A River Runs Through Us: The Bear River Watershed Education Project

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A RIVER RUNS THROUGH US:
THE BEAR RIVER WATERSHED EDUCATION PROJECT

by

Robert M. Parrish

A paper submitted in partial fulfillment
of the requirements for the degree

of

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Abstract

Teachers have the difficult job of creating an educational climate in which subjects are linked and systems are mutually dependent. Watershed education affords teachers this opportunity by using water quality monitoring as a basis for the study of any academic subject. A River Runs Through Us: The Bear River Watershed Education Project (BRWEP) is a student-based program in Utah, Wyoming, and Idaho. The program aims to increase understanding and concern for the Bear River watershed by engaging students in water quality monitoring. Based on our experience in creating, managing, and evaluating this program, a process model for watershed education was developed. The model describes how to organize resources, enlist participants, train and support them, and evaluate the program. This information can be used by watershed education practitioners to implement similar programs in other basins. In its first two years, BRWEP has been particularly effective at developing support materials and training teachers in water quality monitoring. A formative program evaluation was conducted to illuminate ways that the program could be improved. The results suggest that BRWEP administrators can better assist teachers with creating an interdisciplinary curriculum, provide teachers with more content knowledge, and devise ways to allow schools to increase their participation time. In addition to the model and evaluation, I present a multi-scalar analysis of volunteer monitoring, discuss the relevant literature, and offer a series of recommendations to improve BRWEP.
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Figure 1. Map of the Bear River watershed
CHAPTER 1

INTRODUCTION

This paper is the result of a process to implement a new watershed education program in schools throughout the Bear River watershed of Wyoming, Idaho, and Utah. It contains the following five chapters:

1. An introduction to the Bear River watershed and the goals and objectives of A River Runs Through Us: The Bear River Watershed Education Project (BRWEP).
2. A historical, national, and regional examination of watershed education programs, including relevant literature.
4. A formative evaluation of BRWEP.
5. A summary of recommendations for future guidance of BRWEP.

Like watersheds themselves, these five sections cover a lot of ground, ranging from the theoretical to the practical. Each section can almost be considered a stand-alone product, useful to multiple audiences and in different situations. I hope this product is not only representative of the knowledge and experience I have gained as coordinator for BRWEP, but in the long run, useful to other educators.

As the State of Utah now moves toward employing its first watershed education coordinator, the timing of this document could not be better. BRWEP is the largest program in the State and thus stands poised to provide the model for other programs to come. In describing
the evolution of our program, learning from the collective experience of other watershed education groups and the literature, I believe this paper can substantially assist these future endeavors.

**Problem Statement**

Environmental education (EE) is a young and emerging field within the broader education community. Debates are still common throughout the literature and among practitioners over its purpose and future direction. Many people argue that one reason EE has been ineffective is due to its typical mode of dissemination and science-based content matter. In a survey of national EE coordinators, Wade (1996) found that teacher training efforts are primarily activity-based, national programs (e.g., Project WET) rooted largely in science, and concerned more with environmental content than educational context. She believes that EE has failed to connect students and teachers to their local environment, and has often provided material of little direct relevance to the learner. Perceptions of EE by teachers confirms many of these beliefs; one study reported that 62 percent of teachers believe that science is where EE should be nested (Sewing, 1986, as cited in Ham et al., 1987).

Similar to Wade (1996), we maintain that EE is not a subject, but a process. For those of us who train teachers in EE, we should focus not so much on *what* to teach, but *how* to teach. We believe that EE is a teaching philosophy whereby environmental themes can be used to educate students about any subject, using a familiar, common, and fundamental unit—place—and not purely environmental issues or concepts. To inculcate the importance of place, a teacher may use watersheds as a structural lattice upon which subjects and concepts are layered. Local subjects offer teachers great flexibility and creativity while providing topics of emerging relevance for
students. Furthermore, EE should not add subjects to existing curricula but rather, provide a more meaningful, dynamic and connected framework for teachers to structure their existing lessons and coordinate with colleagues.

Simply put, watershed education is really nothing more than systems education. Yet when used as part of an integrated approach to education, it becomes a powerful, holistic thread around which several teachers can weave their lessons. For students, this demonstrates interconnectedness, nurtures citizenship, and enables teachers to use “real world” objects and issues to create lasting knowledge.

BRWEP seeks to engage students in interdisciplinary education by using the watershed as a central, organizing theme. As Chapter 2 demonstrates, many leading watershed education groups are also pursuing this approach. We believe a watershed approach can have educational permanence and positive environmental benefits.

While BRWEP is not only applicable within the field of science education, it does nonetheless have some direct significance. Current science education reforms, including those from National Science Education Standards (National Research Council, 1997) and numerous practitioners, call for the inclusion of student-driven scientific inquiry as part of the curricula. By involving them in field-based, investigative science activities, BRWEP engenders these skills among students. As part of their stream investigations, they are asked to make observations, pose questions, collect and analyze data, formulate answers, and communicate their findings through an Internet database.

Greater use of student inquiry is but one of the common desirable reforms that BRWEP invokes. Although the specific type and extent of reform is not universally agreed upon by the
science education community, certain features are nonetheless ubiquitous (Yarer, 1992). As Yarer (1992) argues a good program should, BRWEP provides real-life problems (e.g., water quality and watershed-related issues), offers a suite of hands-on activities, fosters relationships between teachers and practicing scientists, and promotes a “less is more” strategy for teachers.

If successful, BRWEP will have helped produce a more scientifically literate community who understands not just the process of science, but also the motivation behind it. When teachers expand their program outside science classes, BRWEP can be used as a vehicle for place-based education. If our students understand, appreciate, and work toward improving their “place,” there is hope for resolving some of the complex socio-ecological issues that exist within our local communities. As educators, parents, citizens, and stewards of the Bear River watershed, this outcome is perhaps the most important contribution we can offer to our children.

As the discussion below illustrates, water quality and quantity issues are certainly of growing concern in the Bear River basin. As we have suggested, long-term watershed education programs can be one way to address these issues. A glance at the number of volunteer monitoring organizations operating throughout the nation shows that Wyoming, Idaho, and Utah have far fewer programs than most other states (Environmental Protection Agency, 1998). What’s more, a recent survey of elementary teachers in Wyoming found that many educators believed they had adequate knowledge of relatively few water topics and thus failed to give them priority in their curricula (Beiswenger, Sturge, & Jones, 1992). Students must learn not only about our natural resources and the problems facing them today, but how these are ultimately social issues that we must confront together. We argue that if educators do not even teach about water-related topics, then there is little hope of resolving many of these complex social issues. In light of this evidence,
we contend that watershed education programs such as BRWEP are sorely needed in our area.

The Bear River Watershed

The physical geography of the Bear River watershed (Figure 1) is both unique and complex. It begins high in the Pinta Mountains of Utah at an elevation of over 12,000 ft. amidst dense coniferous forests. Three major tributaries exit the Andes and converge to form the mainstream Bear River on its way toward Evanston, Wyoming. North of Evanston, the river straddles and crosses the Utah border twice. Just before the Bear River enters Rich County, Utah for the first time, it encounters the first impoundment, the Woodruff Narrows Reservoir. Returning back to Wyoming, it continues through agricultural lands, sagebrush-, and grass-dominated rangelands before eventually turning west into Idaho.

With the completion of a diversion dam, inlet and outlet canal, and pumping station in 1918, the Bear River ended its 28,000 year geologic isolation from adjacent Bear Lake (ID). This diversion greatly expanded the size of the natural Bear Lake to provide hydroelectric power generation and irrigation water for agriculture. Previously an oligotrophic waterbed, Bear Lake is now a sink for the considerable organic nutrients and sediment that enter via the inlet canal.

Continuing its northward trek, the Bear River reaches Soda Springs, Idaho, where it then makes an abrupt U-turn after the Alexander Dam. On its way back to Utah, the river is denatured at Stewart Dam and Black Canyon. In Idaho, six dams temporarily hold the Bear River to provide power and irrigation water for local communities.

As it flows through the lacustrine sediments of Cache Valley (Utah and Idaho), the Bear River entrains its most significant tributaries. The Cub, Logan, Blacksmith Fork, and Little Bear Rivers have joined the mainstream by the time it exits Cutler Marsh (UT). A brief northward
swing and subsequent U-turn carries the Bear around the Wellsville Mountains, where it makes its final push south to meet the Mala. River, and soon thereafter, the Great Salt Lake. Just before it enters the Great Salt Lake (to which it contributes 1.2 million acre feet/year), the river passes through the ecologically and politically important Bear River Migratory Bird Refuge— a vital part of the Pacific Flyway. In total, this circuitous journey drops over 9000 feet in elevation in 500-river miles, yet terminates a mere 80 miles from its source. The Bear River watershed is 7,583 square miles in size and has also earned the distinction as the largest river in the western hemisphere that does not reach an ocean.

Human development throughout the watershed has resulted in significant water quality problems. Most notably, non-point sources such as agriculture, grazing, forestry, and urban development have contributed to this decline. Data compiled by the EPA for the 1998 303(d) list (Environmental Protection Agency, 2000) of impaired water bodies indicates several water quality issues of concern. Upstream of Bear Lake, pathogens and sediment are of minor concern in a few isolated reaches, while total residual chlorine becomes a problem just downstream of Cokeville, Wyoming. From Bear Lake to Cache Valley, nutrients (primarily total phosphorous and inorganic nitrogen), flow alterations, and sediment are the parameters of greatest concern. Within Cache Valley, the Cub River, Little Bear River, Logan Lagoons, and Spring Creek add considerable sediment, phosphorous, inorganic nitrogen, ammonia, and Cominform bacteria (Ecosystems Research Institute & Bear River RC&D, 1995). As it nears the Great Salt Lake, the mainstream Bear and Mala. Rivers continue to exhibit many of the same problems with sediment, chlorine, nutrients, and Cominform.

Numerous point sources such as confined animal feeding operations and wastewater
treatment plants contribute some pollutants to the Bear River, as is allowed by their discharge permits. The rapid “ramping” (short duration flow adjustments) of certain dams is also thought to contribute significantly to the sediment problems in the river (Dobrowolski, pers. comm., 2000). Perhaps not surprisingly, the American Rivers Council listed the Bear River as one of the ten most endangered rivers in the United States in 1999 (American Rivers, 1999).

To date, the Bear River still yields a surplus volume of water that is under consideration for development by the more populous counties of the Wasatch Front. Numerous proposals for dams and other storage projects threaten to place additional burdens on this already heavily taxed river. If the Bear River is to provide drinking water for municipalities and continue to support its existing beneficial uses, then these issues must be addressed in the near future.

Nonetheless, considerable progress has been made in recent years toward improving water quality in the Bear River basin. Reductions in both point, and non-point source pollution are helping trend water quality in an upward direction. Continued effort, funding and interest on behalf of states, watershed groups, industry, and citizens will drive these watershed improvements in the years ahead.

**A River Runs Through Us: The Bear River Watershed Education Project**

The goal of BRWEP is to educate students and teachers by promoting skills in problem-solving, scientific inquiry and analysis, as well as cooperation and understanding. To attain this goal, the following objectives have been developed:

1. To support teachers as they undertake long-term monitoring activities with their students.
2. To teach students the scientific method and involve them in all stages of it.
3. To introduce students to aquatic/riparian ecology and water quality.
4. To help students think about river systems on a watershed scale.

5. To instill life-long caring for, and interest in the scientific, historical, political, and cultural aspects of river systems.

6. To help students prepare and present data to interested parties; agencies, organizations, municipalities and schools.

7. To offer opportunities for students to participate in restoration projects.

8. To develop a model process which can be used by other schools and communities to investigate and monitor river systems at the watershed scale.

In addition to this paper, a student monitoring protocol (Utah State University Extension, 2000) and Internet database (http://www.ext.usu.edu/bearrivered) have been developed to help achieve the program's objectives. Chapter 5 contains a list and discussion of recommendations for improving the efficiency and effectiveness of BRWEP.


Based on experience from BRWEP, this manual contains our learned knowledge about developing a watershed education program. The goal was to produce a guide for future coordinators of this project and others throughout the Intermountain West. In concert with two monitoring protocols (Geiger & Mesner, 2000; Utah State University Extension, 2000), this manual provides much of the necessary materials to implement a student-based watershed education program in Utah or elsewhere.

The structure of this guide is organized upon a process model (Figure 2) developed through our experience with BRWEP. The process is, however, generalizable to any other watershed education program. The model contains the following components, each of which is
discussed in detail in Chapter 3:

1. Gathering resources to begin a watershed education program.
2. Selecting a watershed and developing local partnerships.
3. Creating goals and objectives.
4. Information on project implementation, including organizing a teacher training workshop and providing classroom and field support.
5. Information on developing an interdisciplinary education curriculum based on a watershed theme.
6. Using technology to enhance learning.
7. Analyzing and interpreting data.
8. Presenting and sharing information.
10. Information on program evaluation.

Supporting information gleaned from the relevant literature and numerous appendices are included with the discussion. The specific recommendations provided in Chapter 5 are also relevant to the model because they offer suggestions for moving beyond the present BRWEP structure, in hopes of producing a more effective program.
CHAPTER 2
AN OVERVIEW OF WATERSHED EDUCATION

At the school level, watershed education is most commonly pursued by initiating student-based water quality monitoring programs. A broader view of student- and citizen-based monitoring provides an excellent perspective from which to examine the context of the Bear River Watershed Education Project (BRWEP).

Volunteer water quality monitoring is a rapidly evolving field whose origins can be traced to the start of the mainstream environmental movement of the late 1960's and early 1970's. Much has been accomplished since this time, and BRWEP is testament that it is still an evolving discipline, especially in the Intermountain West. This chapter examines: 1) the history of the broader citizen and student volunteer monitoring efforts in the United States, 2) BRWEP within a national and regional context, and 3) current ideas and future avenues in watershed education. This information is useful and interesting, not just from an historical or educational point of view, but also from an organizational perspective. It supports our belief that BRWEP is headed in new directions meaningful to teachers, students, and administrators alike.

History of Volunteer Monitoring

The earliest evidence of using volunteers to monitor the environment dates back to the 1880's when citizens began recording meteorological conditions for the National Weather Service (National Climate Data Center, 2000). Although computerized data stations are becoming increasingly common as we enter the 21st century, volunteers still play a pivotal role in weather monitoring; over 97% of nationwide stations are maintained by unpaid individuals (Lee, 1994). Volunteers have also submitted data on bird populations to the National Audubon Society and the
U.S. Fish and Wildlife Service since the early 1900's, and fisheries information from creel censuses has been used by the National Marine Fisheries Service since 1954 (Lee, 1994). These examples demonstrate that volunteer monitoring programs have existed for quite some time, however, water quality monitoring programs are a relatively newer phenomena.

Volunteer water quality monitoring efforts grew simultaneously with the environmental movement of the late 1960's and 1970's. Passage of the Clean Water Act in 1972 forced many state and federal agencies to develop new strategies to assess our nation's waters. Faced with the overwhelming burden of data collection, in many ways this legislation provided the motive for initial efforts in volunteer monitoring.

Lakes were the focus of the earliest volunteer water quality monitoring activities. Joseph Shapiro, a limnologist at the University of Minnesota's Limnology Research Center, was among the first scientists to tackle this problem in the early 1970's. He began collecting turbidity data on over 250 Minnesota lakes by distributing Psych. disks and training volunteers to use them (Lee, 1994). These data were then provided to the Minnesota Pollution Control Agency. The Maine Department of Environmental Protection received legislative funding to begin its own volunteer lake monitoring program in 1974, and this was subsequently followed by similar efforts in Illinois, Michigan, New Hampshire, New York, and Vermont (Lee, 1994).

Conceived on the first Earth Day in 1970, the Maryland Save Our Streams Program, founded by Malcolm King, was the first formal attempt to use citizens for stream cleanups and to raise public awareness about the condition of our nation's waterways (Save Our Streams, 2000). Later adopted by the Izaak Walton League of America, the program was taken on the road in a motor home equipped with stream monitoring equipment. Traveling throughout the U.S.
demonstrating stream monitoring techniques to school and community groups, the program helped to raise public awareness of water quality and was the first to use monitoring as an educational tool (Lee, 1994).

Although many of the earliest volunteer water quality monitoring programs were funded by state and federal agencies, considerable skepticism existed over their ability to collect scientifically accurate data. Matthew Scott, of the Maine Department of Environmental Protection states: “At that time [pre-1980’s] most people in the water quality business were chemists and engineers who believed testing needed to be done by professionals. It was like being a heretic to suggest volunteers could collect [accurate] data (Lee, 1994).” It was not until 1987, when the Chesapeake Bay Citizens Monitoring Program prepared an Environmental Protection Agency (EPA)-approved Quality Assurance Project Plan (APP), that volunteer data had any credibility within the agencies (Mario, 1994). In 1991, amended EPA guidelines for section 305(b) of the Clean Water Act stated that volunteer data could be accepted on par with professional data if volunteer groups completed an EPA-approved APP.

