. Have each group work in different sections of the creek
6. Have each group do a survey of general creek conditions to record data on specific day, weather, location and conditions of study area.
7. If possible, have students perform water quality tests before they survey for macroinvertebrates.
8. Have groups tally for each family they are able to collect – students do not need to count specific number of same critters, but may want to use in later discussion
9. Have groups collect data and observations on critters they are unable to identify.
10. Following the steps of the PTI, have each group complete the survey to determine the PTI at their site.

Share observations

- Have class share creek survey information and water quality test data from the survey day.
- Summarize for group and discuss differences.
- Share tally of families and numbers present for macroinvertebrate survey.
- Have groups report their individual PTI numbers and do one collective PTI for the completed class data.
- Discuss differences and ask students to share their explanations and challenges completing the survey.

Scientific explanations

- Share statistics for macroinvertebrate studies within your watershed for comparison of PTI numbers.
- Provide research information for comparison of other waterways including PTI numbers and other methods of study.
- Have students research other riparian studies that focus on monitoring water quality and riparian habitat preservation.

Journal reflection

Now that students have completed a PTI survey, make a plan with students to complete research on pollution levels in their watershed. Have students work in their journals, using these bullets for journaling:

- Make a monitoring plan to continue survey work over a longer period of time. Do they have any prediction of things that may change as the seasons change?
- Have students do research on other issues in their watershed.
- Have facilitators research watershed projects that have used water quality index or PTI as a basis for health measurement. Have facilitators present the data collected at other research sites and compare to their study site data.

Tips for teachers...

Students could do special projects on their own time to collect further data on their field site. Students could complete surveys over time to study bird populations, vegetation and tree studies, soil conditions, and macro-invertebrate populations.

Facilitator Field Day Planning

Facilitators determine how to go about teaching students. To structure the lesson planning process, refer to the *Team Lesson Plan Worksheet* (Template 1) in the *Tools for Implementation* section.

Based on the lesson planning discussion, the high school teacher reviews and summarizes facilitator suggestions and develops an overall agenda to give to the entire group for the field day (see *Field Day Agenda* (Template 2) in *Tools for Implementation*.

Have students consider the following:

Terms and Concepts
With a partner, review the material learned in this unit by describing the following macroinvertebrate terms in words that fourth grade students would understand. After each partner takes turns describing the term in his or her own words, write down your definition of the word.

Macroinvertebrate
Decomposer
Scraper
Invertebrate
Shredder
Larva
Metamorphosis
Detritivore
Nymph

EVALUATION

Reflect on your field day teaching:

- Do you think the students learned what you intended?
- How can you tell?
- Is there any part of the new material about which you are unclear?

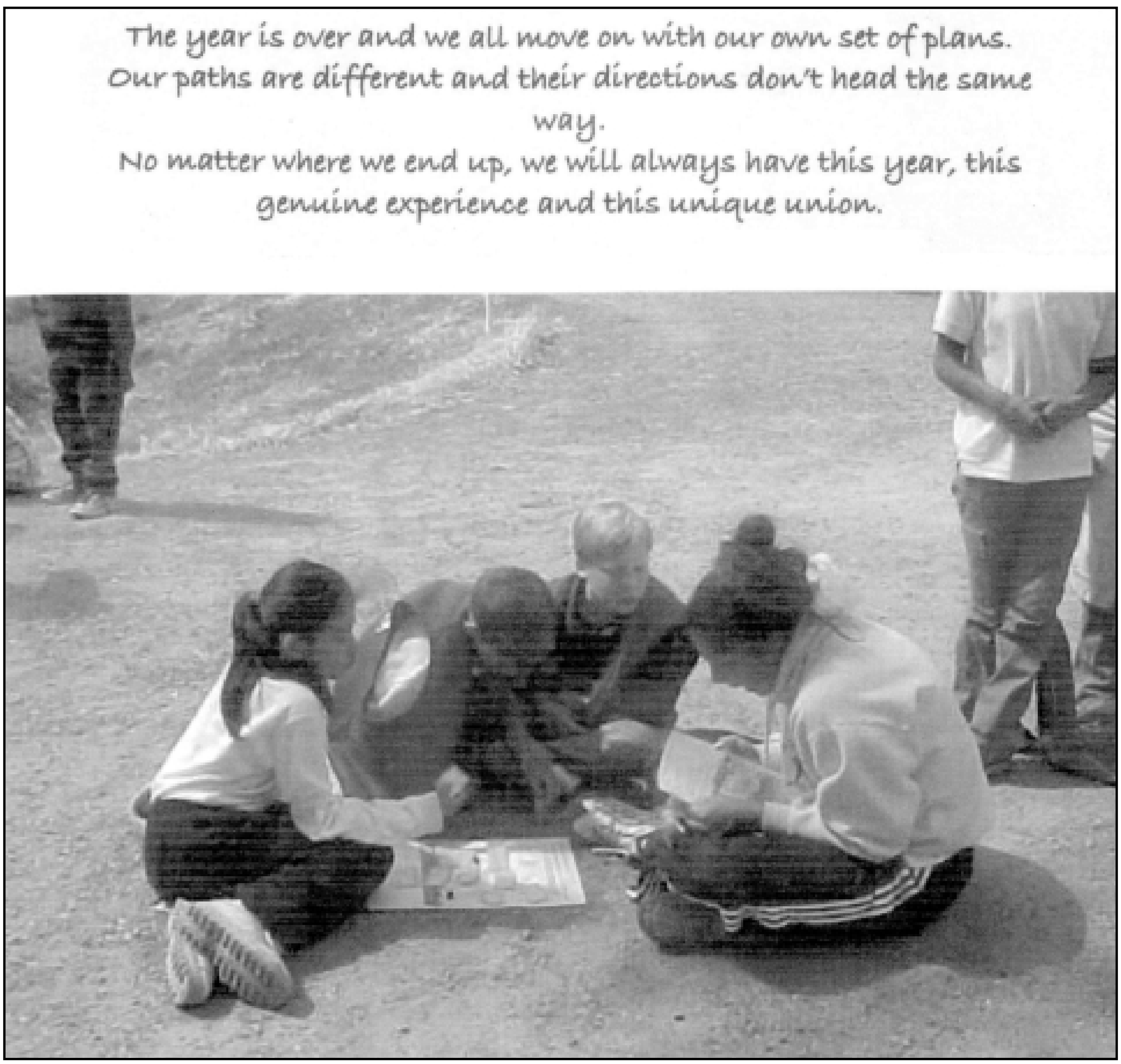
Activities Assessment

Consider the following questions about the activities:

- What went well?
- What can be improved upon for next time?

Journal

In your journal, write down your thoughts about the above questions and issues so that you can keep a record of your teaching experience.



High school students created this reflection piece

RESOURCES

Technology

As the BioSITE program grew, so did the technology we use to support student learning. Technology in the program has evolved from humble beginnings – digital cameras and hi-8 video cameras – to BioSITE online, a data and resource center for students and teachers. You will find that you can integrate technology into your lessons at your own comfort level – from inexpensive digital cameras and data spreadsheets to global online databases.

DIGITAL CAMERA AND VIDEO USE

During the course of this program, you will want to photograph and document the activities. This documentation is useful for documenting the river, capturing the students' process, and enhancing the students' final presentations. The photo and video documentation can also be used for publicity and funding of your program. Allowing students to take photographs is a good way to build student participation into the program.

Documenting the River

Photographic data can be compared over time, giving students a record of how the river has changed. At the BioSITE Pioneer data collection site, the Guadalupe River is in the process of being restored. Photographs taken at the beginning of 2002 and 2003 illustrate the progress made in restoring the flora to the river's edge.

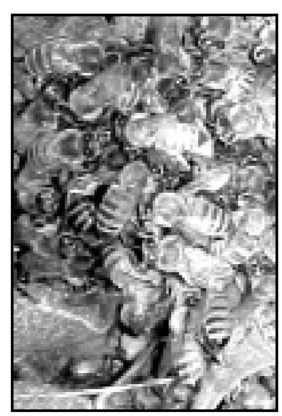
If each group has access to a camera, you can create a photo "scavenger hunt," asking students to photograph as many things as they can from a list.

Documenting Students' Process

One student in each group can be chosen to be "documentarian" on each field day. The student takes pictures of the group's process, documenting the work they did on that day. The pictures the student take provides a window into the group's activities, which can later be used for presentations or reflections, which we discuss below. If you only have one camera, the documentarian can be assigned to get pictures of all groups.

Restoration 2001

Field site 2004



Tips for getting good quality images

- Use a photo release form to be sure you have permission to use photos to promote your program. One is included in the *Tools for Implementation* section.
- Avoid taking photos in bright sun or deep shade.
- When photographing people's faces (like students doing an activity), take the picture when faces are pointed in the direction of the sun to avoid shadows.
- For print-quality images from digital cameras, take photos at high resolution.
- Save downloaded images as JPG files. For digital images only (for Web site), GIF files take up less memory but only use 256 colors, so they are not as good for print.

If you shop around, you should be able to find good quality digital cameras (2 megapixels or above) for less than $50.

Database of Images for Projects, Reports, and Presentations

Once we have the images, we transfer the data onto a desktop computer into folders organized by the date of the pictures. There is software available which can help you and your students organize and find pictures. One option is Adobe Photoshop Album Starter Edition, which can be downloaded for free from Adobe's Web site (You'll need a PC running Microsoft Windows).

We use these photos in a variety of ways.

- Post on our Web site for anyone who is interested (students, teachers, funders, environmentalists, etc.) to view.
- Use the photos in presentations by students and BioSITE staff. The pictures are not only useful in the classroom, but travel out into the environmental education community.
- Post the pictures on *BioSITE online* for students to look at and reflect on. We will talk more about the online reflection tool later in this section.

DEALING WITH DATA

Students gather their data into their field journals. From there, students enter their data into Excel spreadsheets and create graphs to visualize the relationships among their tests. Refer to BioSITE online for sample graphs. A couple of interesting relationships include:

- Dissolved oxygen and temperature over time (an inverse relationship)
- Turbidity and rate of flow over time (a direct relationship)

We found early on that we needed the students to focus on the accuracy of the data. The validity and reliability of the data requires accurately calibrated equipment, replicable collection methods and conditions, and careful data entry. If you have access to handheld devices, such as Palm Pilots, data entry can be done electronically at the field site. This provides interesting data for comparison with results from chemical test kits while reducing the possibility of error.

The data the students collect is useful for learning purposes in the classroom, but increases its impact when it becomes part of local and global environmental efforts to make our world a better place. When students are able to share their data with others, their work becomes less of an exercise and more of an important activity which feeds into a network of scientists around the globe.

Several online education programs enable students to share their data worldwide. These include:

- The Globe (www.globe.gov/fsl/welcome.html)
- Global Rivers Environmental Education Network (GREEN) (www.green.org)
- Global Water Sampling Project (www.k12science.org/curriculum/waterproj/index.shtml)

BioSITE online
BioSITE online (www.cdm.org/biosite) is the BioSITE Program Web site hosted by Children's Discovery Museum of San Jose. Our Web site contains templates, activities, resources, and other great tips for teachers. It's also the place where students enter the water quality data they collect and compare it with data from our other BioSITE field sites. We were able to get funding to build our own online database, so that we had control over the look, feel, and function of the tool. For example, we were able to create a data entry page that followed the data pages in the students' journals, making data transfer fast and efficient.

We have a number of goals for *BioSITE online*. The database should:

- Provide access to water quality data collected each week by BioSITE students;
- Facilitate data exchange between BioSITE students with other students, educators, scientists and environmental organizations from the local level to the international level;
- Provide access to data in the form of simple tables and graphs;
- Engage students in manipulation of graphs and maps to help students make connections across study sites; and
- Help students visualize how data changes over geographical space and time.

BIOSITE online

www.cdm.org/biosite

Periodically we have students analyze the data, looking for potential errors in the data. Once students have a large pool of data to look at, unusual entries in the data can be easily spotted. Using a scatter plot to graph the data can also give the students clues to which data points are likely to be inaccurate.

Your class can use the pool of data at BioSITE online to do your own analyses. For example, you may want to compare dissolved oxygen levels in the Guadalupe River with those in your local river. Students can hypothesize why the levels are similar or different, perhaps using other data such as the rate of flow to support their arguments.

WEB RESEARCH

There are many good resources available on the Web, globally and in our local area. We have students do Web research by providing them with a list of sites we have screened (please visit www.cdm.org/biosite/curriculum.htm#links, for example), and we give them a worksheet asking them to reflect on the site and its relationship to BioSITE. Sites include current information on the Guadalupe River, scientific studies of the river, and links to other field projects that focus on environmental education.

The worksheet is structured as follows:

- What is the URL of the site?
- What is the name of the site?
- Looking at the home page, what kinds of things do you expect to learn? Does the site look interesting? Why or why not?
- What did you learn from the Web site?
- How will the things you learned help you in BioSITE?

The goal of Web research is to introduce the students to the many resources they have available to them. We use this activity when students have extra time at the end of a class period, and our hope is that this introduction is enough to spur students to use these resources on their own – when they are preparing for a presentation, for example.

REFLECTION TOOLS

We built another online tool which gives students the opportunity to reflect on past experiences. The students are presented with a series of pictures that they took in the field, and are asked to respond to one of them with their memories of the event. The responses are submitted via a Web form and are e-mailed to the Program Leader to read and evaluate.

The Program Leader chooses a variety of pictures which represent different aspects of the work the students have done—gathering data, analyzing data, talking with visiting scientists, etc. Students choose a picture and reflect on their activity that day. Writing reinforces learning, and it also provides assessment opportunties for the teacher.

Questions we ask the students

Take a look at the photo handed to you and reflect back on a recent day in the field.

- What were you investigating?
- What do you remember happening?
- Why did it happen that way?
- What would you change to make the activity more successful in the future?
- Write your reflections in the box below.

We get a wide variety of responses from the students, but typical, unedited responses include the following:

Response 1.
In this picture, we were learning about how the creek behind Pioneer was recreated and wild plants were put back. We were learning how that they put barriers that appeared to be natural, such as logs and how they helped control the rate of flow. Kevin also taught us about the bridge and how it dictates the rate of flow as well. He pretty much taught us how humans had influenced and reconstructed the river to what it is now and are trying to reconstruct it back to its natural state.

Response 2.
This picture was taken when we went to take some tests with our kids. I remember first meeting them and getting to know them, and seeing what they knew and what they wanted to learn. It was pretty cool because most of the kids were enthusiastic to learn and were getting into our lesson. I remember that most of the days out there have gone well, but sometimes the kids have gotten a little distracted by the creatures around the stream. Next time we just need to make the tests and our lessons more fun to help keep the kids attention.

When the responses are submitted via the form, a series of e-mails ends up in the BioSITE coordinator's e-mail box. We use Microsoft Outlook as our e-mail client, and found that an easy way to consolidate all the messages is to select them all in the Inbox and forward them to your own e-mail address. What will happen is that all responses for that class session will be attached to one e-mail. Then you can delete the individual e-mails, making your box more manageable.

WEB CURRICULUM

BioSITE online also houses the online version of this curriculum, as well as a teacher forum dedicated to providing support for BioSITE teachers. Visit our Web site for an online version of the BioSITE curriculum. You will need to have the free Adobe Acrobat Reader (www.adobe.com/products/acrobat/readstep2.html) to open the documents. The online version:

- Posts updates to this document and offers a forum for teachers to post modifications and extensions.
- Displays student work for teachers to review for assistance with assessment of their own students.
- Provides supporting worksheets and materials
- Allows students and teachers to share project ideas and work in an easy way, also via the online forum.

There is no registration necessary to view the information in the forum. In order to post messages or participate in the discussions, you will need to register. To sign up for the forum, send the BioSITE coordinator at Children's Discovery Museum a request (biosite@cdm.org) with your e-mail address and a short note about your interest in BioSITE.

Facilitator Field Day Planning

Teachers help facilitators plan their field days with elementary students. As facilitators gain experience over the course of the year, they may feel more comfortable using the lesson plan as a guide while feeling free to deviate from it to address the content their students are interested in, or to pursue a teachable moment.

At the end of each unit is a Facilitator Field Day Planning exercise in which the teacher guides facilitators to identify what they want to teach about the subject and how they will go about teaching it. On a field day with elementary students, in addition to water testing, facilitators will teach Activity 1 or Activity 2. They will model and modify the pedagogy used by their teacher.

Materials:

- List of terms and concepts (from Unit)
- Template 1: Team Lesson Plan Worksheet (on page 157) copied on overhead transparency
- Overhead projector

Planning

1. *Terms and Concepts*
   With a partner, review the material learned in the unit by describing each of the terms and concepts in words that 4th grade students would understand. After your partner takes turns describing the term in his or her own words, write down your definition of the word.
2. *Team Lesson Plan Worksheet* (on overhead)
   In field groups, ask yourself the following questions:

Learning goals

- What do you want the students to learn from the lesson?
- What can you do to get them there?
- How will you know what they have learned? (This usually becomes the basis for the journal activity)

Student management

- What techniques can you use to keep the students attentive and engaged?
- What are the potential “trouble spots?” (For example, at some point there may not be enough “jobs” for every student in the group to be engaged; the activity introduces lots of new vocabulary at once; the water quality test has many steps before students get a result, etc.)
- What will you do to overcome them?
  Determine who on your team will perform the following teaching roles (three people are not mandatory):
- *Lead Teacher:* does most of the talking, leads the activity
- *One-on-One:* walks around, engages students one-on-one to refocus them on an activity if they are drifting, keeps time
- *Teaching Board:* holds teaching board, explains diagrams, notes students’ comments and questions

Field Day Agenda

3. *Template 2: Field Day Agenda*
   Based on the team lesson plan discussion, the high school teacher develops an agenda for the field day. The agenda summarizes the plan on a single piece of paper for facilitators to use in the field. It also lists facilitators’ suggestions for activities, games to play, and journal lessons (see Template 2: Field Day Agenda on page 158).

TEMPLATE 1

Team Lesson Plan Worksheet

Let's teach! In your field groups, discuss:

Learning Goals

- What do you want the students to learn from the lesson?
- What can you do to get them there?
- How will you know that they have learned? (This is usually the basis for the journal activity)

Student Management

- What techniques can you use to keep the students attentive and engaged?
- What are the potential trouble spots? What will you do to overcome them?

Teaching Roles

Determine who on your team will perform the following roles (three people are not mandatory):

- *Lead Teacher:* does most of the talking, leads the activity
- *One-on-One:* walks around, engages students one-on-one to refocus them on an activity if they are drifting, keeps time
- *Teaching Board:* Holds teaching board, explains diagrams, notes students' comments and questions

TEMPLATE 2

Field Day Agenda

Date:

Introduction or Question of the Day:

Agenda:

Greeting Students (15-30 min.)

-
-
-

Testing (30-45 min.)

-
-
-

Activity (15-30 min.)

-
-
-

Journal (15-20 min.)