The mid-1980’s saw a tremendous expansion of efforts to involve volunteers in monitoring, in part due to shrinking agency budgets and because volunteer monitors were now regular faces at public forums on management decisions. The Adopt-A-Stream Foundation and the Colorado River Watch Network were two such examples of outreach-based groups that began at this time. The Interactive Rouge River Water Quality Project in Michigan, which later evolved into the Global Rivers Environmental Education Network (GREEN), grew out of students’ concern for a high number of hepatitis cases contracted from the Huron River (Global Rivers Environmental Education Network, 1998). This program resulted in the publication of the
seminal Field Manual for Water Quality Monitoring by Dr. William Stamp, a guide still widely used by school groups.

Several important trends have emerged in volunteer water quality monitoring over the last decade. The use of computers to share data expanded in the early 1990's and has now become almost commonplace. This method of communication has become increasingly important as many monitoring programs are dispersed over a wide geographic area and are collecting data at the watershed scale. Also, many volunteer groups now collect data to submit to water management agencies for use in decision-making, or engage in some form of political action based on their findings.

Volunteers now also seem to be monitoring several different habitat types. Previously, many groups monitored only one environment, however, in 1998 53% of nationally reporting groups claimed to measure more than one environment (e.g., streams and lakes, land and estuaries) (Environmental Protection Agency, 1998). This is significant because it highlights an intellectual shift among monitoring programs that recognize the interconnectedness of different ecosystem components by using a multi-environment sampling protocol.

Lastly, as BRWEP demonstrates, there is a growing number of educators who have recognized the potential for interdisciplinary learning that water quality studies provide. For example, the Illinois Rivers Curriculum Project has produced a series of books for teachers that utilize the watershed as a foundation for teaching concepts in biology, chemistry, earth science, geography, language arts, mathematics, invasive species, groundwater, and wetlands. This interdisciplinary model for learning seems likely to become more common among the 52% of nationwide monitoring groups who are school-related (Environmental Protection Agency, 1998).
In addition, the volunteer monitoring field as a whole experienced a 49% growth rate from 1994 to 1998 (Environmental Protection Agency, 1998).

**A National Perspective of Volunteer Water Quality Monitoring Programs**

The most recent National Directory of Volunteer Environmental Monitoring Programs (Environmental Protection Agency, 1998) contains information regarding the current state of volunteer monitoring that is useful for understanding BRWEP within a national context. It should be noted however, that while this is the best source of such information available, the data collection methods are potentially imprecise, and the listings are likely incomplete.

Data were collected through a written survey (mail-back) that was distributed to over 12,000 individuals whose names appeared on various national and state volunteer monitoring lists. The survey attempted to quantify information such as: who is conducting monitoring, the organizational structure groups, funding sources, the environments monitored, the tests performed, and how the data are being used. As is the case with any survey of this kind, interpretation errors are possible on behalf of the respondent; in this instance, the loose organization of some monitoring groups makes them difficult to categorize. Furthermore, the changeable nature of many programs (often due to budget and personnel changes, varying school regulations, etc.) can render much of the information inaccurate in a short period of time. Although the Directory has a large circulation, it is likely that some groups were not included in the tally and are thus not reflected in the volunteer monitoring statistics. Nonetheless, this information is useful in gauging where BRWEP fits into the national monitoring scene.

One point the data make clear is that monitoring groups are not evenly spread throughout the country. Concordant with the evolution of environmental monitoring, a disproportionate
number of groups still exist in the Great Lakes region, the Northeast, the mid-Atlantic, and the West coast. Fortunately, the field appears to be growing quickly (49% growth from 1994 to 1998) and BRWEP is testament that the "interstitial spaces" are now being filled in.

Of the 772 reporting groups, 76% are monitoring streams or rivers. In comparison to other stream-only programs, BRWEP students measure all of the nine most common parameters (water temperature, dissolved oxygen, pH, macro invertebrates, phosphorus, nitrogen, flow, turbidity, and habitat assessments). BRWEP appears to be somewhat unique in that only 16% of other groups are also monitoring terrestrial vegetation and 9% are recording wildlife. These patterns are not unexpected really—most volunteer water quality test kits are cheap and uncomplicated, and the shallow nature of many streams enables students to easily measure numerous chemical, physical and biological parameters.

The 1998 survey also reported that data collected by volunteers (type of data not specified) are used by state and local governments, as well as community organizations in 56%, 55%, and 54% of instances, respectively. Furthermore, 84% of programs use their data for educational purposes (the most common use) while only 14% submit their data to the state for inclusion in the 305(b) report. At present, BRWEP is primarily an educational program and does not yet submit data to a water quality agency or community organization. It seems that programs with CAPES and groups which have existed long enough to gain scientific credibility are among the most likely to have their data used by another group. It is also interesting to note that a full 48% of groups reported engaging in advocacy campaigns as a result of their findings. At this time, BRWEP neither encourages or discourages the use of data to undertake political advocacy if the situation is merited.
Historically, some watershed education programs have failed because they lack adequate funding to pay a coordinator, purchase equipment, etc. In other words, good intentions only go so far–money is needed to stay afloat. The national median annual budget is $2000; considerably less than the $18,850 budget for BRWEP in 2000-2001. This is significant because it speaks to the potential longevity of BRWEP. We believe the ability to raise funds is, in part, testament to a program’s quality and perceived value to the community. Despite this, BRWEP still faces continued financial uncertainty. Volunteer monitoring efforts tend to be inexpensive operations since they are just that–volunteer. However, they are commonly funded by “soft monies” which are seldom disbursed for more than a year or two. Although BRWEP’s present budget is derived from “soft money,” it’s source was the EPA, a trait shared by only 214 other groups (of 694, or 31%). The report found that state government funds monitoring groups most often (45% of instances), followed by donations (44%), local government (37%), and businesses (22%), with most utilizing a combination of sources.

From a programmatic perspective, BRWEP appears to share some common traits with other watershed education programs. Although not officially tallied in the 1998 Directory, it appears that many groups have similarly adopted a uniform monitoring protocol and an Internet database. A uniform monitoring protocol allows students to compare data throughout the watershed, and on-line databases have become important tools for sharing information. In addition, many other groups engage in restoration activities and have relationships with professional scientists. Many of the larger programs such as the Illinois Rivers Project and Kentucky Water Watch are also trying to engage students in interdisciplinary river studies that extend beyond traditional science lessons.
The aforementioned data shows that 52% of volunteer monitoring groups are school-related. However, it is still unclear just how many of these groups are operating throughout all segments of their watershed (i.e., at a watershed-scale). While we might speculate that few groups truly have basin-wide connectivity in watersheds as large as the Bear River (7,583 sq. mi.), no confirmatory data yet exists. Although a national perspective is useful in understanding the demographics of the national volunteer monitoring population, it is perhaps more enlightening to examine BRWEP within a regional context in order to compare the program with others that have similar social, economic, and ecological resources.

**Student-Based Water Quality Monitoring Programs in the Intermountain West**

As described earlier, many of the first volunteer water quality monitoring programs originated in the Great Lakes region, the Northeast, and the mid-Atlantic. Not surprisingly, as the 1998 EPA report shows, the greatest number and concentrations of programs still exist in these areas. Disappointingly, in 1994, of the five states where no monitoring groups existed, three of them were in the Intermountain West (NV, UT, WY) (Environmental Protection Agency, 1994). Even today, Nevada and Wyoming are only reporting one monitoring group each, while BRWEP is but one of only two statewide in Utah. Fortunately, other Rocky Mountain states seem to be reaching a broader audience. Of note are three programs in Montana, Colorado, and New Mexico which illustrate the variation in water quality monitoring programs in this region, as well as their ability to reach large and diverse audiences.

The Montana Volunteer Water Monitoring Project (MTVWM) shows how a broadly supported group can acquire a substantial body of information, while accommodating and respecting a breadth of interests related to water quality issues. MTVWM is a cooperative effort.
between the Montana Natural Resource Information System, Montana Department of Environmental Quality, Montana State University, Project WET, and Montana Watercourse. By involving so many different groups, MTVWM is able to draw upon extensive financial and human resources and thus reaches a large, diverse target audience. An excellent on-line database (see: http://nris.state.mt.us/wis/volwatmon.htm) allows participants and visitors to download and view raw data collected from water bodies around the state. Considerable GIS data are also available on their web page, as is a participant newsletter. In addition, MTVWM hosts an annual "Water Summit," a gathering of teachers and students to share data and experiences, and partake in activities related to water quality and water quality issues. MTVWM has six supporting staff members and an annual budget of $30,000.

The Rivers of Colorado Water Watch Network (ROCWWN) is a great example of how a school-based monitoring program can provide an agency with data on which to base management decisions. A rigorous student/teacher training program by the Colorado Division of Wildlife and an EPA approved monitoring protocol allows participants to study the physical, chemical, and biological parameters of the eight major watersheds in Colorado. Although it is unclear exactly which data the state uses in their biennial 305(b) report, some volunteer data is used for "river/water management" and has even been used to develop water quality standards for at least one stream (ROCWWN, 2000). Their extensive web page (see: http://riverwatch.state.co.us/) also includes a searchable database, yearly watershed reports based on volunteer data, a biannual newsletter, computer manuals, as well as quality-control and technical water quality information. ROCWWN has a full-time staff of five to work with the 260 participating schools and is supported by $180,000 from U.S. Fish and Wildlife Service Wallop-Beaux funds.
Project del Rio is a unique program for secondary school students in the U.S. and Mexico who live within the Rio Grande watershed. Now involving over 2200 students and 90 teachers, their annual budget of $220,000 allows them to support schools as they undertake studies of land uses, community water quality, and local drinking water and sewage treatment systems. Students also collect data that are shared in a bilingual, on-line database and hold an annual water conference to share results, talk about issues and solutions, attend action-taking workshops, and work with professionals from both countries. The program demonstrates how the watershed theme can be useful to teachers and how a cooperative effort can provide a cross-cultural experience for students.

Thus, it appears that BRWEP is wisely focusing its efforts on many of the same areas of program development. Building a support network from numerous partnerships, embracing an interdisciplinary approach, recruiting professional mentors, and on-line data sharing are all facets that we share with others in the region. In light of this examination, it seems that other programs have benefitted by developing a APP. This would be a logical progression for BRWEP if we wish to find additional uses for student data.

One conspicuous shortcoming, however, is BRWEP's current management situation. The program is administered primarily by a single graduate student, whereas others employ larger staffs. This will likely change soon, as efforts are already underway to hire a full-time coordinator for the Bear River basin and future programs in Utah.
CHAPTER 3

STAY IN THE THALWEG:

A GUIDE FOR WATERSHED EDUCATION COORDINATORS

The information contained in this chapter draws upon our collective knowledge and experience gained through the Bear River Watershed Education Project (BRWEP), the literature, and from investigating similar volunteer monitoring groups across the United States. This chapter will be beneficial to regional and local watershed education coordinators. We have chosen the title “stay in the thalweg (the deepest part of a stream or river channel)” because it provides an excellent metaphor for watershed education. These programs require deep involvement and continual input and attention on behalf of coordinators. A laissez-faire management approach will not yield a great program, but hands-on, personal contact with participants and involvement in day-to-day activities will produce excellent results.

Watershed education programs are most effective when they are pursued in an organized, systematic manner whereby the administration and participants have a clear set of goals and objectives, a plan of action, and evaluative tools in place. Therefore, the structure of this chapter is based on a process model (Figure 2) which organizes the management actions necessary to implement a school-based watershed education program. First, the model outlines the administrative steps that must precede program initiation. Next, it describes how to identify appropriate watersheds and participants, and offers suggestions on how to create an effective management organization. The formation of partnerships with teachers, mentors, and volunteers is the next step, after which, a workshop is held to train participants. Once the program is underway, schools then analyze data and report their findings, often turning their concern into
Figure 2. Process model for watershed education
action through service-learning activities. Lastly, the model provides information to help coordinators conduct a program evaluation. Throughout the chapter, considerable attention is given to the application of an interdisciplinary approach to watershed education. This uses the watershed as the underlying premise for teaching content in all subjects.

When used in conjunction with the following two chapters, a comprehensive watershed education program can be designed and implemented based on the process model described here. Chapter 4 presents the results of a formative evaluation of BRWEP and can be used as a template for conducting a program evaluation. In Chapter 5, an itemized list of recommendations for BRWEP will allow the next coordinator to quickly access pertinent information on immediate program needs. These suggestions have also been incorporated into the structure of the model so that they are applicable to any watershed.

Introduction To Program Management

This guide is intended to help a program coordinator work with teachers, students, steering committees, mentors and citizen volunteers to create and manage a school-based watershed monitoring program. Watershed coordinators have sometimes been called "instigators" (Andrews, 1995) and even "cheerleaders" because of their pivotal role in organizing a watershed education program. Without a knowledgeable, dedicated, and enthusiastic individual (or group), a program is apt to sputter, or worse, be abandoned altogether. Lacking a central figure to plan, train, and motivate others, a watershed education program becomes loosely organized and lacks basin-wide connectivity. With such a person at the helm, a watershed education program can provide a rich educational experience for schools and become a model for community cooperation. If you have nobly decided to become this person, congratulations and read-on!
Several other excellent resources exist that can help in developing a community or citizen-based monitoring program (Andrews, 1995; Behar & Dates, 1995; Firehock, 1994b). However, if you wish to develop a program strictly within an educational environment, then it is important to utilize strategies uniquely suited to this realm. This manual will guide you through these waters as you embark upon this long and rewarding journey.

Be forewarned: starting a school-based volunteer monitoring program is an enormous undertaking. It is important to recognize that it will involve a great deal of effort on behalf of a large number of people, require sufficient funding, and perhaps not produce obvious benefits for quite some time. Nonetheless, the potential rewards far outweigh the necessary sacrifices of time, energy, and resources. Many of these obstacles along the road to success can be avoided or at least minimized if the proper steps are taken. To this end, this guide can be used as a step-by-step manual for creating a watershed education program from scratch, or can be used as a troubleshooting handbook along the way. Note, however, that this process may be slightly different in each instance, with a myriad of possible situational factors. Nonetheless, we believe this process model (Figure 2) is thorough and will help you develop a comprehensive program that is flexible, inclusive, and educationally valuable.

It is highly recommended that you begin organizing your program by writing down several pieces of information. For instance, decide how much time, energy and resources you are willing to devote to the project. It may also be helpful to list the water quality, logistical, and programmatic information you already have, so that you can determine which information you will still need to acquire. This blueprint will help you systematically organize your program in the most efficient way possible and will eventually develop into a timeline for program development.
**What Is Volunteer Water Quality Monitoring?**

Volunteer water quality monitoring is the process of collecting data on the physical, chemical, and biological parameters of a waterbody by non-professionals to evaluate environmental conditions. Naturally, most citizen volunteers conduct monitoring in order to determine whether a waterbody is polluted. Typically, these water quality measurements are then compared against state standards to determine if a parameter is outside of normal limits. Professional water quality specialists often determine whether a waterbody is polluted in much the same way by comparing their data to beneficial use standards. The U.S. Environmental Protection Agency (EPA) requires states to identify those waterbodies that are impaired because they do not meet the beneficial use criteria assigned to them (e.g., drinking water source, primary contact recreation, aquatic life support). With proper training, equipment, quality control measures, and professional support, volunteers can collect accurate and meaningful data about their waterbodies.

**Why Monitor Rivers and Streams?**

Humans have long had intimate relations with rivers and streams. In cultures throughout the world, rivers have not only facilitated settlement in distant regions, but were a major factor in transportation and trade. Historically, rivers were strategically important for warfare, offering natural barriers for protection, and allowing the rapid transportation of troops by boat. Today, many of these same roles persist but modern societies seem to have placed even greater demands on these finite resources. Citizens insist that rivers yield ecological benefits and social amenities such as wildlife, drinking and agricultural water, hydroelectric power, waste disposal, fish production, and countless recreational activities. Rivers even provide cultural and spiritual
sustenance to many Native American tribes and other groups.

So many demands have indeed placed tremendous burdens upon our aquatic resources. With increased demands have also come precipitous declines in water quality and seemingly endless battles over quantity, water rights, and availability. Nonetheless, despite the often distressing condition of our nation's waterways, do not be misled into thinking that people do not care about rivers and streams—quite the contrary. Compassion and caring are among the most common motivations that lead citizens into watershed monitoring. Perhaps not surprisingly, recent concern for our nation's rivers has risen to historic proportions and interest in volunteer monitoring continues to grow.

Many people have become involved with volunteer river/stream monitoring because they are worried about the ecological quality and livability of their watershed. In other cases, groups may only develop concern for water quality after they have collected and analyzed data (Behar & Dates, 1995). Typically, these groups form and come together to identify common interests, develop program goals and objectives, and formulate specific questions that they wish to answer in their monitoring program (Lopez & Dates, 1998). While teachers may become involved in a watershed monitoring program for these same reasons (i.e., water quality concerns, hopes of solving social issues), there are some other potentially significant reasons why this group may decide to study flowing waters.

From an educational perspective, a river/stream provides an excellent opportunity to utilize a physical feature within the landscape that is familiar to students and use it as a foundation for lessons in all subject areas. Rivers/streams are dynamic, living laboratories that afford educators the opportunity to drive student learning by making use of personal connections.
to place. Using a watershed theme, teachers may develop an integrated curriculum for history, language arts, math, science, art, and other subjects. In turn, this creates genuine understanding, nurtures caring and concern for their watershed, and promotes active civic behavior among students.

**Why a Watershed Approach?**

A watershed approach to education is valuable for several reasons. Chiefly, education is most powerful when presented in a connected, systematic manner. Most traditional education teaches discrete subjects and makes little effort to demonstrate interconnectedness between systems. This effectively leaves students with only a vague understanding of how concepts relate to one another and portrays the world as a place unaffected by spatially or temporally removed actions. In many schools chemistry teachers rarely coordinate their lessons with biology teachers who don't communicate with history teachers, and so on. Does this not tell students that chemistry has nothing to do with biology or history? Nonetheless, if we are to adequately prepare students to meet the demands of an increasingly complex society, then we must provide an educational climate in which subjects are linked and systems are mutually dependent.

Second, using a "real world" object provides deeper understanding and relevance to one's own life. For example, it seems logical that a student would be more apt to understand the water cycle if they could test and observe how a pollutant dumped upstream eventually appears downstream. Consider your own education: how many things were you taught, only to quickly forget them after the test because they never really had any bearing on your life? In the example above, might you have perhaps remembered the water cycle if your own drinking water supply was downstream from a nuclear power plant? Thus, the watershed is a tangible entity that can
help students intellectually organize subject material and retain information because they interact with it on a daily basis.

Lastly, the watershed concept can help teachers better organize their existing curriculum to teach more effectively. It is no secret that teachers already bear tremendous burdens imposed by the large number of state curriculum mandates. In many ways, environmental education (EE) has failed to help teachers because it often asks them to add environmental concepts to their existing course load. Instead, EE can enable teachers by not telling them what to teach, but rather, offer them new ways to present the same material more efficiently and effectively. The watershed theme provides a practical, tangible unit around which to structure the existing curriculum without adding a single requirement. Furthermore, as a connective thread, a watershed is marvelous because it includes every conceivable activity and entity within it—everything is contained in the watershed. Therefore, a study of watersheds is really a study of ourselves and our relationships with the world around us.

**Getting Started**

If you are interested in creating a school-based volunteer monitoring program, recognize that it is important to proceed with this process systemically to ensure that you will have adequate human, financial, and educational support. An organized and thorough approach to a watershed education program will provide the maximum amount of benefit to the intended participants, the community, and the watershed itself.

Although this process is presented linearly, circumstances may dictate that you be creative and adaptive with your planning process, allowing for changes and unique situations. Therefore, much like the natural systems you are studying, it is important to be flexible to meet the ever-
changing needs of your participants and the watershed. However, it is to your advantage to not run out and start recruiting teachers without first selecting a watershed, creating a communication strategy and monitoring protocol, and procuring adequate funding and equipment. Having these resources in place before you recruit schools will make your proposal much more enticing to teachers and administrators.

Although you're going to need to be flexible during this process, this section on getting started should precede all other steps. By addressing these issues first, you will find that it is much easier to entice teachers to participate and improve your chances of success in the long run. As the watershed education coordinator, you should not have to burden these busy people with such details—hand them a program that is ready to go. You will also notice that we present the creation of goals and objectives at two separate points: 1) at the onset of program development, and 2) when you form a steering committee. In the case of the former, this will guide the direction of the broader program as you initiate projects in different watersheds. Once you are established within a specific watershed, work with your steering committee to create goals and objectives that they deem most important and relevant to the issues at hand. This latter stage of development should be an organic process that addresses the watershed issues of concern, as well as the unique educational circumstances present within participating schools. First begin, however, by collaborating with your existing partners (e.g., agencies, donors, colleagues) to determine the program-wide goals and objectives.

**Development of Program Goals and Objectives**

As mentioned above, this is first of two times when you'll create goals and objectives for your program—the second time will be with the steering committee. At this point you must seek
direction about how to implement the program in your region. Perhaps you have ideas about creating watershed education programs in multiple watersheds? Perhaps you hope to set up water quality monitoring programs throughout your entire state? In either case, developing some basic goals and objectives will help not only guide you through this process, but also provide you with some criteria for an evaluation.

The creation of formal goals and objectives need not be a complicated process. In fact, all you really need to do is to sit down with your partners (agencies, donors, colleagues) and ask yourselves, 1) “what do we want the program to accomplish,” and 2) “how will we get there?”

Mistakenly, goals and objectives are terms often used synonymously. Goals are statements about what you wish to achieve through implementation of the program, and objectives are measurable steps that identify when you have reached your goals. BRWEP’s goals and objectives can be found on page 11.

There are, of course, many possible desirable outcomes for a volunteer monitoring or watershed education program. Some groups may want to bring about positive changes in water quality or influence the political process, while others might wish to use the watershed as a vehicle for interdisciplinary teaching in the classroom. In all cases, it is important to clearly define the goals of your group—not just for guidance, but also because you’ll probably be asked to provide this information to donors, agencies, and the public at some point.

To create your objectives, clearly specify the steps you’ll take to achieve your goals. It is often valuable to create goals and objectives that contain different time components. Objectives can be thought of as benchmarks that allow you to measure incremental progress. For example, if your short-term goal is to influence the political process, then your objectives could include
sponsoring a letter-writing campaign to a local politician, or producing a 25% increase in citizen turnout at public watershed management meetings. Creating a citizens advisory committee is a noble long-term goal that will require a different set of objectives than above. In essence, objectives are simply formalized statements that tell you if you’re making progress toward your goals.

Goals and objectives should be formalized (i.e., written-down) because they can also provide you with some baseline criteria for evaluating a program. During the early stages of development, formative evaluations offer administrators information about how well the program is going and can suggest possible changes. Attainment of your goals and objectives is one way to gauge progress or “success” as part of an evaluation.

It’s plausible that your goals and objectives will evolve over time—different participants, new information, successes and failures can lead to changes in how a program is run. Only a strong commitment to your cause will see the program through changing times. Also, consider listing the goals and objectives on your public documents or web pages; this makes it explicitly clear to visitors what you’re doing. The creation of goals and objectives within the steering committee is somewhat of a different process and will be discussed later in this chapter.

Unfortunately, BRWEP created goals and objectives to meet the needs of the administration instead of developing these with input from participants. Initially, there was little discussion among the steering committee members about specific goals and objectives. An unclear vision about the direction of the program resulted. In the future, a statewide coordinator should develop goals and objectives that are applicable in any watershed. Afterward, an basin-specific agenda can be determined by the local administration to meet the needs of participating
Communication

Perhaps the most important component of building a successful watershed education program is developing effective methods of communication. If water quality information is to be collected throughout the watershed, then how are participants going to examine one another's data? How are program coordinators going to communicate with teachers? These and other pivotal questions should be addressed through a standardized communication protocol so that information and ideas can flow freely and quickly among participants.

E-mail

Due to its pervasiveness, speed, power, and convenience in today's society, electronic communication is usually the most efficient means of communication available. E-mail is an excellent way to plan events, communicate information, and keep all participants abreast of news throughout the watershed. Consider using software such as Microsoft Outlook or Eudora 5.0, some of which are freely available on-line, so that you can easily send electronic messages to one person, or a whole group. Within these programs, it is particularly useful to keep all of your e-mail contacts in appropriate folders to provide quick access to information. Here, you can also store address, telephone, fax, and other information, and easily distribute it to participants. Make sure to back up this and all other hard-to-replace information on a floppy disk or on-line (e.g., http://www.mydocsonline.com).

BRWEP found that e-mail, although it is easy to use, cannot completely replace other types of communication. Some teachers were very good at responding quickly to important e-mails, while others waited for days. One teacher refused to use it at all. It was particularly useful
for sending out general announcements such as equipment updates or coordinating among members of the steering committee. However, often I was unsure if e-mails were read by teachers due to the lack of immediate responses I received. To increase the likeliness that these will be read, it is best to keep e-mails short and to the point, often with a “catchy” title in the subject line and important items bolded in the text. In addition, phone calls were much more effective for arranging sampling dates and discussing specific details or teacher problems with the database.

**Developing a web site/database**

If you have committed to using an electronic communication format, you should then begin developing the project’s web site. A web site is an excellent means of sharing data amongst schools because it can be accessed by anyone, anytime, and from anywhere in the watershed. Many water quality monitoring programs such as BRWEP have effectively used a web site to house their central database, display maps, pictures, student findings and other site-specific information. Here, you can also highlight student artwork, writings and other non-science projects, and provide forums to express ideas, concerns, and comments about the program.

The use of computers to communicate also brings up several concerns as well. First, despite its apparent ubiquity, many schools in both rural and urban areas alike are not adequately equipped with computer equipment. Some schools simply don’t have software to work with data, others lack computers that are capable of handling graphics-intensive web pages, and many have frustratingly slow Internet connections. Therefore, before you begin designing a web page, it is very important to find out how well-equipped your prospective schools are. To get a feel for this within a watershed, consider visiting a number of schools and talk with teachers, administrators, or technology specialists. Here are a few basic questions that you may wish to ask:
Do all teachers have access to computer facilities?

What is the ratio of available computers to students?

Do all schools an Internet connection?

How fast or slow is the connection?

Are the computers PC's or Macintosh systems?

How much memory (RAM) is on each machine and at what processor speeds do the computers run?

What software is available on each machine?

Are there computer projection capabilities available for presentations or whole-class lessons?

How comfortable are most (or individual) teachers with using these technologies?

How familiar are students with these technologies?

Is there a technology specialist available to help?

Obviously, it would be foolish to go through the effort of developing an electronic communication protocol, as well as a web page and database, if most teachers did not have familiarity with or access to adequate computer facilities. Therefore, the more information you have about computing capabilities throughout the watershed, the more successful you will be at recruiting schools.

Furthermore, consider your own comfort-level and access to each of these technologies as you will have to purchase a dedicated computer if you do not already have one. You may also wish to purchase broadband Internet access (e.g., DSL, cable) or rent space on a server if you plan on being the primary data repository and information clearinghouse. Do not be afraid to ask for
help from university extension specialists, computer consultants, or people more knowledgeable than yourself if you are not competent with these technologies.

The telephone is another vital link between participants. As you begin to contact teachers, remember that they are often not available at consistent times throughout the day—you may find it best to call right when school gets out for the day (often 2:30-3:30). If you cannot reach them at school, it may be necessary to call them at home if they are willing to give you that information.

If you choose to communicate electronically, be aware of its limitations. You may even find teachers who do not have, or are reluctant to even use computers; in this case, arrange alternative methods of communication. Although "snail mail" seems to be falling out of favor among professionals, using it, in conjunction with a telephone and a fax machine can still be an effective means of communicating with one another. In fact, published materials (e.g., newsletters) are sometimes refreshing in this electronic age.

Based on our experience with BRWEP, we can offer some specific advice on developing an integrated web page and database. A visual assessment of nationwide volunteer monitoring program web sites reveals that similarly, many possess an on-line database. Here, students can add, view, and download data that has been collected by other schools. It is important to allow students to enter their own data into the computer as this constitutes a key step in the learning process. Alternatively, some programs have students submit their results to the database administrator for quality inspection and entry. This is important because if students do indeed enter their own data, you will need to construct a password protected database to limit access. Assign a username and password to each teacher and ask them to keep it private. Do not give this out to students, instead, have teachers enter data with their class. A separate page should permit
students and the general public to view entered data.

A database can be created in several ways. How you create yours will depend on how much data you wish to store, how you want it to be retrieved, and how elaborately you wish to link data sets, among other considerations. A database is made up of numerous tables, each containing records and fields for each parameter that students measure. The user will be interacting with the tables, but only through simplified data entry and retrieval screens.

Technically speaking, the HTML interface with the database can be done several different ways.

One way to build an integrated web page/database is to work within an ASP (Active Server Page) environment. This combines HTML, data scripts, and ActiveX server components to create a friendly, efficient, and powerful on-line interface for schools. While this is an excellent tool for developing large databases, it also requires some programming knowledge and familiarity with script languages such as Visual Basic or C++. Some easier-to-learn software such as Microsoft Access, Microsoft Visual FoxPro, Claris FileMaker Pro, Lotus Approach, and R:base Oterro may also suit your needs. Microsoft Access 2000 contains pre-built wizards that can walk a user through setting up a web database. Access 2000 requires little expertise to get started but can involve more effort in customizing how it meshes with the web page. All of these products support a Windows platform but can be limiting for some extensive databases with multiple querying layers. If you hire a web developer to construct your web page, it is best to contract someone who has database and HTML experience, thus eliminating the need to hire two people. See the section on Data Management later in this chapter for more information on maintaining your database.

Consider providing a means to view data other than in tabular form—these are not visually
stunning. Instead, a java-enabled graphical program will allow users to create and overlay many
different data layers. Although powerful graphics can greatly aid interpretation of data, make
sure that each school has the computing "firepower" to handle these potentially slow-loading and
processor-intensive programs.

When designing the data viewing page (or query page), you will first need to decide which
sorting parameters to use. Although sometimes it may be useful to download the entire data set,
more likely, users will want to view data by stream, county, date, school, or
chemical/physical/biological parameter. In some cases, the sorting fields that you choose will
determine how your database is constructed. Therefore, it is best to decide exactly how you want
the query page to operate before you build the database.

Ideally, the data entry page on the web should be seamless with the field data sheets. That
is, minimize the possibility for confusion or errors when reporting data by making the web page
look exactly like the data sheets in your protocol. Nonetheless, we have found that you will
probably need to train each teacher in use of the database, regardless of how simple it may seem.

Invariably it seems that the quality of volunteer data is called into question by those who
will question your methodology and accuracy. You can deflect some of these criticisms by
incorporating some quality assurance/quality control measures (QA/QC) into your database
design. Obviously, your ability to make conclusions about the ecological condition of your
watershed is only as good as your field data. However, even when your sampling methodology is
of high quality, the possibility of committing significant errors when entering data still exists.

One way to minimize data entry errors is to put messages next to each data entry box
stating the range of expected values. However, this is less effective than a database that will
automatically reject data outside these limits. So for example, design the database to disallow any pH values below 1 or above 14. If an error does occur, a friendly, intelligible message should result that tells the user exactly where the error was committed. If typical software default messages are generated, students may encounter such nonsensical jargon as “Q208704-ACC2000: Application-defined or user-defined error.” What are they to do with this information but give up or enter a false value until the database accepts it? Take the time to design “kid-friendly” error messages to minimize frustration and improve the accuracy of data transferred from field data sheets.

Your web page is generally a less complicated affair than the database and can be developed quite easily by either hiring a professional or using any number of available software yourself. Microsoft Front Page, Macromedia Dreamweaver, and Adobe GoLive are all popular web authoring software packages. If you are choosing different software packages to design your web page and database, make sure to ask a computer specialist if they are compatible and easy to use with one another.

Many good web pages also post their monitoring protocol on-line, often in PDF and HTML (hyper-text markup language) format. Other common features include a project’s history, goals and objectives, on-line newsletters, a calendar of upcoming events, a chat forum, water-related links, and digital maps. Compare web site styles by using the list of nationwide volunteer monitoring programs provided in the Appendix.

All of this said, we found that a web page/database was indeed an effective means of sharing information among participants. However, BRWEP experienced problems with the functionality of its database once it was field tested by schools. Many teachers also seemed
uncomfortable with computer data entry, as evidenced by the lack of input so far. If they were not immediately successful, they seemed unwilling to try again without assistance. I believe that individual teacher training and school visits will alleviate this problem.

Selecting a Monitoring Protocol

All of the participating schools in your project should use the same monitoring protocol so that you can compare data across the watershed. Scientific data on the same subject is often not comparable because the methods used to gather the data may have been different. Therefore, it is important to choose a monitoring protocol that can be used by everyone in your program.