-
-

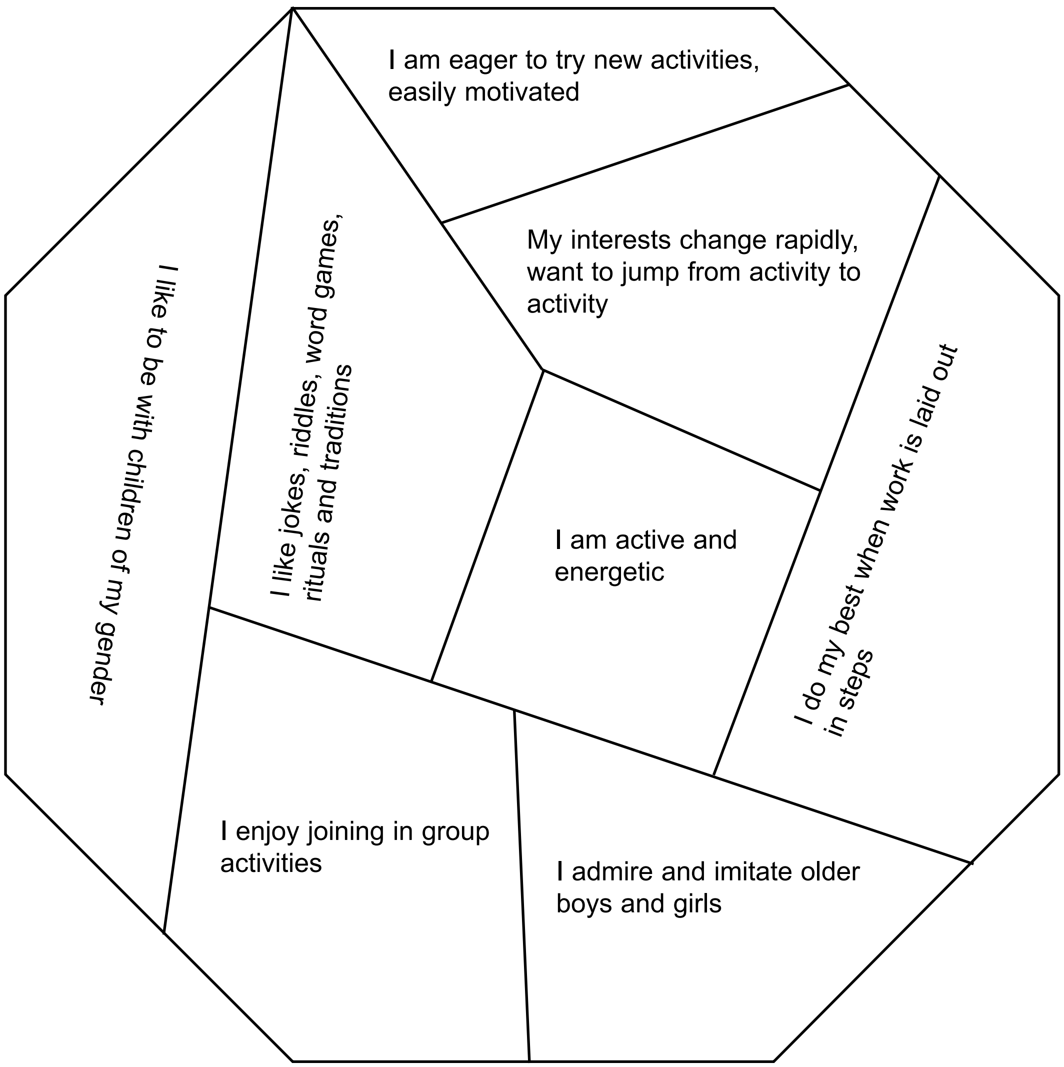
Observations:

Connections:

TEMPLATE 3

The Puzzle of Children (ages 9-12)

Adapted from *Teenagers as Teachers*



TEMPLATE 4

Visiting Scientist Lesson Plan Guide

Thank you for sharing your time and knowledge with BioSITE students. We have provided the following guide to help you develop your class. Feel free to ask the BioSITE teacher about any of the terms and suggestions below.

I. Learning Goals

- What do you want the students to learn from the lesson?
  (what scientists do, to observe and describe a watershed, to analyze data, to compare/contrast)
- What can you do to get them there?
  (what kind of learning progression needs to take place, what do you need to provide them with, what do they need to do or use to learn and understand?)
- How will you know that they have learned?
  (what will tell you that they know what you want them to know, what should they be able to do, how should they be able to respond, what kinds of conclusions should they be able to make, what kinds of questions should they be able to ask?)

II. Teaching Strategies

- What specific teaching strategies would you use in the lesson?
  (brainstorming, collaborative group work, think-pair-share, wait time, assigning procedural roles, asking questions)
- What will “students” and “teachers” be doing during the lesson?
  (talking, hypothesizing, measuring, weighing, handling equipment, asking questions, answering questions, reporting out)

III. Materials Management

- How will materials be prepared and managed?
  (when, how, and where will students/groups get and return materials, how will they be arranged, what exactly will each student need, how exactly will materials or equipment be shared?)
- How will the area be arranged?
  (how will students know where to go to accomplish different tasks, what is the “working area”)
- What potential problems may arise during the lesson? (running out of materials, broken equipment, nature not cooperating, what are your back up plans?)

IV. Time Management

- How long will it take the students to complete the task? (easy to underestimate!)
  (introducing, retrieving materials, asking and answering questions, discussing results)
- What alternate plans do you have if students need less or more time?
  (additional questions/challenges for students, alternative ways to wrap up activities quickly)

V. Student Management

- How will the students be organized during the activity? (individual work, pairs, group work, procedural roles)
- What techniques can you use to keep students on task?
  (time limits, guiding questions, competitive vs. non-competitive challenges, reporting out)
- What are potential trouble spots?
  (different skill levels, transitions between lesson components, materials use and distribution)

VI. Assessment of Student Learning

- What techniques could you use to assess what the students already know?
  (brainstorm, warm-up activity, what do you know/want to know, think-pair-share)
- What techniques could you use to assess what the students have learned?
  (group discussion, collecting student work, written products, follow-up activity, observation during group work)

Student Management Strategies for Visiting Scientists

While the BioSITE teacher will be in the classroom with you, we have provided the following guide to help you prepare for your teaching experience.

Communicating with Classroom Teacher

- What does the teacher know about these students?
  (students' previous experiences or knowledge, any special student concerns, particular student interests)
- What techniques and/or routines does the teacher use?
  (how does the teacher call for attention, what are the policies regarding talking, restroom, snacks?)
- What content or skills would the teacher appreciate you emphasizing?
  (how can the field day complement the classroom experience, how will it prepare them for things to come?)

Lesson Planning...Consider

- Materials management
- Clarity in instructions
- Questions to ask and answer
- Transitions between phases or components
- Contingency plans

Introductions

- Learn names whenever possible (have each student say his/her name, then repeat it after them, students tend to respond more positively when you know their name, try to think of a technique or devise that will help you remember their names)
- Set the tone early
  (establish your presence and authority, be clear about your expectations of them and goals for the day)
- Ask if there are any questions after any introduction

Rules and Expectations

- Be familiar with the teaching style and rules of their classroom teacher
  (how can they be adapted for your style and your setting?)
- Develop your own set of 3-5 rules that are general enough to cover a variety of situations and state them in the positive
  (act for the safety of yourselves and others, show respect for yourself and others, be prepared, create a learning environment for everyone, ask questions, assist others)
- Think about and use consequences (both positive and negative) that relate naturally to behavior
  (talk about consequences with students and provide concrete examples: if we can be efficient about directions, we'll have more time to look at the animals, if the equipment is handled carefully, everyone can have a chance to use it)
- Maintain expectations consistently and fairly

General Tips

- Use open-ended questions (can't be answered yes/no; are open to many different interpretations)
- Practice "wait time." When asking a question, wait 5 seconds before calling on anyone.
- Use eye contact to engage students.
- Finish all instructions before passing out materials or giving students the go-ahead.
- Acknowledge the positive: "Thank you for getting ready so quickly."
- If you must correct a student in front of others (safety issue?) do it firmly, quickly, and return to teaching.
- Yelling over kids who are making a lot of noise is usually unproductive and ineffective. Devise a quiet strategy for getting student's attention (holding up hand)

TEMPLATE 6

Field Data Chart

The following chart should be reproduced on a large poster board and located at each field station ("upstream," "midstream" or "downstream"). Students will collect and record data on this chart throughout the year.

Suggestions for making a board that can last throughout the year:
- Use permanent marker
- Laminate poster board

Station: ______________									
Date:	10/1	10/3	10/8	10/10	10/15	10/17	10/22	10/24	Etc…
OBSERVATIONS									
Time									
Location									
Weather									
River Conditions									
WQ TESTS									
River Height									
Rate of Flow									
Conductivity									
Dissolved Oxygen									
Temperature									
Turbidity									
pH									

To make data more consistent, choose a set of terms about the weather and river conditions for students to apply to their observations. For example:

Weather: clear, cloudy, fog, rain, other
River conditions: clear, muddy, oily surface, foam, scum, odor, other

TEMPLATE 7

Field Journal

The Field Journal is one of the key assessment tools for students. Sample journal pages for your use are found on the next pages, but you can find many more online! A complete journal template can be found and downloaded from BioSITE online. BioSITE online also includes pages in Spanish.

Journals can be designed to meet the unique needs of each school or program, but these pages are essential to the program:

- Name Page
- Daily Observations
- Water Quality Data Chart
- Water Quality Test Instructions

Note: The Test Instruction pages in our journal are written for the test kits we use, which are the following:

Dissolved Oxygen Test--catalog no. 1469-00
HACH Company (www.hach.com)

Turbidity Test--catalog no. 7519
LaMotte Company (www.lamotte.com)

pH Test--catalog no. 1470-11
HACH Company (www.hach.com)

Total Dissolved Solids Meter--catalog no. 5-0080
LaMotte Company (www.lamotte.com)

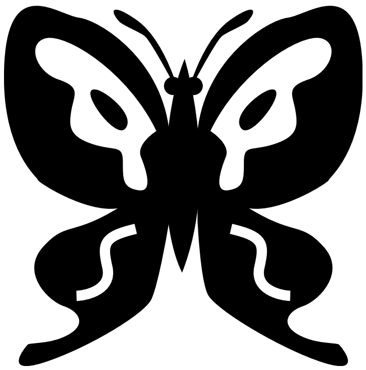
Students Investigating • Their Environment •

CHILDREN'S DISCOVERY MUSEUM OF SAN JOSE

BIOSITE

My Field Journal

Children's Discovery Museum of San Jose
180 Woz Way
San Jose, CA 95110



My Field Journal

This field journal belongs to: ______________________________

School: ______________________________

Grade: ______________ Teacher: ______________

Area of Study: ______________________________

Things I want to learn: ______________________________

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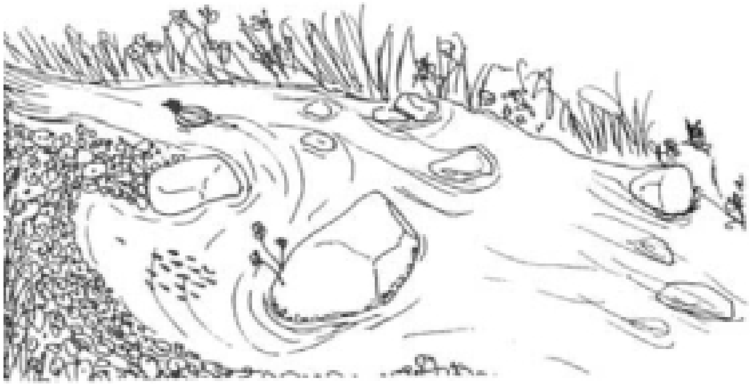
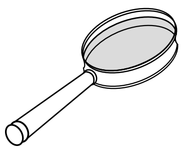
Journal Template



Date: ______________________

Name: ______________________

Place: ______________________



Observations:

Connections:

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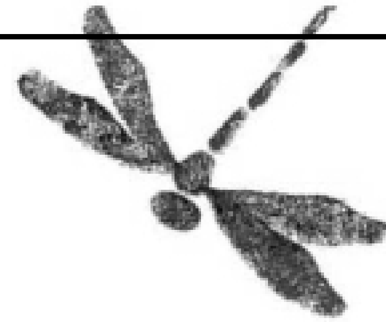
Journal Template



Safety First

1. Water testing requires that you handle chemicals. Follow all instructions under supervision.

2. Read directions carefully and proceed only when you understand each step

3. Wear goggles when specified and be careful not to allow chemicals to come into contact with your skin.

4. Dispose of waste materials in appropriate containers. Never put waste liquids in any other type of container.

5. Carefully rinse materials used and make sure all materials are returned to the proper storage space.

6. After handling chemicals, always thoroughly wash your hands.

I have read and understand these guidelines and agree to follow these rules of safety.

____

Water Quality Data Chart

Date				
Time of Day				
Location				
Weather Conditions				
River Conditions				
River Height (M)				
Rate of Flow (M/sec)				
Total Dissolved Solids (ppm)				
Dissolved Oxygen (ppm)				
Temperature (C)				
Turbidity (JTU)				
pH				

Water We Have Here?

Water Data Analysis Information

Use this chart as a **guide** to help in interpreting water quality data gathered in the field. Remember that each aquatic system is different. This chart is only a guideline, not a hard and fast rule!

Water Test	What It Measures	Natural Reading	Danger Reading	Source	Remedies
Salinity	amount of dissolved salts	varies – higher in the summer and fall, lower in the spring	–	fresh: rain and streams salt: ocean water (evaporation can also increase salinity)	–
Dissolved Oxygen	amount of oxygen in the water	7 – 14 ppm (parts per million)	3 - 5 = stress 1 - 2 = poor 0 = anoxic (no oxygen available in the water)	• wind • waves • running water	• control nutrient content, algae growth • more wind/water movement
pH	Level of the acidity (acid) or alkalinity (base) of the water	generally 6.5 - 8.5 Bogs are naturally acidic; pH can be as low as 4.2	below 6.5 or above 8.5	• acid rain • industrial pollution • chemical spills	• pollution controls
Phosphates and Nitrates	amount of these nutrients in the water	0.0 - 0.65 ppm 0.0 - 0.08 ppm	any reading higher than normal	• sewage, industry • detergents • fertilizer, animal wastes	• removed by water treatment • restrictive or banned use
Temperature	amount of average heat in the water	varies	generally above 27°C (>24°C for trout streams)	• waste heat • solar heat	• riparian vegetation for good shade cover
Turbidity	cloudiness of the water	80 - 120 cm (0 - 8 FTU)	increased turbidity (cloudiness)	• sediment • excessive algae growth • weather	• sediment controls • reduced nutrients to reduce algae • healthy vegetation on banks

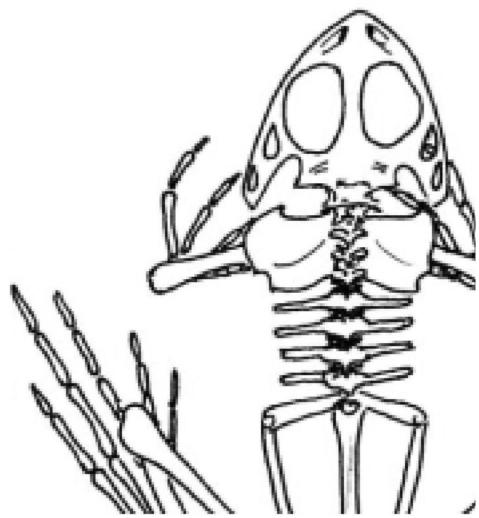
CAREFUL! CAREFUL! CAREFUL!

Dissolved Oxygen (DO) Test Kit

1. Fill the large bottle all the way to the brim with river water.

2. Stopper the bottle and tilt sideways to check for bubbles and pour off excess.

3. Put on goggles. Unstopper and add contents of “Dissolved Oxygen 1 Reagent” and “Dissolved Oxygen 2 Reagent” packets to the bottle.



4. Stopper the bottle, excluding air bubbles.

5. While wearing goggles, carefully shake the bottle until it is well mixed.

6. Let stand until floc has settled halfway down the bottle.

7. Wear goggles. Shake again and then add contents of “Dissolved Oxygen 3 Reagent” plastic pillow.

8. While wearing goggles, restopper the bottle, excluding air bubbles. Shake again until floc disappears.

9. Holding the bottle over the waste container, fill the plastic measuring tube to the brim with the prepared sample.

10. Pour the measured amount from the tube into the square bottle.

11. Add one drop of sodium thiosulfate solution to the square bottle and swirl the bottle to mix well.

12. Repeat the previous step, keeping count of the total number of drops added, until the sample changes from yellow to colorless.

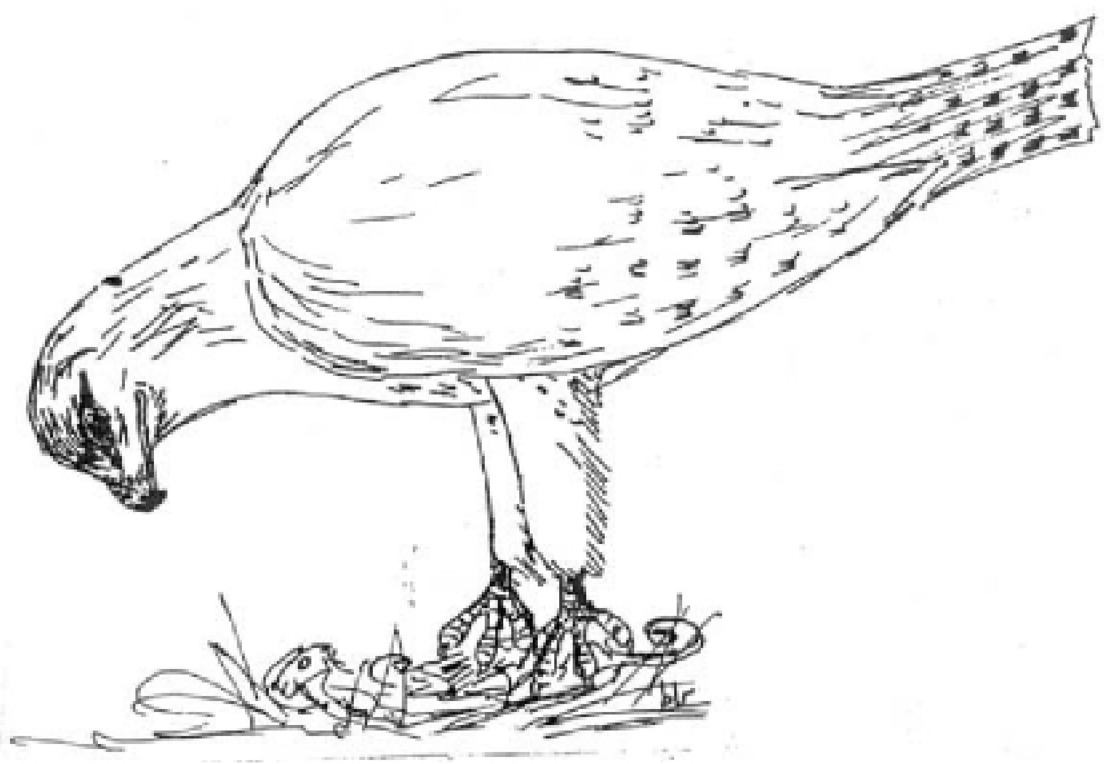
Journal Template

DELICATE INSTRUMENTS DELICATE INSTRUMENTS

Total Dissolved Solids/Conductivity Test

1. Remove black cap of calibrated TDS or conductivity meter.
2. To turn the meter on, press the ON/OFF button.
3. Fill the film canister with the river water to be tested.
4. Place the electrode end of the meter into the film canister.
5. Let two minutes pass before you take a reading. Check the reading while the meter is in the water and after the reading shown in the display window has stabilized.
6. After you finish the test, press the ON/OFF button to turn off the meter. ***Check to make sure that the meter is turned off; no numbers should be visible in the display window of the meter.***
7. Place the cap on the electrode side of the TDS/conductivity meter.