Environmental educators have a tendency to recreate lessons, curricula and other educational materials to suit their unique tastes and situations. Before you spend a great deal of effort on designing your own monitoring program, make sure to look at the large number of protocols already available. Here are a few that you may find useful:

- **Utah Stream Team**: An excellent general stream sampling manual that is applicable well beyond Utah. Includes pre- and post-field activities, background information on physical, chemical and biological properties of streams, and an extensive list of resources. It can be applied to a single stream or at the watershed scale. (Geiger & Mesner, 2000)

- **Bear River Watershed Education Project**: Designed specifically for the Bear River watershed (UT, ID, WY), although it is applicable most anywhere. It is most useful for smaller tributary streams that are wadeable by students. It includes procedures for measuring physical, chemical, and biological properties of streams including macroinvertebrates and riparian vegetation. It was developed in
conjunction with an on-line database and takes a watershed-scale approach to monitoring. (Utah State University Extension, 2000)

- **Streamkeeper’s Field Guide**: This offers complete background and monitoring information, along with data sheets for measuring physical, chemical, biological, and human influences of streams. It includes an excellent macroinvertebrate key, information on presenting your data, and suggestions on using your data for political action. It can be applied to a single stream or at the watershed scale. (Murdoch & Cheo, 1996)

- **Save Our Streams Project**: A nationwide monitoring project that includes information on how to organize stream cleanups, conduct stream surveys, restore riverbanks, study the impact of construction sites on streams, and collect and analyze macroinvertebrates. It also includes supporting materials for interdisciplinary studies. It can be applied to a single stream or at the watershed scale. (Firehock, 1994a)

- **Field Manual for Water Quality Monitoring (GREEN)**: The seminal volunteer monitoring book that includes procedures and data sheets for nine chemical, physical, and biological water quality tests. It includes additional information on testing for toxic metals, macroinvertebrates, documenting land use practices, and taking action with data. It can be applied to a single stream or at the watershed scale. (Stapp & Mitchell, 1997)

- **Volunteer Stream Monitoring**: This EPA manual provides sampling procedures for both students and citizens. Instructions for doing visual surveys, habitat surveys,
stream flow measurements, chemical tests, and macroinvertebrate sampling are included. It has perhaps the best discussion of how to use different macroinvertebrate metrics to assess stream condition. It also includes information on managing and presenting data. It can be applied to a single stream or at the watershed scale. (Environmental Protection Agency, 1998)

As you look through the innumerable protocols available, ask yourself the following questions to help make a decision:

- What age groups are going to be using the protocol?
- What water quality issues or pollutants are of special concern within the watershed?
- What questions do I want students to be able to answer through monitoring?
- Does the protocol adequately address the needs and abilities of participants?
- Does the protocol address our scientific questions and pollutants of concern?
- Is the protocol applicable to tributaries or a river’s mainstem?
- Are there local specialists available to provide assistance with water quality monitoring procedures?
- How often will we need to monitor each parameter?
- What equipment will the protocol require us to buy?

Based on the information you have gathered, decide whether you can use or modify an existing protocol, or must you create an entirely new one? In either case, recognize that you will be training a large number of teachers and students in these methods. Choose carefully.

Consider developing several “levels” of participation for school groups. Some schools may want to participate because of the educational opportunities monitoring provides, whereas
others may want students to collect data that is used in management plans. If schools want to provide data to state agencies for use in their 305(b) report (a statewide assessment of water quality performed every two years), then you will need to develop an agency-approved quality-assurance plan (see: Consider the Limitations of Your Protocol) along with your monitoring protocol. Perhaps some schools only wish to monitor certain parameters or want to participate only in restoration activities. Therefore, create a list of monitoring activities that are appropriate for each grade level (e.g., elementary school, high school) and develop a set of guidelines to allow different interest levels. For example:

- Level I: Schools participate only in service-learning or restoration activities.
- Level II: Schools collect only chemical data.
- Level III: Schools collect chemical, physical, and biological data for educational use only.
- Level IV: Schools collect quality-assured data this is sent to a state water quality agency.

Familiarity with the guidelines for submission of volunteer data to the state 305(b) reports will help you specify which level of monitoring is right for your program.

Generally speaking, there are three classes of monitoring procedures that you will need to be familiar with:

- **Chemical monitoring:** This is the most common type of monitoring done by students and is also termed “water quality testing.” Common tests include: temperature, pH, turbidity, conductivity, alkalinity, dissolved oxygen (DO), total suspended solids, nitrates, phosphates, and biological oxygen demand (BOD). Although it is actually a biological parameter, coliform bacteria is often lumped with chemical monitoring because it is measured with similar test kits. Chemical monitoring tests are usually easy to perform in
the field by students, most testing equipment is relatively inexpensive and easily purchased, results are obtained quickly, and students generally feel empowered and "scientific" when they test for these water quality parameters. Chemical tests provide students with definitive values, making them moderately easy to compare with state water quality criteria. In contrast, some biological data (such as macroinvertebrates or riparian vegetation) does not have accepted state standards, or often yields a suite of data (i.e., no single value). Thus, physical and biological data are harder for students to interpret and assess stream condition. However, some significant limitations to these procedures exist and should be recognized as you design your monitoring program. Water chemistry can change throughout the day, sometimes making it difficult to compare data collected at different times. Some commonly used chemical test kits may not be sensitive enough to detect concentrations of a pollutant that are biologically significant (e.g., phosphate) although most are quite accurate. In addition, chemical tests usually provide a snapshot of the current conditions and may not tell you what happened in the stream say, last week or last month—these pollutants have already washed downstream. Most schools measure a dozen-or-so common pollutants, often neglecting the more difficult and expensive ones. If your tests show good water quality but the stream still seems a lifeless, toxic environment, consider that perhaps something else is going on there. Also, bear in mind that field techniques for chemical data collection are not the same as those accepted by the EPA. These drawbacks notwithstanding, chemical monitoring is a vital part of any comprehensive monitoring protocol.

- **Physical monitoring:** Many teachers find physical monitoring a very powerful
educational tool. They often measure physical parameters such as stream shape, channel shape, width, depth, and velocity (to calculate stream flow). A more comprehensive protocol will include determining the pool:riffle:run ratio and the substrate composition, both of which give students a sense of the proportion of available habitat types. These measurements are particularly valuable when teachers link concepts in biology, hydrology, math and earth science, allowing students to observe firsthand how physical processes affect everything else. Teachers can also use these data in conjunction with the chemical test results to show how concentrations and loads are calculated. Another benefit not to be overlooked, collecting physical data allows students to enter the stream and “get wet.” It is not uncommon to see students clambering over one another to get into a pair of waders! Unfortunately, physical data such as flow are often very inaccurate when compared to nearby stream gauge information; in large part, this is due to the great amount of natural variability in the current and the rudimentary measuring equipment used. Even professionals have widely disparate data for many physical parameters, making it inherently more difficult than chemical tests.

- **Biological monitoring:** Groups that conduct stream monitoring activities collect biological information. In this category, far and away the most common activity is the collection and analysis of benthic macroinvertebrates, commonly known as “stream bugs.” These marvelous creatures are very engaging for students of all ages, partly because of their diversity and novelty (many students have never thought about animals other than fish that live in streams). Macroinvertebrates afford teachers lots of educational possibilities to explore biological subjects, including life histories, evolution,
environmental adaptation and more. Macroinvertebrates are easy and fun to collect, provide students with living subjects to examine, and can be roughly indicative of water quality. There are many different ways to interpret how the macroinvertebrate composition is related to the condition of your stream (also known as metrics). For example, some protocols count the number of taxa (a group of related bugs) that are sensitive to pollution, while others assign points based on all taxa present in your sample. BRWEP has adopted the system also used by Save Our Streams. By this method, the number of pollution intolerant taxa present is totaled and multiplied by three, moderately tolerant taxa by two, and pollution tolerant taxa by one. Therefore, a stream with a higher score has a macroinvertebrate assemblage with more species indicative of good water quality, as well as greater diversity overall. Any of these or other methods may work equally well for you—simply select one that your students will have the least difficulty working with (i.e., the one that is easiest for you to understand). Although bugs are valuable indicators of water quality since they live in the stream and respond quickly to different environmental conditions, for a variety of reasons, it is often difficult to make accurate generalizations about the condition of your watershed based on these data alone (See: http://www.epa.gov/owow/monitoring/volunteer/stream/np_108.html for more details). Therefore, be cautious when saying whether your water quality is good or bad based solely on your bug data. Rather, students should use it in conjunction with their other information to draw conclusions. There are also several other valuable biological criteria that you can monitor including riparian and in-stream vegetation, as well as birds and other wildlife. As in the case of physical data, these parameters are quite tricky to
measure, even for professionals.

**Consider the limitations of your protocol**

Although it is often overlooked, it is very important that participants understand the interpretive power and potential limitations of the data they will collect. Some teachers may have intentions of quantifying "stream health" through their monitoring efforts. Although you don’t want to render them feeling incompetent to collect meaningful data, describe to schools that even water quality specialists are still struggling with the myriad of ways to assess the condition of rivers/streams.

Nearly all of the common professional methodologies attempt to quantify stream structure (the biotic and abiotic components of the system) and/or function (the biological processes that operate between structural components). Often, stream condition is assessed by measuring a variety of structural and functional parameters (metrics) that collectively give us an idea of overall ecological condition. Stream systems are incredibly variable and not all of them respond to human impacts or natural disturbances in the same way. Even within a single watershed, streams may exhibit different properties that can be mistakenly interpreted as being "unhealthy" when compared to one another. However, if you wish to help schools make some conclusions about the condition of their stream (and you should), select a protocol that uses metrics known to be more appropriate for your watershed or region. Federal, state, and university aquatic biologists can guide you in selecting the appropriate metrics and sampling techniques and may be able to provide help with interpreting data. Some monitoring groups have even used university labs to process their samples for analysis and later compare them with student field data.

With these difficulties in mind, we recommend that you choose a sampling program based
on your educational goals and not necessarily your desire to assess overall stream condition. For example, an appropriate goal may be for students to understand how water chemistry changes from the headwaters to the mouth of a river. A more unreasonable goal would be to determine exactly which landowners are adversely affecting water quality throughout the basin. Although there are indeed many success stories of volunteers detecting changes in water quality and incriminating corporate polluters (e.g., Interactive Rogue River Project), these instances should be considered anecdotal to the educational goals for your program.

Lastly, if your goal is to produce data that can be used by a state agency for Total Maximum Daily Load (TMDL) or management information, then you will need to develop an additional quality assurance and management plan. Information on how to develop Quality Assurance Project Plans (QAPP) can be found at: http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm and is also discussed in Chapter 5.

While there are other good reasons to complete a QAPP, most groups use this to gain credibility for their data.

Funding

Many great programs have failed because, inevitably, they need some funding to sustain them. This is not to say that money is the solution to your dilemmas—indeed, nothing can replace hard work and dedication. However, adequate funding can help support teachers to the extent that they need it. Thus, if you wish your program to have permanence within the schools and the communities throughout your watershed, then it will require some money. The questions then become, how much and where do we get it?

As the program coordinator, you should start by constructing a budget. Make a list of all
possible expenses, including salaries, monitoring equipment, office space, telephone and computer
bills, travel, printing and mailing costs, office supplies, computer equipment, and vehicles.

Things often cost more than you expect, so it is recommended that you make your estimates based
on actual research into costs. An annual budget for BRWEP is included with a grant proposal in
the Appendix.

Once you have developed a written outline of your foreseeable expenses, then the
challenge becomes knowing where to find it. There are two primary means of obtaining money:
via donations and through grants.

Donations are preferable to grants because they are often easier to get and come with
fewer stipulations. In reviewing your budget, you may recognize an opportunity to ask a state
agency to donate office space, a sporting goods store to donate waders, or a local business an
older computer. Whatever creative means you can utilize to get what you want in the most
expeditious and inexpensive way, use them! Many businesses, agencies, organizations, and
people are willing to donate to your group if you have a demonstrated need, a positive track record
(e.g., word-of-mouth, press coverage, teacher success stories), tangible outputs (e.g., web page,
book of student writings, etc.), and a non-profit status.

Many volunteer monitoring groups have incorporated as non-profit, educational
organizations (501(c)3) to be eligible to receive donations and to indemnify the administration
from potential liabilities. Non-profit status is also sometimes necessary to apply for grants,
although it may be possible to get an existing non-profit to sponsor your group for the purposes of
obtaining the grant. Local nature centers, educational groups, or environmental organizations may
agree to form strategic partnerships because it fits with their mission statement and objectives.
Explore these options first before incorporating as a 501(c)3. If you decide to embark on the long (it takes up to seven months to review and process an application) and expensive process of obtaining this status ($1500 - $2500) to meet your long-term financial goals, it can be well worth the toil in the end.

Once you have determined what portion of your needs cannot be met by donations, you must then begin the process of soliciting money elsewhere. Many volunteer monitoring coordinators would say that fund-raising is the most uncomfortable part of their job. However, it need not be such a painful process if you pay particular attention to a few important principles:

- **Thoroughly investigate all available grant possibilities.** There is often lots of money available from foundations, private businesses, corporations and government agencies. Water-related projects were hot political topics in the 1990’s and will continue to be so in the 2000’s, possibly making your program particularly attractive to donors right now.

  - Leave no stone unturned!

- **Research the particulars of the grant you are applying for.** Many proposals have been unsuccessful because they were not a good fit with the donor or incorrect documentation was provided. It is important to ask for appropriate sums of money (i.e., not too much or too little) and to respect all deadlines, submission guidelines, and format requirements.

- **In your proposal, clearly outline how the money will be spent and develop measurable criteria for determining “success.”** Also, an explicit proposal that includes a problem statement and thorough list of expenditures will make it easier for donors to understand your goals. While some donors do give “seed money” or smaller sums that may be used for general purposes as you’re starting a program, often they would rather see a proposal
that has specific goals in mind. In addition, many groups fail to, or are afraid to, develop objectives that quantify the impact of their program. For educational programs, it is often a good idea to define how you will measure the “success” of your program and include this in your proposal. A comprehensive proposal should include this evaluative tool, even at the risk of possible non-fulfillment or failure to reach one’s goals.

- **Provide as much matching funding as possible.** Matching and “in-kind” funds are those monies, resources or materials that can be provided by your group or an outside source. This can include donated equipment, facility space, volunteer time and other charitable gifts. Donors often like to see lots of matching funds because it shows that you have some level of community support and are seeking creative solutions to your funding challenges.

- **Apply for several grants to increase your chances of acceptance.** Competition for many grants can be intense and you may not receive any funding from even those donors that seemed like a perfect match, success is rarely guaranteed. Essentially, don’t put all of your eggs into one basket–diversify your funding sources. Also, it is a good idea to have a contingency plan for survival in case your proposal is not accepted.

- **Don’t be discouraged if your proposal is not accepted.** If your proposal was not accepted, take notes on why this happened so that you can change this in your next proposal. Sometimes donors will provide you with this information, and other times you may have to actively seek such criticisms. Make the appropriate changes and reapply during the next funding cycle.

In many situations it is a good idea to start looking for funding locally. Perhaps a business owner, county or local official even has a student in a class you are working with. Even if this is
not the case, it is much more probable that folks within the local community have already heard of, and been impressed by the work of your program, more so than a large national donor. Furthermore, these community connections will be important ties that strengthen and support every aspect of your program as you grow and become established.

It is also a good idea to talk to groups in your area that have historically been successful at raising money. Perhaps a nearby nature center, conservation organization, or school teacher has some advice on where to look for money and how best to get it. They can also help proofread your proposal before it is submitted to the donor.

Once you have exhausted your options locally you should begin to look farther abroad. Large watershed monitoring groups such as Save Our Streams, Adopt-A-Stream, or Global Rivers Environmental Education Network (GREEN), as well as university professors may also have some recommendations on where to find money (contact information for these groups is available in the Appendix). Your library may also have resources or personnel available that can help you search national databases for charitable organizations.

BRWEP was initially funded by a small EPA grant. We made considerable progress with only $5,000 and were able to develop an effective program structure. Unfortunately, however, a lack of long-term funding plans left us wondering if the program might be abandoned soon after it was created. Fortunately, University connections to the EPA helped renew this support; however, no permanent funding plan yet exists. Therefore, deeper and more consistent funding, perhaps from the Utah legislature or a state natural resource agency, would broaden the options available to administrators.
Equipment

Choosing equipment that meets both your needs and your budget is an important part of your monitoring program for several reasons. First, it may either confuse or instill confidence in teachers who’ve not had any experience in volunteer monitoring, according to its ease of use. Second, your choice in equipment can either help enrich educational experiences or simply provide another sterile lab exercise, only outdoors. Lastly, the sensitivity of monitoring equipment will dictate how accurately participants can state their conclusions about water quality and river/stream condition. For these reasons, be sure to choose your testing equipment wisely, as it will be a costly part of your program.

Your equipment needs will probably vary somewhat, depending on the protocol that you choose. Therefore, consider the cost and usability inherent in each brand and model available as you select the monitoring protocol. Depending upon which parameters students will be measuring, you’ll find yourself choosing between a number of equally confusing and daunting pieces of equipment. Unfortunately, the chemical test kit manufacturers don’t make the situation easier by offering a myriad of different products and chemical reagents, all purchasable using long, nonsensical order numbers. The best way to avoid this headache is to talk with someone who’s used the test kits before and get their recommendations. Although every group has different needs and preferences, the equipment list provided in the Appendix can guide you.