CAREFUL! CAREFUL! CAREFUL!



CAREFUL! CAREFUL! CAREFUL!

Turbidity Test Kit

1. Fill one turbidity cylinder to the 50mL line (top white line) with river water. *Variation – if after adding river water, the dot at the bottom of the cylinder is not visible, fill to the 25 mL line instead.*
2. Fill the other turbidity cylinder to the same line with clear tap water or distilled water.
3. Place the two cylinders side by side on a flat surface. Look down the tubes at the black dots to examine the difference in clarity.
4. If the black dots are equally visible in both cylinders, the turbidity is zero. If not, proceed to the next step.
5. Shake the "Standard Turbidity Reagent."
6. Add 0.5 mL of the reagent to the cylinder filled with tap water. Stir well using the plastic stick provided in the kit.
7. Compare clarity (not color) of the water in the two cylinders. If the river water is still cloudier, repeat the previous step until the black dots are equally visible. Keep count of the number of additions of reagent. Shake the "Standard Turbidity Reagent" before each addition.
8. For best results, occasionally stir the river water in addition to stirring the tap water after each addition.
9. To determine the test result number in Jackson Turbidity Units (JTUs), use the table below. First, find your number of measured additions in the Number of Measured Additions column and read across the table to find the JTU number for the measured water sample that you used for your test.

Turbidity Test Results

Number of Measured Additions	Amount in mL	50 mL Graduation	25 mL Graduation
1	0.5	5 JTU	10 JTU
2	1.0	10 JTU	20 JTU
3	1.5	15 JTU	30 JTU
4	2.0	20 JTU	40 JTU
5	2.5	25 JTU	50 JTU
6	3.0	30 JTU	60 JTU
7	3.5	35 JTU	70 JTU
8	4.0	40 JTU	80 JTU
9	4.5	45 JTU	90 JTU
10	5.0	50 JTU	100 JTU
15	7.5	75 JTU	150 JTU
20	10.0	100 JTU	200 JTU

CAREFUL! CAREFUL! CAREFUL!

pH Test Kit

1. Fill both pH test tubes to the 5mL mark (the bottom edge of the clouded area on the tube) with river water.

2. Shake the bottle of pH indicator solution.

3. Add 6 drops of pH indicator to one of the test tubes. Stopper and shake the tube gently.

4. Place the test tube of river water in the slot behind the colored dial (the left slot when reading the test).

5. Place the test tube with indicator solution in the slot to the right.

6. Turn the dial to match the colors. For best results, compare colors in a sunny location.

7. The number showing on the dial is your pH level result.

CAREFUL! CAREFUL! CAREFUL!

Field Day Materials Checklist

We suggest the following materials for each team of facilitators and their elementary students:

- ❒ Journals (enough for each student in the team)
- ❒ Binoculars
- ❒ Backpack with the following contents:
  - ❒ First Aid kit
  - ❒ Water Quality Test kits
  - ❒ Safety goggles (for D.O. kit)
  - ❒ Waste bottle for chemicals
  - ❒ Rinse water (to wash hands/eyes if needed)
  - ❒ Notepad
  - ❒ Colored markers
  - ❒ Permanent markers
  - ❒ Dry-erase markers (if using dry board)
  - ❒ Pencils
  - ❒ Colored pencils
  - ❒ Pencil sharpener
- ❒ Small Clipboard (8-1/2 in. x 11 in.)
  - ❒ Field Day Agenda
  - ❒ Small topographic map
  - ❒ Water Quality Test Information
  - ❒ Creek Walk—Questions and Answers
  - ❒ Streamside Observation Checklist
  - ❒ Watershed Map—Santa Clara Valley Basin
- ❒ Large Clipboard (18 in. x 22 in.)
  - ❒ Laminated topographic maps of watershed
  - ❒ Chart paper

Photo Release Form

I hereby authorize and give full consent to ______________________________ to copyright, publish and display all photographs and video taken for the BioSITE Program in which:

- ❒ my son ______________________________
- ❒ my daughter ______________________________ appear.

I agree that ______________________________ may use, or cause to be used, my photograph and video image for any and all exhibitions, public displays, publications, commercial art, Web site and/or advertising purposes, without limitation or reservation or compensation. No names or identifying information will be used with the photos or video.

Parent Signature: ______________________________ Date: ____________

Name (please print): ______________________________

Home Address: ______________________________

City: ______________________________

State: ____________ Zip: ______________________________

Home phone number: (__________) ______________________________

E-mail: ______________________________

School: ______________________________

Teacher: ______________________________

Terms and Concepts

abiotic factors: Environmental influences produced by non-living organisms (physical and chemical, such as temperature, humidity, pH, light, nutrients, wind)

absorption: The process by which water and dissolved substances pass into cells and other materials

acidic: A pH reading (less than 7) characterized by the presence of a high concentration of hydrogen ions

adaptation: A change (over many generations) in an organism's structure or habits that produce better adjustment to the environment; a genetically determined characteristic that enhances the ability of an organism to survive

alevin: Young fish, especially newly hatched salmon still attached to the egg yolk sac

alkaline: A pH reading (greater than 7) characterized by the presence of a relatively low concentration of hydrogen ions

amphibian: Any member of the class of cold-blooded vertebrate animals that includes frogs, toads, and salamanders, and is characterized by eggs laid in water that hatch into gill-breathing larvae and metamorphose into lung-breathing adults

anadromous: The type of fish, such as salmon and shad, returning from the ocean to the rivers where they were born in order to breed

aquatic: Living or growing in or on the water

aquifer: Geological formation, large underground bed of sand or porous rocks that contains water. Aquifers are the reservoirs for wells and springs

aves: The particular scientific family classification that refers to birds

bacteria: Unicellular organism, occurring in a variety of forms, existing either as free-living organisms or as parasites

biodiversity: The variety and number of organisms found within a specific geographic region or ecosystem

biotic factors: Environmental influences produced by living organisms

bird of prey: Any member of a group of birds that kill and eat other large animals for their food, and are characterized by a sharp, hooked beak and strong, sharp talons Examples: hawks and owls

carnivore: An animal that eats meat exclusively

channelize: Process of straightening and "smoothing" of a channel. Channelized streams have a smaller carrying capacity than streams that maintain sinuosity. The water in channelized streams moves faster but this does not necessarily mean more flooding

classification: The method of ordering or grouping of plants and animals according to their natural relationships

community: A group of populations of plants and animals in a given place: used in a broad sense to refer to ecological units of various sizes and degrees of integration

condensation: Process in which water vapor cools into tiny droplets that can collect and form clouds

conductivity: A measure of the water's ability to conduct electrical current (often influenced by the presence of dissolved solids)

conifer: A cone-bearing plant, such as pine, fir, spruce, hemlock, cedar, and redwood

conservation: The act of keeping, protecting, preserving or wisely using our resources.

consumer, secondary: An animal that eats other animals

contaminant: anything added to a substance which makes that substance impure, infected, or polluted that may be harmful to organisms

deciduous: Trees and shrubs that lose their annual growth of leaves each autumn

decomposer: An organism (chiefly bacteria and fungi) that causes the mechanical and chemical breakdown of dead plants and animals

decomposition: The process of rotting and decay that causes the complex organic materials in plants and animals to break down into elements that can be returned to the atmosphere and soil

delta: Triangle-shaped area at the mouth of one or more rivers

detritivore: An animal that consumes or feeds on decomposing organic matter, gaining nutrition from bacteria and fungi on the organic matter

dissolved oxygen: The amount of oxygen in water, generally produced through turbulence or as a byproduct of photosynthesis

dissolved solids: Small particles (which pass through a filter) present in water, including minerals and salts.

discharge: The specific quantity of water that flows past a point along a stream or river in a given amount of time, usually expressed as liters per second.

diversity: Number of species in a community or region.

ecology: The science of the relationship between organisms and their environment

ecosystem: A basic functional unit consisting of complex interactions between plants and animals and the physical and chemical components of their environment, varying in size from a small field to the entire earth

emergent: An aquatic plant that is rooted in a pond or stream bottom that has stems and leaves above the surface. Example: grasses, sedges, rushes, and cattails

erosion: The process of wearing away soil or rock, caused by the natural actions of water, wind, or ice.

evaporation: The process of water changing from a liquid to gaseous form

feather: The part of a bird's anatomy that covers and aids in insulation and flight

filter: A screening device or porous substance (sand, pebbles, charcoals) used as a strainer to remove solid matter from water

fins: An external appendage on an aquatic animal (such as a fish) used to propel or guide the body

filtration: Third step of water purification in which water flows through layers of charcoal, sand and gravel to remove tiny particles

flood: An overflowing of water onto land that is normally above water

flood plain: Area next to a stream that is subject to inundation during storms

food chain: A succession of organisms in a community that constitutes a feeding chain in which food energy is transferred from one organism to another as each consumes a lower member and, in turn, is preyed upon by a higher member

food web: A network of interconnected food chains within a community

fry: A newly hatched, or juvenile, fish

generalist: An animal or organism whose habits, food preferences, or activities are varied or unspecialized

genus: A biological class ranking between the family and species, comprising related species.

gill: An organ of a fish that obtains oxygen from the water

ground water: The water contained in aquifers that supplies wells and springs. This supply comes mostly from surface water that seeps down through the soil and rock

groundwater recharge: Process of using percolation ponds to replace water taken from an aquifer

habitat: The place or kind of place where an animal or plant usually lives or grows

headwaters: The source of a stream

heavy metals: Metals such as lead, zinc, copper and chromium that can harm fish life when they become dissolved in water

herbaceous: Referring to any non-woody plant.

herbivore: An animal that eats plant material exclusively

hydrologic cycle: The sequence in which water moves from the ocean through the atmosphere, to the land and through it back to the ocean. Also called the water cycle

impervious surfaces: A hard, compact surface that does not permit the infiltration, penetration or passage of water through it

impurities: Substances that contaminate pure materials

indicator species: Species that indicate the quality of a habitat or environment. Used to assess the decline of a habitat (such as Spotted Owl)

infiltration: Process of water or liquid permeating, or passing through, soil by penetrating its pores (the spaces between soil particles)

inorganic: Involving non-living matter, like minerals and salts. Compounds that do not contain carbon

insectivore: An animal, such as moles and shrews, that characteristically feeds on insects.

invertebrate: An animal that has no backbone, but uses some other form of support such as a shell or exoskeleton

lake: A fairly large inland body of fresh water surrounded by land

larva: An immature and usually active feeding stage of an animal, unlike the adult in form

limiting factor: One factor that determines success over another, so that as environmental characteristics change, the limiting factor affects what species will survive

macroinvertebrate: An animal with no backbone, large enough to see without magnification

mammal: Classes of vertebrate animals that have hair on their bodies, self-regulating body temperature, and the females have glands that produce milk to feed their young

metamorphosis: A process by which an immature animal transforms to an adult through a series of developmental changes

microhabitat: A small, specialized home within a larger habitat, such as under a rock

migration: Moving, usually on a periodic or seasonal basis, from one region or climate to another for breeding or feeding

monitoring: Testing for and keeping track of qualities on a regular basis, usually using specific tests or instruments and recording data

niche: The unique function or role of a given species within a community

non-point source pollution: Water pollution caused by a variety of sources that flows into a receiving water through storm water runoff and storm drains

nutrient: Something that nourishes people, plants, and animals and keeps them healthy and growing

nymph: An immature insect or larva that resembles the adult form but is smaller and lacking fully developed wings

ocean/sea: A large body of salt water. Oceans cover about three-fourths of the earth's surface.

omnivore: An animal that eats both plant and animal foods, and fungi

organic: Living or dead plant or animal matter. Any compound that contains carbon atoms.

percolation: The process of water infiltrating and moving downward through soil, through pores or spaces between rock

pervious (surfaces): Porous surface that permits the penetration or passage of water through it

pH: A measure of acidity or alkalinity of a substance, on a scale ranging from 0 (acid) to 14 (alkaline). A neutral pH reading of 7 means there are equal hydrogen and hydroxyl ions. The name of the measure derives from "power of Hydrogen"

photosynthesis: The production of sugars, by plants, from carbon dioxide and water in the presence of chlorophyll using sunlight as the source of energy

point source pollution: Pollution coming from a specific point, such as a factory or refinery

pool: A quiet place in a stream, where the water is deeper and slower than the rest of the stream

pollutants: Contaminants of a natural system, usually harmful chemicals or waste products.

pollution: Conditions of contaminated air, water or land

precipitation: Rain, snow or hail that falls to earth from clouds

predator: An animal that hunts, kills, and eats other animals

prey: An animal hunted for food

producer: An organism that produces its own food (plants)

pure: Free from impurities, dirt, or pollution. In the case of water, it means not mixed with any other substance

rain: Water that has changed from vapor to liquid and falls from the sky, called precipitation

rate of flow: The speed at which water in a stream is flowing; a state that affects many other characteristics of the water

reach: A continuous stretch of a stream or river.

reservoir: Natural or man-made lake used for collecting and storing water

resource (renewable or nonrenewable): Any of the raw materials used to support life. Oil is considered a nonrenewable resource because it has a limited supply. Trees are renewable resources because they can regenerate

riffle: A shallow area extending across a streambed, where water is flowing rapidly over rocks and cobbles, causing small rapids.

riparian: The area relating to the banks of a river or stream

river: A flowing body of water

runoff: Rainfall and other water that is not absorbed into the ground before it reaches the ocean, that runs off into streams, lakes and bays

salmonid: A term referring to the family of salmonidae, including salmon and trout.

scales: Small, platelike, external covering of fishes, reptiles, and certain other animals.

scavenger: An animal that feeds on dead organic matter, either plant or animal

scraper: An animal that scrapes algae off rocks for consumption

sediment: Fragments of material that are made from the weathering of rock, that settles to the bottom of water

shredder: A macroinvertebrate that strips and shreds organic matter into fine particles

smolt: A young trout or salmon that is about two years old and at the stage of development where it is ready to migrate to the ocean

spawn: To deposit or lay eggs (refers to an aquatic animal such as a fish)

specialist: An animal or organism whose food preferences, habits, or activities are adapted to a specific end or use

species: The biological category of classification ranking below the genus

storm drain system: Untreated wastewater system designed to carry off storm water runoff, but not sewage, from homes and industry

storm water: Water from rains which runs off the land, can carry pollutants into a body of water

stream order: A means of identifying or classifying tributaries

subcanopy: The understory of a forest or woodland comprised of woody plants and shrub

submergent: an aquatic plant that is rooted in a pond or stream bottom, with completely submerged stems and leaves

surface water: All of the water on the surface of the earth: lakes, ponds, rivers, oceans, streams, glaciers, snow packs and ice caps

temperature: The degree of hot or cold in an environment (a factor of the kinetic energy, or movement, of particles in matter)

transpiration: To give off water vapor, as from the surface of leaves and other plant parts.

treatment: The process by which water is cleaned and purified

tributary: A stream that flows into a larger body of water

trophic level: One of the hierarchical layers of the food web, characterized by organisms that are the same number of steps removed from primary producers

turbidity: The muddiness of water, created by stirring up sediment and having suspended particles in the water

vegetation: A term that refers to plants in general or plants in a particular region, such as “riparian vegetation”

vertebrate: Any animal having a segmental backbone or vertebral column; bony fishes, amphibians, reptiles, birds, and mammals

water: The most abundant chemical compound on earth; transparent, colorless, odorless, tasteless liquid composed of two hydrogen atoms and one oxygen atom. Chemical symbol: H2O

water quality: The properties or quality of water, usually comparing the natural state of pure water in an environment as "good," and water tainted with pollutants, toxins, or foreign matter that harms aquatic organisms or plant material as "bad"

water cycle: The complete path water travels in nature, including evaporation, transpiration, condensation, precipitation, infiltration/percolation and runoff; also called the hydrologic cycle

watershed: An area in which water flows from any point to a particular body of water. In natural conditions it is defined by physical geography; in urban settings it can also include storm drains

water table: The upper limit of the ground water

wastewater: Water that carries people's pollutants; sewage

wastewater treatment: Process used to clean wastewater so that it can be discharged.

woodland: An area of land, or ecosystem, covered by large trees and woody vegetation

TEACHER RESOURCES

Standards

Alignment with National Standards
The main themes of the National Science Framework provide a context for the BioSITE curriculum. The national standards emphasize science processes, such as thinking scientifically, using science tools and techniques, communicating science processes, and applying science to community improvement. Examples of how the activities are linked to these standards are listed on pages 17-18 of the Curriculum Framework chapter towards the beginning of this document.

BioSITE Alignment with State and District Standards
While the National Science Standards provide a broad framework for the program, especially in the areas of inquiry and the process of science, BioSITE also aligns with state and district standards. The main themes of the California State Science Standards provide a context for the program: patterns of change, stability, and systems and integrations as well as energy, evolution and scale, and structure. BioSITE was used as a model by San Jose Unified School District to illustrate how project-based learning programs can coordinate with standards. To see the matrix of activities alignment with content standards, benchmarks, and knowledge/skills refer to BioSITE online.

For more information on California State Standards, refer to: www.cde.ca.gov. To integrate with district standards, consider the following:

- BioSITE targets the broad science standards of biology, ecology, and life sciences. In addition, the units cover data collection, geology and geography, the water cycle, and system stewardship.
- Study of the watershed leads students to the history of their local area and greater region.
- Water quality testing and data collection program target mathematics, chemistry and physics. Related activities include water quality sampling, journal writing, and analyzing information including mapping, graphing and correlating information.
- Teaching, lesson planning, and project components achieve language arts and visual arts standards and develop communication and life skills.

Assessment

Program Evaluation
Evaluating the program helps ensure a quality learning experience for children and is often required when supported by grant funding. Part of Children Discovery Museum's success in this area has been to develop partnerships with an outside person to assess the program. In cases where this is not an option, we recommend trying to make it a priority to do formative, on-going assessment. This way, you can continually confirm what's working well, modify what's not, remember what original goals are, and whether they're being met or not. If you find that they're not, you can change something to meet the goal or assess whether the original goals were unrealistic and need to be altered. If the program is working, perhaps it is a slightly different program than originally conceived. That's acceptable as long the program is still meeting the essential goals to provide quality learning experiences for students that relate to the content they need to learn, and to provide development and growth for teachers. Additional information on program evaluation can be found in the teacher resource section.

The following pages describe some of the tools and methods we have used to assess program development as well as student learning. The reflection activities built into each unit also will help give you a sense of your overall program's strengths and areas for improvement.