Test kits for dissolved oxygen, nitrogen, phosphorous, turbidity, bacteria, and other parameters that require sensitive or specialized equipment will need to be purchased from water quality companies such as Hach, LaMotte, and CHEMetrics. Ordering information is available in the BRWEP protocol (Utah State University Extension, 2000). In some cases, however, often it is
possible to make your own physical and biological sampling equipment with little effort, time, and money. If you’re on a very tight budget, macroinvertebrate kick nets, ocular tubes for measuring tree canopy cover, stadia rods for taking depth measurements, and other common sampling items can be made for much less than commercially available products. Geiger and Mesner (2000) provide some good instructions for making your own equipment, and they can be found in the Appendix.

As you think about purchasing equipment, here are a few questions you’ll want to ask yourself, a sales representative, or a knowledgeable friend:

- How much can you afford to spend on equipment?
- Does each individual school need its own equipment or can they share?
- Which water quality testing company makes the least expensive field kits that meet your needs?
- How much will it cost to replace the chemical reagent packets when they are used up?
- Which test kits are easiest to use by students of all grade levels?
- Are the kits sensitive enough to detect pollution levels that may be biologically significant?
- Are the chemicals toxic?
- Is technical support available to schools if they’re having trouble?

BRWEP found that equipment-related issues consumed a great deal of administrative time. Each school should have their own monitoring equipment to avoid the hassles of loaning and keeping track of common trunks. It was also extremely difficult to maintain supplies. Schools must be responsible for replenishing their own lost or used equipment. Communicate
with teachers to find out which equipment is too complicated to use, is easily broken in the field, or is producing inconsistent results. Once you are familiar and pleased with your equipment inventory, it will be easier to provide to new schools.

**Selecting a Watershed**

Next, you must determine where you will focus your efforts. A watershed is an area of land that drains into a lake or river that includes the surface and subsurface water (Williams et al., 1997). By this definition, a watershed can be as small as a local creek or as large as the entire Colorado River basin. Thus, you'll need to think realistically about how large an area you wish to monitor. Here are some questions you may want to ask yourself as you are determining the scope of your monitoring project:

- Are you going to sample tributary streams or the mainstem river?
- Do people live throughout your watershed or is much of it within a National Forest or Park?
- How many schools are there throughout the watershed?
- Are the schools located next to or nearby a stream?
- Are potential sample sites in your watershed accessible by school bus?
- What sort of access concerns will you face in this watershed (i.e., is there a considerable amount of private land)?
- Are the rivers/streams accessible throughout the year or only during the snow-free months?

Thinking about these issues beforehand will save you a great deal of time and frustration and help you determine which watershed is most appropriate.
From a water quality perspective, it is also very helpful to research some of the existing issues within your chosen watershed. Start by contacting the county extension agent, the state Department of Environmental Quality, or university water quality specialist for help in identifying the pollutants of concern. A great deal of water quality information is also available on-line from the EPA at http://www.epa.gov/surf. Even if your watershed does not have any known water quality problems (although it most likely does), using watershed monitoring as an educational tool to teach other school subjects can be extremely valuable.

If you are interested in turning student data into action, it is also possible to involve schools using a watershed education program. Historically, monitoring groups such as the Interactive Rogue River Project have caught pollution problems that might otherwise have gone unnoticed, and presented their data to state agencies.

Lastly, most any watershed you choose will provide schools the opportunity to be involved in service-learning projects. A common service-learning project is participation in restoration activities such as tree-plantings, garbage clean-ups, and fencing of riparian areas. Some schools may even encourage their students to take political action with their data. In the end, knowing the watershed issues of concern will help you plan these activities and design your educational program accordingly.

Our project was initiated by a single teacher working in the Bear River watershed. Jack Greene, a Logan, Utah high school biology teacher, procured grant money and began the program before he recruited participants, developed a monitoring protocol, or even a web page/database. He was able to generate interest and enlist volunteers afterward because of his extensive community connections. For most projects, however, it is best to develop a more thorough plan
Developing Watershed-Specific Goals and Objectives

The process of developing programmatic goals and objectives was discussed earlier. Now it is time to create watershed-specific goals and objectives with the steering committee. Although you may have strong convictions about what a watershed education program should accomplish, these may differ from those of the steering committee. Remember, your program should be representative of all participants and their collective interests. Therefore, the development of goals and objectives for your program should be an organic process that is unique to each watershed and group of participants. Since they are sometimes confused as being synonymous, clearly outline to the committee how goals and objectives are different. Again, goals are statements about what you wish to achieve through implementation of your program: “what is the purpose of our organization?” Objectives are measurable steps that identify when you have reached your goals: “how do we get there from here?”

One particularly useful resource to help your group through the planning stages is "Thinking Strategically" (Kehler et al., 1997). They emphasize why it is important to proceed systematically through this process rather than incrementally. Instead of designing a monitoring program without any inter-school cohesiveness or specific program goals in mind, approach this process strategically whereby each objective builds on one another toward a desired educational or ecological endpoint. Strategic planning should also help to elicit different ideas from the steering committee, reduce burnout and distribute workloads, all common plagues of volunteer monitoring organizations.

Start a discussion among members of the steering committee by asking why they feel a
watershed education program in the community can be valuable. This will guide the discussion toward the development of goals. The goals of many national watershed education programs often appear similar. Here are some of the more common ones to give you some ideas:

- Produce active, informed stewards of the watershed.
- Teach students by involving them in place-based education lessons.
- Increase student understanding of aquatic ecosystems.
- Provide an opportunity to connect school subjects with real-world problems.
- Help state agencies identify water quality problems.
- Address a known water quality issue of concern.
- Introduce teachers to interdisciplinary teaching methods.

In some cases, it may be advantageous to also develop a mission statement to guide program development. This can be particularly useful for programs that are implemented within several watersheds where common outcomes are desired. When you have multiple goals, a mission statement is a good way to encapsulate them all, letting others know why your group exists. Basically, a mission statement is the reason for your groups existence. This can be useful because some grant applications require you to provide a mission statement to determine if your group is a good fit with their ideology.

You may find that your goals and mission statement change over time with experience or because of personnel changes within the steering committee. For example, one GREEN group found their initial goals served them well for the first six months, however, the steering committee then later clarified its mission and reorganized its goals to reflect these changes. In their case, they did not develop objectives until the second year (Cole-Misch et al., 1996).
We suggest developing both short- and long-term goals. Short-term goals are useful because they provide a measure of accomplishment and help you focus on immediate program needs. Long-term goals should be lofty and always give you something to strive for. Periodically revisit these goals to ensure that they are still consistent with the aspirations of the group. Remember, your goals provide a basis for evaluating your success, so try to be realistic. For example, if your long-term goal is to discover negative water quality impacts, make sure that your sampling methods and equipment are sufficient to even accomplish this.

Naturally, the program's objectives will need to be tailored to the specific goals, but in general, set objectives that are agreeable, achievable, and provide maximum benefit to a specific audience (i.e., teachers, students, or the watershed). As in the case of your goals, your objectives should also have short- and long-term components that are flexible if your needs should change.

Here are some sample objectives to meet the goals provided in the example above:

1. Produce active, informed stewards of the watershed.
   a. Help interested students create an environmental task force to take action on their findings.
   b. Have students participate in one restoration project during the school year.

2. Teach students by involving them in place-based education.
   a. Administer a pre/post-test to determine the effectiveness of the program at teaching about local cultural history.
   b. Have some students present writings about the river in the school newspaper.

3. Increase student understanding of aquatic ecosystems.
   a. Teach a science unit in stream hydrology.
b. Administer a pre/post-test to determine the effectiveness of the program at teaching aquatic ecology.

4. Provide an opportunity to connect school subjects with real-world problems.
   a. Invite a water quality specialist to discuss existing information gaps for a local stream. Have students develop a monitoring schedule and program to address these needs.
   b. Have students take action with their findings.

5. Help state agencies identify water quality problems.
   a. Conduct sampling in tributaries, irrigation canals, or other areas where agencies currently do not.
   b. Be a "watchdog" for water quality problems in a particular stream over time. Report problems if they exist.

6. Address a known water quality issue of concern.
   a. Revegetate a reach of stream to reduce sediment inputs.
   b. Help a local rancher raise money to construct an animal waste confinement structure away from the river.
   c. Have students develop a list of ways to improve the health of their watershed and distribute it to residents.

7. Introduce teachers to interdisciplinary teaching styles.
   a. Hold a yearly workshop to model interdisciplinary teaching styles.
   b. Have at least one school use the watershed theme to teach all subjects that year.
   c. Develop a curriculum guide for teachers on interdisciplinary teaching.
Teachers should also develop individual goals and objectives that specify exactly why they are participating in the program and what they will accomplish. These goals and objectives should be congruent with those of the larger program, be realistic, and measurable. Teachers should put these goals in writing so that they can assess teacher/student performance and justify their participation to school administrators. For example, “Bill, a teacher at Pine City High School, wants students to develop a complex understanding of aquatic biology (his goal).” Students will demonstrate this by “writing and presenting reports on a specific macroinvertebrate species (his objective).” But, in the first year Bill decides that he does not have enough time to teach about macroinvertebrates in the classroom, so instead, students will just explore this topic in field activities. His goal would become “to give students an introduction to aquatic insects” and build upon these experiences to change his unit the following year. His objectives would then become “to have students observe macroinvertebrates in the fall and develop art projects that demonstrate an appreciation for their diversity by the spring.” These written goals are now achievable, measurable, justifiable, and took very little time to develop. Bill would have a detailed record of what he’s trying to accomplish in the classroom were his supervisors to ask him to justify his curriculum. More detailed information on program evaluation can be found at the end of this chapter. An action research outline is provided in the Appendix for teachers who wish to evaluate their participation in a watershed education program.

Select Administrative Participants

At this point, you may already be working with, or have personal connections to a group in a particular watershed. If you do, chances are that these people are helping develop communications and monitoring protocols, making local contacts, and securing funding and
equipment. If you do not, then you will be undergoing the process of getting started in a new watershed without inside connections. Your core group of administrative participants includes a local watershed education coordinator and a steering committee. Most importantly, the more broadly-based and diverse these groups, the deeper your support structure becomes. To reduce the complexity of this task, the following section will help you identify the people best suited for these positions.

First, you should determine where your program is going to be “nested” if you have not done so already. Watershed education programs commonly fail because their continuance rests with one individual and not a deeper support network. In the case of BRWEP, Jack Greene began the program alone, with full-knowledge that he could not manage it by himself. He chose administrative participants known to him who had been involved in similar programs before. In an ideal situation, however, you should identify and recruit people from a broad spectrum throughout the community, perhaps even enlisting those outside your normal range of contacts.

A program should be firmly located within an organizational entity or group so that its structure will not evaporate if the coordinator leaves. The investment of an agency or a national watershed education group such as GREEN, Save Our Streams, Adopt-A-Watershed, or River Watch Network (contact information in Appendix) can provide a structural “backbone” if you do not yet have one.

**Coordinator(s)**

Perhaps you have already decided to become the central coordinator for a watershed education program. Perhaps you are looking for someone to administer a program in another basin. In either case, there are several qualities that make a good coordinator. It is very important
to select this person carefully since he/she will greatly influence the direction of the project.

First, the most effective coordinator is a resident of the watershed in which you’re trying to start a program. Persons with intimate knowledge about the watershed are more likely to know the physical geography of the basin, understand the ecological issues of concern and the social environment, and perhaps have direct relationships with teachers and citizens in the community. A project commanded by a local person is also more apt to understand local ideals and values, and thus, be more effective from an educational perspective.

Second, an effective coordinator exhibits certain personality traits. Naturally, strong leadership skills are desirable but one must also be able to work with diverse groups of people and possess a clear vision about where the program is headed. This idea of a guiding vision is supported by Cashel (1994) who, when speaking of effective leadership behaviors for outdoor-based programs, outlines five emergent traits. She states that in addition to possessing a guiding vision, leaders should have passion, integrity, trust of the group, and be “calculated” risk takers.

Furthermore, someone with a solid understanding of educational theory and practice will be an asset to your program.

While many job vacancies state that “excellent communication skills are a must,” it is truly a requirement in this position. One must be able to speak knowledgeably, respectfully, and compassionately with teachers, school administrators, donors, landowners, volunteers and others, often within the same day. This is especially true for communicating with teachers since they are the focus of your program. If one cannot understand or recognize the limitations and special considerations of the school environment, then teachers will not get the support they need and deserve. Thus, for this job vacancy, the ability to speak “teacher-eese” is a must.
Lastly, consider hiring a practicing educator for the position. Too often outreach programs that involve schools fail, not because they aren’t good, but because information isn’t communicated properly. EE has long been a pursuit of practicing scientists who try to communicate complex information to an audience with little or no training in the subject matter. Other programs have enjoyed success when they use a science educator to translate this information to teachers. A coordinator with experience at understanding and interpreting scientific information to a lay-audience will be more successful than one who cannot. Therefore, consider finding a coordinator with teaching experience as well as a scientific background. This becomes an especially important qualification as your program moves toward interdisciplinary watershed studies.

*The Steering Committee*

Building a diverse steering committee is one of the most important elements of a successful watershed education program. The steering committee is a group of people responsible for guiding the program over time. This group can help not only during the formative stages of program development, but also when the program grows and matures, by helping adapt to new challenges and keep on track with long-term goals. The steering committee does not need to be involved in day-to-day management—that is the job of the watershed coordinator. Ultimately, a steering committee gives the program depth within the community and ensures its longevity if the coordinator leaves.

So what is the make-up of an effective steering committee? The answer to this question will vary depending upon your specific program needs, however, the golden rule is: *diversification*. Selecting members from different sectors of the community will bring strength by
providing access to multiple resources, along with a breadth of different opinions and ideas. Your committee should include both dreamers and leaders, people who are great at generating new ideas, and those who help keep a program on track toward achieving its goals. Make sure to include educators, both experienced and new, agency officials, practicing scientists, landowners, and even students themselves. With great success, some groups such as Adopt-A-Stream have even solicited participation from groups within the community who were publicly at odds with one another over watershed issues (Dyckman et al., 1993).

A diverse steering committee will also have access to various resources throughout the community that a single individual otherwise would not. Draw upon their personal strengths and insights to shape the various components of the program throughout its development. In reality, it may be difficult to assess the character strengths of each individual until after your group has formed, however, try to estimate their prowess during an interview prior to making them an offer.

A project coordinator who is a longtime resident of the watershed is likely to know many potential candidates offhand. Do your best to include not only those folks that you may already be familiar with, but also those who you don’t know. As is the case for recruiting mentors (discussed below), write a detailed job description to give to potential steering committee members. This should include information about what skills and knowledge you are looking for, the obligations of the position, length of commitment, and the amount of time involved. Once you have a number of interested people, set up interviews to further discuss each one’s qualifications. It is wise to be selective because this group will be your stable core that remains involved over a long period of time. Too many personnel changes in the steering committee can slow or derail your program’s evolution. It is also a good idea to keep this group small—perhaps 4-
8 people. Logistically, it becomes difficult to arrange meetings and work efficiently if the committee is much larger than this.

After the group understands its roles and responsibilities to the program, you may find it useful to develop various subcommittees. Subcommittees can be extremely efficient at addressing specific issues or program needs such as funding, curriculum development, monitoring quality assurance/quality control (QAQC), equipment needs and issues, web/database maintenance, mentor relationships, protocol revisions or training, and restoration projects. Essentially, these subcommittees are responsible for “micro-management” and help reduce the burden on the coordinator.

BRWEP effectively used sub-committees to deal with the myriad of needs initially facing the program. Tasks were differentiated and given to those people with interest in working on them (e.g., finding mentors, developing the web page, procuring equipment). While this technique worked well, it became clear that strict deadlines were necessary to receive products when they were needed.

**Forming Partnerships**

BRWEP was conceived by a teacher with extensive personal connections throughout the watershed. In many cases, however, you will need to form partnerships in a watershed where you may not know teachers, scientists, community groups, or others critical to the success of your program. This section will help you create and build these relationships.

**Teachers**

If teachers are to be the main focus of your watershed education program, then the obvious question becomes “how do I find them?” To get you thinking about this, there are several
questions you’ll want to ask yourself. First, which type of teachers do you want to involve in your program? Science teachers? Teachers with experience in EE? If you really want to develop an interdisciplinary program, then you’ll need to recruit teachers in both science and non-science subjects, and those with and without experience in EE. Although it may seem obvious to target science educators due to the nature of water quality monitoring, do not limit yourself to this candidate pool. You will find that many history, English, art, and math teachers can also use student monitoring activities to meet their state education requirements. Furthermore, many teachers already participate in EE and field-based programs with their students, but try to involve inexperienced teachers as well.

Some evidence, however, suggests that experienced teachers can be the most effective proponents for recruiting others within their school. Several leading watershed education groups in the Pacific Northwest have found that those teachers who already use EE are more likely to influence and enlist other teachers in their school (Dyckman et al., 1993). This “self-selected” audience is also an efficient use of your finite human and financial resources, they propose. When you approach teachers, your “sales pitch” should focus primarily around the idea of using their watershed as a unifying theme to connect subjects. It is also very important to impress upon teachers that this is a long-term commitment to the program. They should plan on participating every year, continually building upon the data and experience of the previous years. If you can demonstrate that secure, continuous funding is available, your proposal is often more attractive.

It is also important to consider which grade-levels you wish to involve. We have found that students of nearly any age can participate in monitoring activities at some level. Naturally, there are significant differences between the cognitive abilities of elementary, middle, and high
school students. For example, it may be inappropriate to engage 5th graders in complex mathematical analyses of invertebrate metrics or developing watershed management plans. These are usually better suited to high school classes. Conversely, elementary teachers may find it easier to create an interdisciplinary program because they already teach multiple subjects. Therefore, it is wise to design an adaptable program which allows students to participate in monitoring at different levels. And remember: students often rise to the occasion once they are challenged!

Now that you have some ideas about which teachers to contact, how do you actually find them? Obviously you will contact teachers that you already know and your list will probably snowball from there. Here are some additional suggestions:

- **Contact those teachers that you already know within the watershed.** As in many professions, teachers often share similar social circles. Chances are that one good teacher in a particular school knows colleagues in other schools. This is the first and most effective way to recruit teachers.

- **Talk to school administrators.** Phone schools in prospective areas and ask to speak with the principal or someone else knowledgeable of individual teachers. Describe your program in detail and find out which teachers have experience taking students outside or studying nature in the classroom. Are there any dynamic and open-minded non-science teachers that might be interested in an interdisciplinary program working with other teachers from their region? Follow up your conversation with a thank you letter or e-mail.

- **Speak with your state Project WET coordinator.** Most states have an office that maintains a database of teachers who have taken a Project WET (or P. Wild, P. Aquatic, etc.) workshop. They should be willing to provide contact information for these participants.
(See: http://www.projectwet.org/ or http://www.projectwild.org)

- **Contact EE specialists.** Many colleges and universities now have at least one faculty member who teaches EE. Or perhaps, you have a local nature center or EE facility that already works with many teachers in that area. Many western states also have EE groups that are chapter organizations of the North American Association for Environmental Education (NAAEE, http://www.naaee.org):

  Arizona: Arizona Association for Learning in and About the Environment

  Colorado: http://www.caee.org/

  Idaho: http://rmcclos.idbsu.edu/~iseee/

  Montana: http://www.montanaeeassociation.com/

  Nevada: http://nnrec.org/

  New Mexico: http://www.eea.nm.org/

  Oregon: http://www.teleport.com/~clearing/eeao/

  Utah: http://www.usee.org

  Washington: http://www.eeaw.org/

  Wyoming: http://wind.cc.whecn.edu/~waee/

- **Other education specialists.** Most colleges and universities will have an elementary and secondary education department that maintains a regional network of teachers for their students. Some departments will even have science education specialists.

  Your time spent nurturing relationships with individual teachers will pay off with great dividends. Some teachers will require little help once they are up-and-running, while others may need constant support in the classroom and in the field. Do not recruit teachers unless you can
adequately support them! Watershed education programs may begin with the best of intentions but require adequate human resources to grow them into something worthwhile. As Jack Greene said, "...this strategy [of recruiting teachers you already know] proved very successful. Now to keep them involved (Greene, pers. comm., 2001)!" To this end, all participating teachers, science and non-, should be required to come to your initial training workshop.

**Mentors**

Providing each classroom with a professional mentor should be an early priority. These relationships are very important for training and the sustenance of monitoring. They serve as an excellent resource for technical information on water quality, macroinvertebrates, riparian vegetation, land use practices, and other disciplines that teachers may not otherwise have knowledge of. Social science professionals can also be great mentors for teaching cultural and natural history, as well as natural resources law and policy. They also serve as another source of motivation and inspiration for teachers to continue their monitoring program over time. As your program grows, limited resources will probably not allow you to continue accompanying all teachers on their field days. Mentors, however, can be that additional impetus for teachers to continue monitoring activities and watershed education in the classroom.

So, who is an appropriate mentor? As in the case of the steering committee, look broadly when identifying possible mentors. That is, consider folks from a wide array of disciplines, groups, and backgrounds. In the water quality field, natural resource professionals exist at the federal, state, and local levels. A local EPA representative, US Geological Survey (USGS) water resources specialist, or interested folks from the Natural Resources Conservation Service (NRCS), USDA Forest Service, National Park Service, Bureau of Land Management, Bureau of Indian
Affairs or other land management agencies would be appropriate. At the state level, personnel from the Department of Environmental Quality, Department of Natural Resources, Division’s of Wildlife and Water Resources, and others deal with environmental issues. You may also find partners in county and city governments (Community Development, Parks & Recreation Department, Municipal Water Districts), university faculty (natural resources, agricultural, or hydrology specialists), canal or utility companies, and extension agents. Non-governmental watershed groups (e.g., Bear River Water Quality Task Force, Bear River Resource Conservation & Development), Audubon chapters, or agricultural groups like 4-H can also be very effective because they have considerable knowledge of the basin and deep-seeded roots within the community. You can locate many of these groups on-line at the EPA Adopt-A-Watershed website (http://www.epa.gov/adopt/network.html). Also, check to see if there is a nature center or EE facility nearby that could offer mentorship services.

What is the best way to initiate relationships with mentors? We have found the most efficient way to enlist help is to have an outline that describes exactly what role they will play and how much of their time will be involved. A generic letter that describes the watershed education program goals and objectives, the responsibilities of a mentor, and the time commitment required is best (see examples in Appendix). It is also worthwhile to solicit help at public meetings, asking among community groups in the area, or by doing “cold calls” in person. However, a recruitment letter is preferable because it is more clear to the candidates what you are asking of them and avoids putting people on the spot.

Once you have distributed the letter and allowed time for people to mull it over, then it is advisable to follow-up with phone calls or conduct in-person interviews. A letter of agreement is
then drafted to solidify this relationship (see example in Appendix). Mentors will have varying levels of commitment and time available, so you may find it best to let them individually arrange their relationships with the teachers they will work with.

BRWEP has only recently entered into relationships with professional mentors. We have experienced some difficulty finding scientists available to help in small communities throughout our watershed. Thus, we have had to look farther afield to find assistance. To date, it is difficult to say exactly how beneficial these relationships have been.

**Community Volunteers**

Similar to what we have advocated already, volunteers enlisted from within the community will help to deepen your program’s support and overall strength. For a watershed education program in public schools, parents of students are the most obvious candidates to approach for support. As in the case of professional mentors, it is a good idea to draft a letter that clearly states the roles and time commitments required of parents. Be aware that some parents may be suspicious of, and feel isolated by, a *scientific* program. To many parents, a watershed education program is indistinguishable from an advocacy campaign because it deals with the environment. This is especially true in rural watersheds throughout the West where some landowners are suspicious of any phrase containing the word *environmental* (especially if it is followed by *education*). Take the time to explain your goals and objectives to these folks and you will probably find them becoming some of your most important allies. Make sure to use everyday language if you’re explaining scientific concepts. Do not push people away by making them feel unknowledgeable. On the contrary, quite often they have a tremendous amount of local insight to share. BRWEP has found that some excited landowners even offer students the opportunity to
monitor on their property when it contains stream and riparian communities.

Parents, especially, have a tendency to feel “useless” on field days because they don’t have an understanding of water quality concepts. Avoid this by briefing them ahead of time. Some parents are very eager to help and will be enthusiastic leaders in the field, while others will sit back, perhaps feeling unknowledgeable or unsure about what to do. You should provide them with content information, familiarize them with the equipment, and provide a time schedule to help alleviate these common problems.

Perhaps you will want to consider recruiting other community volunteers such as political figures, business people, civic and church leaders. Once you know these people well enough to assess their strengths, you can fit them with tasks suited to their abilities. Perhaps these folks would rather help organize a trash clean-up day or write an article for a newspaper. Again, enlist people from different social spheres, explain the goals of the program, get them excited about participating, and match them to the most appropriate task. Also, don’t forget to thank them often, either verbally, in letters, or by holding special thank-you functions. This really helps to maintain support and prove that you value their input.

**Administrative and Teaching Assistants**

If your program involves dozens of schools, then it is not only impossible, but fallacious of you, as coordinator, to play all the roles in a successful watershed education project. It is important to recognize when you are overextended or cannot manage every last detail; this is what the steering committee is for. Besides, your program is built on diverse ideas and opinions—yours should not be the only one that counts in the end. Surround yourself with competent people to fill the program gaps or personal shortcomings. After all, a great leader is one who can recognize
when he/she needs to delegate authority and assign tasks better handled by others.

Once you've recognized the areas in which you'll need help, it is time to go and find it. Administering a large watershed education program can involve many duties ranging from accounting to teaching. Perhaps your budget is substantial enough to necessitate hiring a bookkeeper. Better yet, try to find an accountant who is willing to donate a few hours of their time each month. Maybe you could really use some insight and help with fundraising? Anyone who has written a grant knows that it can consume an enormous amount of time. Don't be reluctant to search for experienced “money-getters” who are willing to share their advice and time on researching and writing proposals. Also, remember that teachers are best supported on field days by folks with monitoring and teaching experience—so make sure to ask for help from university students, experienced high school students and natural resource professionals (mentors).

**Group development processes**

There is a considerable body of literature available describing how to lead and work in group situations. Having knowledge, skills, and experience in building a working team is valuable because it creates a sense of unity and promotes a cooperative atmosphere. A highly organized group also has an effective means of flushing out new ideas and solving disputes. It is beyond the scope of this manual to discuss this topic although this information can be extremely helpful to the coordinator and participants alike. Recommended reading includes: general group dynamics and team building (Brown, 2000; Parker, 1996; Phillips & Elledge, 1989), handbooks for team leaders and facilitators (Dyer, 1987; Parker, 1994), team members (Pritchett, 1992), and conflict resolution and creative problem solving (Leonard-Barton, 1999; Lorsch, 1972). The
Community Leader’s Guide” (Institute for Extended Learning) is also a good resource on organizational development specifically written for volunteer groups.

Program Implementation

Congratulations! You are now well on your way toward developing a comprehensive watershed education program. To this point, you have been building the infrastructure that will support your program. Now comes the real test—how well can you pull it all together?

In a long-term, school-based program, you will be working with teachers (and not students directly) because they will remain with the project from year-to-year. Some teachers may have experience with water quality monitoring while others may be completely new to taking students out of the classroom. Regardless of their prior knowledge and skill levels, there are two primary ways to prepare teachers for participation: a preliminary training workshop and follow-up classroom/field support.

The Preliminary Training Workshop

It is imperative that all teachers, science and non-science, regardless of their background or experience, be trained in how to use your chosen monitoring protocol. Data is not comparable unless schools use the same methodology. Therefore, an initial training workshop will help bring everyone together and teach them to sample streams the same way. The quality of their data will also be reflective of the quality of instruction they have been given.

Of course, the specific agenda for your workshop will vary in each case, but at a minimum, you should train everyone in water quality monitoring techniques. If you have time (i.e., several days), it’s a good opportunity to expand your training schedule to include activities on interdisciplinary curriculum development, local natural history, service-learning projects, etc.
You may also consider providing training on student management, effective teaching styles, and lesson planning. If you already have several teachers from the same school committed to working together on a watershed education program, make sure that they can all attend, even if you only plan to cover monitoring techniques. They still need to understand what the others are doing.

One full day is the minimum amount of time necessary to train teachers in monitoring. Evidence by Mayer and Fortner (1987) suggests that one-and-a-half-day workshops are best, as these yielded greater long-term program adoption than lengthier ones. Whatever workshop duration you choose or subjects you intend to cover, BRWEP has found several things that can make this time more productive:

- **Hold the workshop in a convenient location.** Select a location where **all** teachers can easily attend. If your watershed is geographically large, then choose a place that is most convenient for everybody. Remember, you are trying to encourage communication and cooperation between schools so it is imperative that you start off on the right foot by bringing together everyone at once and working somewhere that is representative of their sampling locations.

- **Hold the workshop when environmental conditions are representative of what teachers will encounter.** Schedule the workshop at a time when environmental conditions are representative of those that teachers will encounter. No amount of talking about working with students in the field can prepare you for the real thing unless you present teachers with those same conditions. If possible, work on a stream that is neither too high nor at baseflow. If they will sample in the spring and fall, they will probably encounter stream levels somewhere in between. Most teachers will not find the monitoring protocol
difficult to learn but many will be challenged by the considerations of managing 25+ students in the field. Consider working with a test group of students to confront teachers with these same obstacles and give them a flavor for what they’re likely to face when doing it “for real.”

- **Have a lesson plan.** The workshop should be highly structured so as to demonstrate your teaching and organizational abilities. This helps instill confidence and makes the best use of everyone’s valuable time. Your lesson plan should also be flexible enough to accommodate unique group needs and desires.

- **Model your teaching as you wish it to be done.** The most effective workshops are those where the facilitator teaches in exactly the same way as you would with students. For example, if you believe that a constructivist approach to watershed education is the cornerstone of a great program, then conduct the workshop in a constructivist manner [see Brooks & Brooks (1993), Klein & Merritt (1994), and Lord (1999) for more information on constructivist teaching practices]. In your own experience, have you ever attended a Project WET or similar workshop, come home, and taught the exact same activities you learned while you were there? Typically, educators teach how they have been taught. Knowing this, take the opportunity to train them in the manner in which you’d like them to teach. Of course, teaching styles vary and people tend to choose the one that they are most comfortable with. However, modeling your teaching provides them with a platform from which they can derive their own ideas and make personal modifications.

- **Offer chances for group discussion.** Strictly adhering to a tight schedule of activities often does not allow for ample discussion time. Having time to ask questions and share
insights will enhance learning and understanding. Allow experienced teachers to share their insights and advice on field teaching, student management, etc., with novice teachers.

- **Personalize the workshop.** Frequently asking teachers about local conditions or current issues within their region of the watershed helps bring the workshop closer to home. If teachers can experience something that has a parallel in their home reach (e.g., a degraded stream bank, a municipal outflow pipe, a channelized reach), they are more apt to understand the information you are presenting. Offer chances for them to share this comparative information, thus reducing the complexity of a topic.

- **Bring in mentors and community volunteers.** Extend participation to all people that you will be involving, including professional mentors, parents, and other volunteers. This will reduce the number of different times you have to teach the monitoring procedures and increase their value to students when in the field.

- **Don't overwhelm teachers with new information.** Water quality monitoring jargon and concepts may seem daunting, especially to non-science teachers. Speak simply and present information sequentially. Remember the old axiom: less is more. If you cannot cover all the sampling procedures at the workshop without overwhelming them, then don’t have teachers performing those monitoring tests right away. It is better that teachers feel comfortable with fewer tests than to do a poor job trying to cover them all in a single field day.

- **Provide lots of supporting materials.** Undoubtedly, you won’t cover all there is to know about monitoring in a single workshop so provide participants with materials that they can always rely on for accurate, understandable information. For example, the Utah Stream
Team manual (Geiger & Mesner, 2000) is an excellent supporting resource for information on water quality. If you’re going to hand them out, take the time to demonstrate how to use these materials for retrieving information.

- Schedule your next training session. It is important to quickly follow-up the workshop with additional training to reduce “loss.” People are prone to forget specific details about monitoring if they do not practice; so try to arrange your next school visits for one-on-one tutoring as soon as possible. This also helps maintain teacher enthusiasm for the project.

BRWEP’s initial training workshop was able to generate teacher enthusiasm, however, it did not adequately prepare several novice teachers for monitoring. A great deal of time was spent re-training these folks at their local stream. It was also difficult to wean them off of administrative support once they had come to rely on the extra help. A workshop based on the tenants stated above should help alleviate this problem in the future.

The discussion by Ham and coworkers (1987) may also be helpful reading as you are planning your workshop. Their study indicates that workshops can clearly reduce some of the barriers to implementing an EE program in the classroom, although some logistical constraints such as lack of time, preparation time, and class sizes must still be addressed at the individual school level.

**Developing An Interdisciplinary Program**

As it is used here, interdisciplinary learning: 1) draws content from a number of different subjects (e.g., earth science, biology, chemistry, social studies, mathematics, creative arts, etc.), 2) promotes cooperation and collaboration between teachers, and 3) engages students in hands-on, student-centered learning. This concept is also closely related to thematic instruction or the
Environment as an Integrating Context idea (Lieberman & Hoody, 1998).

The watershed is, by its very nature, an interdisciplinary concept. It includes the streams, forests, animals, insects, soils, people, and all physical and biological entities within a particular area. Nothing within that basin can be excluded from the watershed and all these forces are constantly at work shaping it. Therefore, a study of a watershed is an investigation of any subject contained therein. Make use of this ingenious attribute by using the watershed as a central theme around which to base your scholastic investigations. Said another way, this concept is most powerful as an educational tool when several different teachers work together to develop a year-long study of their watershed. We believe that you should prioritize adoption of the watershed theme in school curricula and encourage a high level of cooperation and inquiry-based learning techniques among participating teachers. Although this may require extra effort on behalf of the coordinator and teachers, the rewards can far exceed the difficulties.