BIOSITE online
www.cdm.org/biosite

Student Performance

BioSITE uses the journal and the portfolio as the primary assessment tools for evaluating student performance. Teachers may use homework, quizzes, and presentations to supplement as needed. To see what other students are doing, teachers can log on to BioSITE online to view and compare the posted work of other BioSITE students with that of their own. Classes may also post their data online to share. This requires confidence in accuracy and quality of the data.

Journal

Each week includes focus sessions for high school facilitators to reflect on personal growth, team evaluations, and group progress. This reflection often happens through journal writing and discussion. Student growth through reflection is a priority in the BioSITE program. BioSITE staff work continually with students, using multiple methods to evaluate ways that the program helps students to learn science content and develop life skills and personal assets. As a team, staff determines future training and activities through interpretation of student writings, questions, and responses to experiences.

Portfolio

Throughout the program students collect information, gather data, develop teaching tools, and create maps of the watershed. All of this work contains evidence of understanding and, considered together as a portfolio of work, illustrates the student's progress through the program. The main components of the portfolio are:

- Three selected journal entries of different field experiences
- Two diagrams showing environmental science content pertaining to their field work
- Two graphs showing water quality data over the course of the year
- A written explanation using the two graphs to interpret watershed and stream health
- One completed site map
- One selection of their choosing that shows their BioSITE experience in a way that is unique

Teaching Board

This oversized clipboard is a "traveling classroom" of sorts. Along with the basic tools given to each group (the watershed map and list of elementary students) facilitators will create two to five visuals for each unit to help teach their students. Examples of visuals may include a list of *Objectives for Understanding*; a pictorial diagram of a water quality test; a chart; a diagram of the food chain; and drawings of leaves and macroinvertebrates. These visuals indicate the level of understanding of a particular subject.

Site Maps

Throughout the program students collect and gather information about the creek and its surrounding riparian habitat. They perform water quality tests and record data. They observe flora and fauna. They count macroinvertebrates and calculate the pollution tolerance index. With each unit, students learn more about the specific characteristics of the creek. These characteristics are recorded in "draft" form on maps. Beginning with the unit on Birds, students start indicating bird species on the map in the location that they observe and identify the bird (they may also note the tree species). During the Macroinvertebrates unit, students mark on the map what insects they observed. Students indicate where on the map they have noticed riffles and pools in the creek.

Towards the end of the unit, students compile all of the information on one Watershed Map. They finish the map by mounting it on poster board and adding color, small drawings and perhaps natural objects from the field (an acorn; a small leaf). They then present their maps to an audience of parents, classmates, future BioSITE students, and interested community and water quality professionals.

Data Sharing

A primary goal of our BioSITE program is to have our students experience and understand the value of sharing their monitoring results and research with the community. Giving students the chance to share their knowledge, concerns, and field research with their peers, the public, and scientists working on similar projects can provide students valuable opportunities to demonstrate successfully their knowledge and leadership skills. Throughout the year, students articulate their knowledge in many different ways.

- Their journals and reflections help to emphasize their understanding of watershed issues and how they apply to other aspects of their education.
- Student teams participate in class presentations to share research findings with their classmates.
- Student portfolios give students a chance to select their best work over the course of the year, and refine this work in order to present the knowledge they have gained.
- Their data graphs, interpretations, and site maps help to show the year's progress and the many ways in which individual students have gained knowledge and awareness of their environment.

Providing water quality monitoring data to other environmental agencies and the general public is an essential part of environmental networking and demonstrates first hand to our students the value of taking action in their community. Our BioSITE data is entered online at www.cdm.org/biosite throughout the year, as part of the students' technology training (see *Technology* section). You can use our BioSITE online database to make comparisons with your students' data. If you are interested in contributing your data to an online database and larger research project, we suggest that you check out the following programs:

- Globe Program - Global Learning and Observations to Benefit the Environment
- International Rivers Network - IRN
- Monitoring Water Quality - US EPA Office of Water
- River Watch Network - RWN
- Save Our Streams - SOS - Izaack Walton League Project
- Surf Your Watershed - EPA - Environmental Protection Agency
- Volunteer Monitor's Home Page - The National Newsletter of Volunteer Water Quality Monitoring

Cross-subject Integration

Teachers have found creative ways to integrate BioSITE with math, language arts, history, and art. For example, one 4th grade teacher uses BioSITE as the basis for lessons in language arts. Students practice paragraph writing, a standard in literacy, after each of their BioSITE experiences and develop vocabulary lists for BioSITE sessions to build language. High school students have used BioSITE for writing stories. They describe the salmon hatching activity by writing from the perspective of the egg brought in to the classroom to be incubated and describe the journey from the creek to the classroom and back to be released into the creek. To integrate with math, teachers have students graph their BioSITE water quality results when they need to learn graphing. Using BioSITE in these ways can be a method of leveraging teaching time.

At the elementary school, there is often limited time to teach science in the classroom, BioSITE can be used as a context for the other academic subjects. Looking for cross-subject integration between BioSITE and other subjects is one way to infuse science into the daily schedule while not taking up much more time.

Service Learning Programs

Service learning combines the objectives of service and learning to provide students with authentic learning experiences that also provide community service benefits. BioSITE is an ideal service-learning program for high school students. Because the project combines science with teaching, mentoring, and sharing data with local organizations, it engages youth in both community service and academic subjects. Activities are structured to give content in both areas. Because students are engaged in meaningful work that contributes to the betterment of their communities, they also exhibit improved leadership skills, character development, citizenship, and academic achievement.
Service learning programs value critical thinking, active learning, problem solving, and reflection. They engage students experientially, building on students' strengths and drawing from multiple academic disciplines. For more information on service learning, the National Youth Leadership Council and the National Service-Learning Clearinghouse Web sites are good resources.

Adaptation for Other Grade Levels

In its years of operation, BioSITE has been adapted to every possible level, from preschool through college. The key to adapting the program to any grade level lies in the choice of activities and emphasis on water quality testing. Teaching about a healthy creek and riparian ecosystem can be a constant at any grade level. The complexity and depth to which water quality testing is taught can increase (bringing in more chemistry) or decrease depending on the age level. Adaptation is built into the structure of the curriculum in that the first two activities are geared towards elementary students and the third activity is geared towards advanced study for the high school student.

For preschool students, BioSITE was modified into a short river walk program; everything was dropped except plant activities and observation skills. Students articulated their findings in other ways besides recording in writing (such as discussion, artistic interpretations, matching leaves, sorting, etc.). For college-age facilitators, the hard science and teamwork/teaching skills were emphasized, as well as more stringent research techniques, such as collecting meta data on the consistency of test kits and sampling techniques.

Our experience with 3rd graders in BioSITE has been that they are more teacher-focused than peer-focused. They tend to want to sit and listen to stories, and respond well to activities in which specific critter and test results are embedded in and relate to a story or narrative context. Activities need to be concrete and their imagination needs to be activated. Water quality testing is somewhat difficult.

With junior high youth, Children's Discovery Museum uses the program to help students build their basic field research skills. They identify their own interests and develop mini field research projects. By the end of the program, their basic field research skills are well developed and they understand how to do water quality testing, journaling, and how to choose a creek site.

Classroom Extensions

When writing this curriculum we chose activities that apply to the broadest audience. Unfortunately we had to leave out many great activities that we use regularly in the year-long BioSITE program. Over time we plan to post these on the BioSITE online Web page. Many of the classroom extension ideas and activities have come from teachers who have participated in the program and developed their own. We invite teachers and museum educators to post activities on the Web site, too.

Other extension activities that fit BioSITE can be found in some wonderful existing curriculum guides, such as *Project WET* and *Streamkeeper's Field Guide* (see *Additional Resource* section). These guides are often sources of inspiration to our BioSITE program director.

Scheduling Suggestions

Scheduling is always going to be the first hurdle, but we want you to know that if you can make time for this type of program, the rewards will be more than you ever expected! Our program has been made possible by the willingness of several teachers, school administrators, and Museum staff to be flexible, work through trial and error, and revise the program as needed. We encourage you to be creative and patient. The schedule for the first year of our program was vastly different from later years, but that first year was important to prove the program's credibility and benefits. Following are some suggestions we have based on our experiences managing schedules for this field-based project:

- *Connect with community service requirements.* Some high schools have active Service Learning Programs that use one class period a week for students to fulfill their community service requirements for graduation. In this model, one week's class session would focus on training and the next week's class would be a field session with high school students teaching elementary students.
- *Create an after-school program.* One of our BioSITE programs is conducted as an after-school program. High school students who volunteer learn science content, conduct research, practice leadership skills, gain teaching experience and earn community service credit. High school students could sign up for one semester, receive training after school one day per week, and a second day per week can be a field session.
- *Offer an independent study or senior project option.* The course can be offered for elective science credit.
- *Join an environmental club or community service club.* Using non-school time, this type of program can work around lunch and after-school schedules. Because of the community focus of clubs, these students can really get the word out to other students and the community about the benefits of the program.

ADDITIONAL RESOURCES

Environmental Study

Global Rivers Environmental Education Network (GREEN) provides a place for students to post water quality data, offers educator training, teacher resources, and links to myriad water quality and youth involvement organizations and programs. Their Web site has great information that can be used as supplemental reading, activities, or assessments. For example, “Water Quality Information Resources,” “Understanding Watersheds,” and “Making Water Quality Connections.” Visit their Web site at (www.green.org)

Field Research

The following have been useful resources for ordering test kits and equipment that are used in water quality monitoring activities.