Evidence to support an interdisciplinary approach

Research suggests that an interdisciplinary approach to education can work, although a serious paucity of rigorous scientific data exists. Strangely, calls for interdisciplinary education seem to emanate from nearly every corner of the broader education field, however, few studies have actually addressed the effectiveness of using an environmental concept as the basis for teaching across subjects. An interdisciplinary approach to education is also sometimes referred to as an infusion model of EE (Rakow, 1985). While we have found no empirical evidence to support using the watershed theme per se, a search of the broader EE literature lends credence to the idea that students perform better academically if an interdisciplinary approach is used.

A recent report from California found that student achievement on standardized tests was
higher in 72% of instances than comparable students who did not receive interdisciplinary instruction (Lieberman et al., 2000). These schools all used the Environment as an Integrating Context (EIC) whereby the surrounding environment and community comprised the foundation for learning. Students used EIC for interdisciplinary studies and received problem-, issue-based instructional methods. Students in the control group were given more traditional instruction that was classroom- and textbook-based, and information was disseminated directly from teachers to students. They found that the EIC approach produced higher overall scores on standardized tests in language arts, social studies, math, and science.

I maintain that a proper interdisciplinary educational program should also employ constructivist learning techniques. In essence, a constructivist pedagogy: 1) poses problems of emerging relevance to learners; 2) is structured around “big ideas” or primary concepts; 3) seeks and values students’ points of view; 4) adapts curriculum to address students’ suppositions; and 5) assesses student learning in the context of teaching (Brooks & Brooks, 1993). Thus, in a study relevant to my endorsement of constructivism, Lord (1999) examined how two different teaching styles can affect student performance. When test scores for two populations of students, one receiving traditional lecture and teacher-centered instruction (control) and the other engaged in student-centered or constructivist methods (experimental), were compared, students in the experimental group scored significantly higher. Performance was markedly better on questions where students were asked to interpret results and predict outcomes in situations not directly discussed in class or reading materials. Course evaluations also revealed that students in the constructivist population enjoyed the class considerably more than those in the control group. Although more empirical research is certainly needed, these papers support our belief that an
interdisciplinary approach using hands-on, student-centered teaching methods can enhance understanding and enjoyment of subject matter.

**Barriers to implementing an interdisciplinary program**

Adoption of a watershed-based interdisciplinary program will certainly not come without some significant challenges. Zoller (1986) states that “translating...such a constructed model...[to fit into] the particular set of local constraints” is ultimately the biggest challenge facing EE. In other words, each school is likely to have a unique set of challenges that must be overcome before teachers can undertake a cooperative, interdisciplinary watershed education program. While we concur with this belief, we also believe that EE, and in particular, watershed education, lends itself to flexibility and adaptability in various situations. Therefore, the model that is presented here must be fitted to the unique circumstances of each watershed. However, if the project coordinator, teachers, and school administrators are willing to fashion the program to fit their educational needs, then they are likely to effect the best results.

There is a large body of literature on barriers to implementing EE programs into the school system which is beyond the scope of this paper to thoroughly discuss. Nevertheless, we concur with Samuel (1993) that fundamentally, “implementation of a project requires an awareness of how to manage change.” As suggested by Samuel, it may be possible to overcome these barriers by organizing a development team [including all interested teachers within the school], utilize extensive planning [goals and objectives, timelines, development of curricula, delegation of duties, etc.], developing a teacher training program [perhaps taught by the watershed coordinator], and identifying and acquiring assistance or expertise [from sources outside the school and the program].
Practical approaches to interdisciplinary education

After the initial difficulties of collaboration, curriculum development, and planning have been surmounted, next comes the task of implementing the program. Generally speaking, an interdisciplinary watershed education program can be: 1) carried out amongst individual teachers during their specified class times, 2) done as a coordinated, collaborative and continuous unit during the school-year, or 3) conducted in an after-school or extracurricular setting. Proper planning and communication are the keys to success, regardless of which implementation route teachers take. Once teachers have organized themselves, it is vital to set specific educational goals and objectives. Remember, the watershed is merely a vehicle to get at these outcomes.

BRWEP has found that time constraints and schedule coordination are the biggest logistical obstacles to developing an interdisciplinary curriculum (Greene, pers. comm., 2001; Masslich, pers. comm., 2000). Data in Chapter 4 also suggests that this is so. Admittedly, BRWEP has not yet developed a rich interdisciplinary education program. Nonetheless, we have made headway in this area by spending time in each school discussing ways to overcome these barriers and have helped teachers generate some new ideas.

Some published research also suggests that logistical barriers are the most significant to implementing EE programs in general [Sewing (1986), as cited in Ham et al. (1987)]. This can be especially troublesome at the middle and high school levels where students take classes from several different teachers throughout the day. In elementary school, the logistical barriers are fewer because a single teacher teaches all subjects, however, they can often feel that their knowledge is inadequate in certain subjects (particularly science). In this case, they will indeed have to do some background reading or perhaps work closely with the watershed coordinator to
supplement their content knowledge. Regardless, this project should be an equally exciting learning experience for teachers as it is for students; get them excited about learning new things themselves. As BRWEP has found, teachers can be just as eager as students to learn new information and try new things.

**Logistical concerns**

Teachers have overcome scheduling problems in several ways. When class periods are long enough, it may be possible to take students on separate field trips with each teacher. Most times however, classes are too short and teachers cannot cut into another’s schedule. This problem is especially prevalent in public middle and high schools. Therefore, here are several ideas to present to teachers for dealing with logistical problems in an interdisciplinary program:

- *Teach a separate unit on watersheds.* Plan together with all teachers to conduct monitoring and teach an interdisciplinary curriculum at a specific time during the year (e.g., an end of the year project). This way, everyone’s schedules are coordinated with each other and there is ample time for group planning.

- *Individual class field trips.* A one-day field trip can provide water samples to be tested in biology, chemistry, or earth science classes at a later time. Another field trip for social studies, language arts, or history can address these subjects.

- *Teach about watersheds when you find time.* Although it is not as powerful because you lose momentum and excitement, try teaching watershed concepts whenever you can free-up a day. Continue doing this throughout the school-year.

- *Offer as an extracurricular activity.* After-school clubs can be good because they generally allow more time and there are fewer students to coordinate. However, arranging
for buses or alternate transportation can be more difficult.

Curricular concerns

Another common barrier to developing an interdisciplinary program within a school is the perceived limitations imposed by state education standards. As suggested by Trautmann (1993), teachers can either rush through their mandated curriculum and teach about watersheds at the end of the year, or they can mold their watershed program to meet state education standards.

Borrowing from Trautmann's ideas, we offer the following insight:

- *Rushing through the mandated curriculum.* Although not an ideal strategy, teachers have sped through the state required topics to have remaining time in the school year to address watershed education. This requires long-term planning and rigid adherence to a schedule if they are to have adequate time.

- *Integration into the existing education standards.* Most state standards are general enough that with a bit of creativity or adaptation, the study of a water-related topic can meet the criteria. For example, here are the 8th grade Utah Science Education Standards (as of April, 2001) and some suggestions on how to adapt them to a watershed-based program:

  a. *Standard:* Students observe and describe chemical and physical change.
     
     *Suggestion:* In the field, each student will list all of the chemical and physical processes that they can observe. Hypothesize about possible effects of natural and human induced changes to water quality. Design and conduct classroom experiments to test these hypotheses.

  b. *Standard:* Investigate changes in biological energy.
**Suggestion:** Each student will create a concept map to describe the possible linkages between abiotic and biotic components of the watershed. Create food webs to describe energy circulation and bio-physical interactions.

**c. Standard:** Relate forces and energy to motion.

**Suggestion:** Discuss the properties involved in fluvial motion such as velocity, gravity, circulation, shear stress, friction, subcritical and supercritical flow. Discuss how heat and objects in the stream can change the flow and habitat structure of the stream. Design a project to have students analyze the physics of hydroelectric dams.

**d. Standard:** Construct various machines and compare the work done by them.

**Suggestion:** Analyze relatively simple machines that operate in water such as stream gauges, centrifugal pumps, and wells. Have students build a model hydroelectric dam based on their investigations of its physics. Have them design theoretical energy sources.

**e. Standard:** Investigate changes in the Earth’s crust and climate.

**Suggestion:** Develop a geology unit that uses a stream as a “gateway concept” to understand other geomorphological processes. Students can study heat transference processes, erosion, physical and chemical weathering, sediment transportation and deposition, etc. Have students investigate past climatic events to predict what their watershed was like during these periods. Have them make predictions about the impact of future climate change on their watershed using the current available data. Use local geologic maps, books and other resources to
recreate the events that have formed the rock types in your watershed.

Additional ideas for developing an interdisciplinary program

Global Rivers Environmental Education Network (GREEN) has developed a detailed planning guide to help teachers through this process (Cole-Misch et al., 1996). Their publication includes planning tools for teachers, curriculum models, lesson plans, and some ways to take action within your watershed. Another excellent resource for teachers is the Illinois Rivers Project Curriculum Guide series (Illinois Rivers Project (various authors), 1997). This ten-book series has been specifically developed for using watersheds to teach biology, chemistry, earth science, geography, language arts, and other subjects.

Classroom and Field Support

Unfortunately, your work is far from over after the initial training workshop. You should provide additional support both in the classroom and in the field to help teachers gain confidence and skill, and assist them with developing a watershed-based interdisciplinary curriculum.

For the first several monitoring seasons, it is preferable to accompany individual teachers on their field days, to the extent that your resources allow. This instills confidence in teachers who may be more apprehensive about field-based projects or that have no EE experience. Even seasoned teachers can benefit from the extra help. Frequent visits also allow you to make sure that they are following the correct monitoring procedures.

Focus your planning efforts such that your students get the most out of the field day, and not the other way around. In other words, don’t sacrifice student understanding of a particular water quality concept just to get through “all the tests in two hours.” Given that most things typically take longer than you expect them to, consider the time limitations and ask yourself “what
is the most important thing for students to understand?" Once you have decided this, you can tailor your field day to meet these objectives.

Depending on which grade level you are working with, the objectives will probably vary. For example, a 5th grade teacher may wish to arrange his/her field day so that by the end students will be able to recognize different aquatic habitats. On the other hand, a 10th grade teacher may want students to have a deeper understanding of the scientific method. In other words, planning should be tailored to the educational priorities of the teacher and specific to the capabilities of their students.

Based on our experience with BRWEP, here are some suggestions for experiencing a more successful field day:

- **Plan extensively with teachers prior to the field day.** Talk on the phone beforehand to arrange logistics and share ideas. It is important to offer suggestions to teachers, however, do not run their field day for them. This will increase their independence and confidence going forward.

- **Monitor during appropriate times of year.** In the Intermountain West, early- to mid-fall is commonly dry with warm days and cool nights. At low elevations, stream temperatures are generally still warm and flows are low enough to safely wade most tributaries. Spring can be less benign with a narrower window of opportunity. It is best to sample before the majority of snow begins melting (often March and April) yet when temperatures are comfortable enough to be outside for half-a-day or more. In late May or June, water levels can be low again but teachers are often rushed to finish their end of the year obligations—plan accordingly.
• Arrange alternate sampling days to accommodate unpredictable weather. Most teachers will not want to venture outside with students if the weather is poor, so have a backup-day. Although the adage “There is no inappropriate weather, only inappropriate clothing” is certainly true, students will collect better data and enjoy the experience more if the weather is pleasant. Having alternate sampling days is especially important in spring. If their site is not within walking distance of the school, planning alternate days can be difficult for teachers who do not have easy access to buses.

• Choose a site that you can use year round. If your intent is to compare data from season-to-season, and year-to-year, then choose a stream that runs year round (perennial). In the fall you can add a larger stream to your sampling menu that might not be accessible in the spring, but choose a smaller stream for monitoring in both seasons.

• Scout your site. Look for the best location to sample each parameter. For example, the best place to measure channel flow may not be the best place to collect bugs. Find appropriate access points so that your students can safely get to-and-from the stream. Most importantly however, identify and mitigate safety hazards. Identifying areas of trash, barbed-wire fences, steep banks, roads (all roads are dangerous), snag trees or broken limbs, deep pools, swift currents, or other potential hazards before the students arrive will help teachers plan for the unexpected. Once familiar with the particulars of the site, you will find that student management is much easier.

• Be familiar with your equipment. Check that your equipment is working and your supplies of chemicals are adequate before getting to the field. Knowing exactly how to use all of the equipment will make for more efficient use of time.
• **Recruit parents and other volunteers to help.** It is ideal to have at least one parent or adult to help each monitoring group in the field (1 adult : every 4-6 students). They can answer questions, keep students on task, watch for unsafe behavior and help maintain enthusiasm. Parents are also much more helpful if they are familiar with the procedures—teachers should send home this information prior to the field day. Before going out, hold a meeting with all the volunteers to let them know your expectations, answer questions, and to thank them for helping.

• **Practice monitoring with students beforehand.** Do a dry run. Like your volunteers above, students will collect better data if they know exactly how to sample and have practiced the techniques. Too often teachers tell their students how to do each test, only to get into the field and have them say “I still don’t know how to do it.” It is possible to practice just about any procedure in the classroom or schoolyard with a little imagination.

• **Teach basic watershed concepts before going out.** Students should at least know what a watershed is, know about the physical geography of the stream they are sampling, why they are monitoring, and what will become of their data. Don’t try to teach these concepts after you have sampled. You have lost much of the power of the experience if you don’t do it first.

• **Outline the field day to students in the classroom.** Students will understand exactly what they have to do and the time limitations involved if they are given a schedule overview.

• **Break students into groups beforehand.** Create groups of students that will work effectively together. Group sizes should be appropriate to the parameter they are measuring (i.e., don’t have 10 students measuring nitrogen or one collecting bugs).
• Less is more. If you are short on time or students, do fewer monitoring activities with greater depth. Students rarely learn much if they are cramming in a number of procedures just to “get through all the tests.” Allow them time to really grasp a concept by measuring fewer parameters.

• Give each student group a “backup activity.” Tell students exactly what they can work on if they finish early so that there is no down-time. Journaling, artwork, creative writing, site mapping and photography are all great uses of extra time.

• Little details can make a big difference. A few suggestions: have teachers send home a required clothing list, get permission slips if the school requires them, give each data recorder a clipboard, copy the procedure and data sheets on “Write-in-the-Rain” paper, and bring extra data sheets.

• Debrief the field day with the teacher. Immediately reviewing the day and writing down suggestions for the future can greatly enhance the experience next time. Try to list things that went well, in addition to those that need improving.

• Monitoring should answer a specific question. Instead of just sampling haphazardly, teachers should guide students toward developing one or more questions that they can hope to answer through their monitoring activities. Once the questions have been identified, students will discover that sampling is not only fun, but has scientific purpose as well. This will also help structure future classroom work as they seek answers to their questions by interpreting data.

• Schedule visits for data interpretation and review. Revisit the data in the classroom soon afterward so that students are still familiar with it. Interpreting data can be very difficult
for teachers so be sure to support them during this stage as well.

It is also really beneficial for teachers if you spend some time in their classroom prior to field days. As mentioned above, students should know at least what a watershed is, the physical extent of their basin, and how to sample. Time spent learning monitoring procedures beforehand will maximize student understanding and pay off with huge time savings in the field. You can also use this time to teach water chemistry, biology, or hydrology, with the field day(s) being the culmination of a watershed unit. Better yet, if you can find several teachers to adopt the watershed as their central theme for the year, you can spend lots of time helping in the classroom as well as the field. More discussion on interdisciplinary education and suggestions for data interpretation can be found later in this chapter.

Lastly, as you begin to work in schools, bear in mind some information about student knowledge and misconceptions contained in the literature. Brody (1996) describes how environmental content knowledge and student misconceptions about the environment are established at a young age. He found that most environmental science concept knowledge is formed at the elementary level. Middle and high school students only added advanced terminology to the knowledge-base they formed when they were younger. Unfortunately, he also found that misconceptions about the natural world are formed at the elementary level and persist through high school. For educators, this illustrates the need to assess student knowledge of watersheds early in the program so that misconceptions are clearly identified and quickly corrected. In addition to terminology, advanced concepts should be presented at the middle and high school levels so as to continually challenge learners.
Ideas for Working with Students of Different Ages

Your water quality monitoring program should be broad enough to accommodate students of any grade level. However, you should not run a field day with 5th graders exactly as you would with high school seniors. Some components of the monitoring protocol will be more difficult than others so you will need to make appropriate adjustments to the field day. Here are some suggestions for working with different grade levels:

Elementary School:

- Because macroinvertebrates are extremely "charismatic," they are usually the best way to get younger students excited about water quality.
- Monitoring riparian vegetation can be difficult and unexciting unless you present it effectively or have students that are already interested in plants.
- Have an adult help students with tests that require some math skills (e.g., measuring flow).
- Specify exactly what type of behavior is inappropriate at the stream, especially if there are swift currents, and be sure to enforce these rules.
- Elementary school students usually have shorter attention spans than older students—plan accordingly.
- If you have enough time, develop a rotation schedule so that students get to try measuring more than one parameter.
- Have lots of waders. Compared to older students, nearly all elementary school children will want to "get wet" at some point during the day, so let them.
- Teachers should collect all data sheets before leaving the field, otherwise they tend to get lost.
• Arrange to have older students as mentors on their field day.
• Teachers need to really stress the importance of scientific accuracy at this grade level.