HACH Company
www.hach.com
HACH Company
PO Box 389
Loveland CO 80539-0389

La Motte
www.lamotte.com
La Motte Company
PO Box 329
Chestertown MD 21620

GREEN
Global Rivers Environmental Education Network
www.green.org
Earth Force
1980 Mt. Vernon Ave.
Alexandria VA 22301

Guidelines for Writing Grants and Funding Proposals

Every great project needs supporters and funding to make it happen! We thought it might help those of you who have never had to write a grant proposal if we included an outline for you in this curriculum. To find organizations that might be willing to fund a program like BioSITE, we recommend contacting:

- Your local water district or water company
- Community groups, such as the Rotary Club
- Groups interested in conservation, such as Flycasters Associations or the Audubon Society
- We plan to add a section to BioSITE online, which will gives information on potential funders for school projects.

Many grant applications will come with a form for you to fill out, but some do not. Either way, we hope that the following outline will be helpful to you should you decide to apply for a grant to fund your program.

1. Describe your proposed project
Why is your specific project needed? What are your specific outcomes for the project?

Project description: Include a paragraph with a very basic description of the purpose of the program and what activities it will include. Be sure to identify program benefits, such as students learning about the watershed, developing basic field study techniques, and pursuing inquiry-based science investigations. Include a list of participants, such as:

- Number of high school students conducting field studies and teaching elementary students. Note the frequency of their field work and focus of research.
- Number of elementary students conducting field studies and the frequency of their visits to the creek.
- Number of teachers who support their students’ studies at the river field sites and facilitate extensions and assessment activities that integrate BioSITE into their classrooms throughout the year.
- If students or teachers are from a minority group that is typically underrepresented in science fields, you may want to make note of this.

Project goals: List the larger goals of your program. For example, we might describe goals such as:

- Providing the opportunity for the students to practice real science research

- Giving students experience using science tools and methods unavailable in the classroom
- Increasing public awareness of environmental concerns within our watershed

Describe some of the activities which will help you succeed in reaching these goals (coordinating the water quality monitoring at the creek site; using a field-tested, hands-on science curriculum; including presentations by students to the community)

<u>Specific request:</u> List the specific requests you have for funding and how they are essential to program implementation and success. These might include the following:

- Transportation – Describe how many trips, to where and for what purpose, and the cost.
- Teacher Training – You may need money for workshops related to the projects or for release time to work on the project.
- Honoraria – It is nice to be able to thank visiting scientists with an honorarium for their time.
- Materials – This includes test kits, first aid kits and safety equipment, backpacks, activity materials, reference books and field guides, binoculars, magnifiers, nets, boots, landscapers' measuring tapes, presentation materials, etc.
- Printing – Field journals and other handouts

2. Who will be involved?

If participants haven't been listed, you could include them here. Be sure to connect the numbers of participants with what they will be doing and how they will benefit from the program. List any community partners, other funders, or volunteer groups as well.

3. How will you measure progress toward achieving your outcomes?

Funders will want to know how you will measure the impact of the program. Some methods we have used for assessment include:

- Journal assessment – Students at the elementary, middle and high school levels enter their research data – including water quality test results, observations of the river environment, and wildlife sighting – in their journals. The journals also serve as an essential tool for portfolio style assessment, through which students create records of their inquiry processes (lists of questions, revelations, descriptions of experiments and results, drawings).
- Pre-and post-program activities in the classrooms – Activities are designed for comparison at the end of the school year, providing an indicator of student progress.
- Written and lab-style tests are used in addition to journals at the high school level.
- High school attendance and enrollment records for the BioSITE program are examined from year to year.
- Program progress meetings attended by a range of stakeholders are conducted during the school year to review goals and discuss program development.

4. What is the timeline and specific tasks for the project?

Create a simple timeline of activities for the school year.

5. Do you plan to promote or disseminate the results of your project? If so, how?

- List any community fairs or outreach your students will participate in.
- Other students can get involved by documenting the program on video, through interviews, or with a photo essay. A school newspaper or school Web site might be a good way to distribute information on the program.
- Research results can be shared with other schools and interested partner organizations at teacher workshops and stakeholder meetings. Share your work with us and we will post it on our BioSITE online Web site!

BIOSITE online

www/cdm/org/biosite

Related Programs & Resources

4-H Youth Experiences in Science (Y.E.S.) and Science Experiences and Resources for Informal Education Settings (S.E.R.I.E.S.): inquiry-based science activities for children 5-12. Human & Community Development, One Shields Avenue, UC Davis, CA 95616. 530-752-8824.

Adopt-A-Stream Foundation: Environmental education and habitat restoration program. Publishes excellent watershed education curriculum (good companion to BioSITE for extension activities): *Streamkeeper's Field Guide*. (www.streamkeeper.org/foundation.htm)

Alabama Water Watch: Collecting water quality data is the means to creating a knowledgable, action oriented team of community leaders. (www.alabamawaterwatch.org)

Bridging the Watershed (BTW): In partnership with the Natioanl Park Service, BTW helps high school students to understand better some of the real world issues that impact natural resources in our national parks. Five high school science modules are available on CD-ROM. (www.bridgingthewatershed.org)

Biological Sciences Curriculum Study (BSCS): This organization develops and supports innovative, inquiry-based science programs and curriulum. Leader in development and implementation of 5E instructional model. (www.bscs.org)

Colorado River Watch Network: Through this volunteer network, teachers are certified as monitors of the Colorado River and its tributaries. A symposium brings together teachers and students to give presentations on their results and celebrate their discoveries. (www.lcra.org/envedu/education.html)

Cyberways & Waterways: Developed by 4empowerment, this program uses online water-based lesson plans and creative collaboration to engage students in hands-on science activities. Lessons fulfill federal science content standards and are easily adapted to state objectives. (www.4empowerment.com)

Earth Force: Earth Force empowers youth to discover and implement lasting solutions to environmental issues in their communities. (www.earthforce.org)

Eastern Kentucky PRIDE Inc.: This program trains and equips teachers to help their students measure water quality at waterways near their schools. The data is posted on the PRIDE Web site and students learn how pollution problems are resolved in real life. (www.kypride.org)

GIS Day: Annual event to see real-world applications of Geographic Information Systems (GIS) software by ESRI. (www.gisday.com)

Give Water a Hand: National watershed education project for youth engaged in environmental service projects. State of Wisconsin. (www.uwex.edu/erc/gwah)

The GLOBE Program: GLOBE is a worldwide hands-on, primary and secondary school-based science and education program. (www.globe.gov)

The Global Water Sampling Project: Semester-long science projects for grades 9-12. Center for Improved Engineering and Science Education (CIESE) Collaborative projects. (www.k12science.org/curriculum/waterproj)

Global Rivers Environmental Education Network (GREEN): Water quality data and locally generated data for biological, chemical, physical, and land use information. (www.green.org)

Hackensack Riverkeeper Organization: The purpose of this project is to pinpoint what, where, when, and how pollution incidents occur in the watershed. The organization trains students from six schools to monitor ten different water quality factors. (www.hackensackriverkeeper.org)

International Year of Water (2003): International Web site to share information about freshwater. Contains photo library, resources and data. (www.wateryear2003.org)

Lewis & Clark 200-Geography and Change: Web site is great mapping resource! Study Lewis & Clark's journey and how geography and technology techniques have changed over time. Provides links to historic maps, classroom learning guides. ESRI. (www.esri.com/lewisandclark)

Project LEAD (Leadership Education for Action Development): Great teens as teachers resource, focusing on problem solving and decision-making skills, community mapping, and cross-cultural communication. Dr. Rasjidah Franklin, UCCE, 1131 Harbor Bay Parkway #131 Alameda, CA 94502. Tel. 510-567-6812.

Project WET (Water Education for Teachers): Nonprofit watershed education program. Web site contains classroom-ready teaching aids and program materials for teachers and students (ages 5-18). (www.projectwet.org)

The River Network: Resources for volunteer water monitoring. (www.rivernetwork.org)

Rivers Project: Water study program designed to improve scientific literacy in high school students. Students submit water quality data online. Curriculum units and materials, news flashes. Southern Illinois University. (www.siue.edu/OSME/river)

Salmon & Trout Education Program (STEP): Non-profit environmental education program devoted to the preservation of the remaining strains of anadromous fish, namely salmon and trout, in Monterey Bay. Great, hands-on activities! (www.steponline.info)

Santa Clara Valley Water District: The water district provides stream stewardship, wholesale water supply and flood protection for Santa Clara County, California. A full range of educational programs for both teachers and students is available. (www.valleywater.org)

Texas Watch: This volunteer water monitoring organization has a Web site with a wealth of information to offer any teacher who wants to plan a water-based curriculum or improve an existing program. Lesson plans and activities can be downloaded and printed. (www.texaswatch.geo.swt.edu/educationx.htm)

Toxics Release Inventory: Information on toxic chemical releases and waste management activities. Database searchable by community. United States Environmental Protection Agency. (www.epa.gov/tri) Draft Report on the Environment: (www.epa.gov/indicators/roe)

Understanding by Design Exchange: Cooperative Web site devoted to the development and peer review of curriculum units. (www.ubdexchange.org)

Urban Rivers Awareness: Philadelphia-based Academy of Natural Sciences museum has a curriculum related to urban rivers. (http://www.urbanrivers.org)

Washington Virtual Classroom (WVC): WVC provides elementary, middle and high school students with the exciting opportunity to investigate the health of salmon spawning streams in different areas. Data is maintained, compared and evaluated throughout the year. (www.wavcc.org/wvc/cadre/waterquality)

The Water Education Foundation: Posters, curriculum, good materials for western schools. (www.water-ed.org)

Watershed Watch: Public-private partnership to provide public information regarding Santa Clara Basin Watershed and watershed pollution prevention. (www.watershedwatch.net)

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Murdoch, Tom, Martha Cheo and Kate O'Laughlin, Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods. Adopt-A-Stream Foundation (2001).

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