Middle School:
• Middle schoolers can be excellent mentors for elementary-aged students.
• Since it is sometimes cool to act bored, find creative ways of getting students involved.
• Put at least one high-achieving student in each monitoring group; this helps to evenly distribute hard-working students (inevitably, certain students end up doing more than others).
• Separate individual monitoring groups from the main group to reduce “chattiness.”
• It is especially critical to keep middle schoolers busy at all times.
• If you are teaching about a particular water quality concept, make sure you know what you’re talking about. Students of this age easily spot a fake.
• Be extra safety conscious. Students have a tendency to horse-around a lot.
• Make sure to ask the teachers what specific techniques they use to manage their classes (e.g., some teachers count or stop talking to get their attention).
• Having professionals present is especially useful; new faces are great engagers.
• Recruit parent volunteers and train them. Parents tend to be less involved at school as children get older, however, students respond well to this extra help. Many parents feel like they’re there just to babysit. Avoid this by training them in use of the protocol.

High School:
• High school students can be excellent mentors for working with elementary or middle schools.
• Ask them lots of questions; too often they are told answers instead of searching for knowledge themselves.

• Focus on interconnections between concepts; illustrate the big picture instead of presenting isolated ideas.

• Students really like to be intellectually challenged at this age; consider doing several channel cross-sections or other math-involved activities to make them think harder.

• Bring macroinvertebrates back to the classroom and prepare the specimens for examination under a microscope. Often high schools have these facilities whereas primary schools do not.

• Emphasize quality control or they may default to laziness.

• Allow students to form their own monitoring groups depending on their personal interests.

• Recruit parent volunteers even though many high school teachers are reluctant to ask for help.

• If students drive their own vehicles to the field site, make sure they know where they’re going.

• Offer extracurricular activities for students interested in learning more.

• Emphasize the scientific method with your monitoring investigation.

Tools to Enhance Your Classroom and Field Experiences

Early 21st century technology offers us some other tools that can be of use to the watershed educator. Chief among these are digital cameras, personal digital assistants (PDA’s), global positioning systems (GPS) units, and Geographic Information Systems (GIS) software.

Digital photographs can be a useful medium for showing pictures of a field site, students
at work, macroinvertebrates, and other applications. Digital cameras eliminate the need to scan 35mm photographs and do not deteriorate in quality over time. Students seem to enjoy taking pictures at their field site and this can be a good way to record the site conditions from year-to-year. Purchase a camera with >2.1 million pixel resolution and with at least 16mb of memory if you plan on printing to paper. That said, digital cameras can be notoriously fickle and data easily lost. Therefore, make sure that you are familiar with your camera’s functions before you hit the field and consider bringing along a 35mm as a backup.

PDA's such as a 3Com Palm Pilot or Compaq’s iPAQ handheld PC can also be useful tools to the technophile. A PDA can be a great way to take field notes when you are with students, record ideas and improvements for next time, or use as a personal planner. If ever you had the money to purchase several of these (cost = approx. $200-400 ea.) students could perhaps use them as field data loggers. In addition to recording data, a handheld PC (cost = approx. $450-800) could also be used to record sound bytes, download picture and video files, or browse the web for water-related information. The biggest advantage to both of these devices is that information is rapidly retrieved, organized, and then easily transferred to a desktop computer. The high cost, unreliability, durability, and distractive nature of these machines are negative points to consider before purchasing one.

A GPS unit is a helpful, field-worthy tool that many schools have used successfully in their watershed investigations. The recent relaxation of federal satellite scrambling practices has allowed these units to recently become more accurate and inexpensive. They are particularly useful for mapping the locations of sampling sites for others to find; sometimes stakes become overgrown or are removed. A quality GPS unit is now accurate enough to mark exactly where
individual objects are within a site (with a +/- error of ~4 ft., depending on which model you buy). For example, you can locate large rocks in the stream channel to determine if they've moved during high flows, mark threatened or sensitive plant species, track anthropogenic changes in land uses, or simply mark the beginning of the reach.

Some schools may find that Geographic Information Systems (GIS) software is a natural link with geography lessons and good way to overlay multiple data layers for analysis. Although the software tends to be expensive, computer-intensive, and challenging to learn, it may really benefit student understanding and enjoyment. Simpler GIS programs such as ARC View can be taught to high school students and teachers, perhaps during the data interpretation phase to work with large volumes of data and complex analyses. A paper and video tutorial are also available to help high school students learn ARC View (Bixby, 1993). The Montana Volunteer Water Monitoring Project uses digitally-created maps to aid students in layering their data and help them conceptualize their watershed within a statewide context. You will need to find a patient teacher who is willing to devote considerable time to learning and teaching this software to students, yet when used properly, it can be a very powerful and engaging learning device. Perhaps seek assistance from local consultants or university specialists who may donate their time and energy toward helping a group of teachers or a particular class learn the software. Although originally intended for a college audience, Guertin (1993) also offers some useful information on teaching and using GIS that you may be able to apply in high school classrooms.

Data Management

Although your database will probably need little attention once it has been created and tested, some periodic maintenance will nonetheless be required. After a school electronically
submits data it will be impossible for them to fix any mistakes they may have made. Once notified of a problem, the administrator must go into the database and make the necessary changes. Your data entry form should have a convenient link to e-mail the database administrator in these situations. You may also find that periodic visual checks for data integrity, breaches in security, and updates that reflect changes in the program’s sampling protocol will be necessary.

How many times have you visited a web site and been excited that you’ve finally found what you’re looking for, only to discover that it hasn’t been updated in two years? Much like space satellites, many web sites are created, launched, and subsequently abandoned. To avoid this problem, budget money every year to make web site updates or learn to do them yourself. An update can range from simple text additions, to posting extensive slide shows and student reports. If your web page is to indeed be the locus of information and news for the program, make sure that participants can always visit and receive the latest information.

Although very few web portals have yet addressed this issue, data archival is likely to be a bigger concern in the near future. Among information technology specialists, there is growing awareness about the burden of storing the staggering amount of information currently available on-line. Water quality information is both valuable and cumbersome, necessitating a secure, accessible, long-term storage solution.

Nearly every volunteer monitoring group forms with the idea of continuing their monitoring program forever. The reality, however, is that many groups may someday dissolve or simply cease to exist. In this case, what becomes of their data? How could their data be accessible to someone looking for this information 50 years from now? What format is the best for long-term preservation? These and other related archival questions need to be addressed by
each volunteer monitoring group, large or small.

Many large volunteer monitoring groups recognize this problem and have begun efforts to ensure the longevity and accessibility of their data. Although there is a need to store both the paper and digital information, we will assume that all of your materials will be converted to an electronic format. Based on information gathered from personal communication with many volunteer monitoring groups, here are some different tactics you might pursue:

- **Universities:** If you are currently working with a university or have ties to one, seek electronic storage of your data on an available server. These institutions have great permanence and thus will be available to the public for many years to come. University extension, natural resources, and education departments may possibly have such repositories. Special collections or libraries may also have space available for your data.

- **STORET:** This massive EPA data warehouse (http://www.epa.gov/STORET/) is now capable of accepting certain volunteer data if it has been agency approved. Originally reserved for land use surveys, and historical information, quality-assured volunteer data (you must complete a QAPP) for many parameters may be considered on par with professional data. Data can be uploaded directly from your program’s server to the EPA site in ASP or spreadsheet formats, among others. This site has the advantage of being accessible via the Internet and is maintained by a government agency. There is software currently being developed to make this interface more user-friendly as it is still quite difficult to understand (information courtesy of Alice Mayio, EPA).

- **State database:** Although your watershed may cross state boundaries, it might be possible to store this information on a state agency database. This is an especially good option if
you already work with a state water quality or natural resources agency.

- **Federal sites:** Information and training about archiving data is available through both the Library of Congress (http://www.loc.gov/) and the National Archives and Records Administration (http://www.nara.gov).

- **Information format:** Irrespective of where you choose to archive your data, it should be in a simple format that is easily read by many programs (i.e., Excel file, tab-delimited text files) both now and in the future. These files should also be of reasonable size and be searchable by logical criteria such as sub-watershed, parameter, etc. Consider storing your data in multiple locations in case a fire or another disaster were to occur (suggestions courtesy of Chris Parson, Friends of the Chicago River).

**Helping Schools Analyze Their Data**

BRWEP has found that even after all the initial obstacles to program development, teacher training, and data collection have been surmounted, a major hurdle still lies ahead—interpretation. Data interpretation is a multifaceted issue that requires considerable technical knowledge and above all, patience. For students and teachers alike, discovering meaning in their data is one of the most educationally valuable parts of their program.

For schools, the process of data interpretation is akin to asking "what does our data tell us about the condition of our stream?" Students may believe this to be the fundamental reason for monitoring, so as coordinator you should ask yourself "what can I do to facilitate student and teacher understanding of their data?" We believe that several program components can help simplify this often difficult process. Therefore, this section presents our ideas for data interpretation and discusses how to use technology (and your web page in particular) to make this
process easier.

**Numbers to Knowledge**

Environmental education is a process of not only engagement and discovery, but scientific questioning, creativity, synthesis, critical thinking, and communication of information. Inquiry in your monitoring program should reflect the concept of a “scientific circle of logic,” thus providing students with a holistic learning experience (Figure 3). While field monitoring often seems like the more exciting or glamorous part of a watershed education program, students must still analyze their data if they are to understand the scientific process and see the “big picture.”

![Figure 3. The scientific circle of logic.](image)

Unfortunately, we have found that many teachers often don’t budget time for this critical step or lack the confidence to analyze field data with students. A coordinator should prioritize helping schools with data interpretation and allocate considerable program resources to the effort. In their excellent manual devoted exclusively to interpretation of volunteer water quality
monitoring data, Dates and Schloss (Dates & Schloss, 1998) outline and briefly describe the five principal steps in this process:

1. **Data entry and validation:** This step involves getting your raw data into a computer so that you can store and retrieve it for analysis. It includes:
   
a. **Entry:** Data should be entered into a computer data management application.
   
b. **Validation:** The entered data must be checked against the field and lab sheets to assure that they have been entered correctly and that the values are reasonable.

2. **Summarizing your data to help with interpretation:** The data are put into a form that allows you to view the set as a whole (e.g., summary tables, graphs) and run simple statistical analyses.

3. **Data interpretation:** This requires asking a series of questions about your data that relate to your study design question(s). Your answers to these questions are organized as findings and conclusions. Based on these, you may develop recommendations for action or further study.

4. **Summarizing your data to tell a story:** Once you know what your data tell you, present them in ways that illustrate your findings, conclusions, and recommendations. This story can be told in text and selected tables and graphs that are organized into an oral presentation and/or a written report. Your presentation or report should be geared to the audience you are trying to reach.

5. **Written reports:** Produce a report that summarizes your monitoring activity, reports your findings and conclusions and makes recommendations for actions to address problems or for modifications to the sampling program, if needed. This report can be the basis for
other types of presentations.

You may choose to modify these steps to fit the needs of each school, however, this process will help students thoroughly and systematically analyze data. Have students return to their original research questions that they developed prior to sampling, answer them, communicate findings, and pass along this knowledge to other school groups. This process will help bring closure to the unit and possibly identify restoration projects or other ways to take action within the watershed.

In addition, mentors can really be a big help to the teacher struggling to work with their data. Many private consultants and agency personnel conduct research of their own and are familiar with statistics, spreadsheets, analytical software and report writing. Ask them to come into the classroom to help students make sense of their data. However, care should be taken not to answer the questions for students. Instead, mentors should help create situations that guide students toward finding relationships, looking for contrasts and asking new questions.

One very important idea that you should take effort to impress upon students is that of data validity. While you hope the quality of data collection and analysis is high, it may nonetheless have some shortcomings. Before they make any statements about the implications of their data, make sure to ask students how accurate they believe their data is. This helps them understand that science has its limitations and methodologies and interpretations should be closely scrutinized. After all, science is still a human endeavor, capable of a great many things, including mistakes. Al Lewandowski, a Michigan Social Studies teacher, said it well: "...my philosophy is that if you really want to understand the nature of your data you have to collect it yourself—you have to get your hands dirty. If my students were presented with a set of water quality data, they
would be inclined to think, “It's on a piece of paper, man—it must be true.” When students collect data themselves, they are all too aware of the errors it might contain (Lewandowski, 1993).

The Utah Stream Team manual (Geiger & Mesner, 2000) also provides some great suggestions on using spreadsheets to tabulate, graph and interpret data. The Appendix contains some examples of how BRWEP has graphed student data.

As data in Chapter 4 suggests, BRWEP has done a poor job thus far at helping schools analyze data. This is not surprising given that most administrative effort has focused on teacher training and monitoring protocol and web page/database development. Many of our teachers do not have the scientific background, experience, or confidence to analyze data with their students. Many teachers have joined BRWEP to participate in field-based activities and have not yet realized that they must revisit their data in the classroom. Program administrators need to focus more on helping school do this in the near future.

**Presenting and Sharing Student Data**

Stories abound of student groups that made startling discoveries of pollution problems within their watershed and took corrective action. If this is the case in your watershed, naturally, you will report the problem to a water quality agency and perhaps to the public. Nonetheless, even if your groups do not “discover” any water quality issues previously unreported, it is vital to provide a forum for sharing watershed information beyond your web site. Unfortunately, many watershed education groups often neglect this component of their program, despite its tremendous educational potential. Remember, communicating your findings is also an important piece of the scientific circle of logic. There are several ways to do this:

- **Student congress:** A yearly gathering of participating students, teachers and administrators
is an exciting way to communicate information. Students may give presentations on their results and conclusions, discuss water quality changes and issues throughout the basin, and share stories, history projects, and writing samples. Invite the public and the press to raise awareness of water quality issues and promote your program. Offer opportunities for students to participate in restoration projects, make formal recommendations to agencies, and modify their sampling regime for the following year.

- **Written reports:** Students should prepare a scientific report at the end of their watershed unit. This paper can be produced either individually or in groups, and should include an introduction, methods, results, conclusions, and recommendations for future studies. Students might also give an oral report of their findings to their classmates or school. These reports should be made available on your web page and published in school or local newspapers.

- **Public presentations:** Students may give oral presentations to local and state officials, watershed councils, or other civic groups. This is an excellent opportunity for students to synthesize what they’ve learned and practice public speaking skills.

  Practicing good science means stating conclusions only to the extent that it is supported by your data. Another important thing to impress upon students is that conclusions are only as good as the methods of data collection behind them. Before students make any statements about water quality, they should question the validity of their methodology and identify possible sources of error. This will help to refine future sampling techniques as well.

  Make sure students base their conclusions on observations and fact, not guesses and suppositions. Have them account for all possible sources of pollution in their waterbody,
including both natural and anthropogenic sources. Be careful not to “cry foul” or point the finger at a potential polluter without adequate supporting data and some information on the background levels of the pollutant. Rushing to judgement is a surefire way to anger some in the community.

Environmental issues are typically presented with overtones of “gloom and doom.” Although you may find poor water quality in a stream, it is nonetheless a good idea to present this data in a positive light. Data indicating a water quality problem should be followed by statements or ideas about possible preventative or corrective measures. This can empower students and stimulate positive citizen behavior and action, rather than perpetuating cynicism and blame.

Beyond Data

A closer look at watershed education programs across the country reveals that many eventually move beyond simply collecting and analyzing data. Often, groups that find water quality problems want to do something about it—this is only natural. This section is intended to help you facilitate this process within schools and promote environmentally and socially responsible behavior.

Service-Learning Activities

For many schools, service-learning is already a component of their curriculum. Those teachers that participate in school-community enrichment projects often find that it’s a great tool for empowering students and provides the perfect capstone experience for your watershed education program.

After learning about watershed concepts and issues, collecting, analyzing and reporting data, it can be very rewarding for students to do something positive within their watershed. According to the National and Community Service Trust Act (U.S. Senate Committee on Labor
and Human Resources, 1993), service-learning:

1. is a method whereby students learn and develop through active participation in thoughtfully organized service that is conducted in, and meets the needs of communities,

2. helps foster civic responsibility,

3. is coordinated with an elementary school, secondary school, institution of higher education, or community service program and the community,

4. is integrated into and enhances the academic curriculum of the students, or the education components of the community service program in which the participants are enrolled, and

5. provides structured time for students or participants to reflect on the service experience.

Among watershed education programs, restoration projects are the most common form of service-learning. As it pertains to students, a restoration project seeks to prevent, mitigate, or fix a problem on a particular reach of stream. A coordinator can provide these experiences by contacting people who may already be conducting restoration projects or those individuals that could benefit from them. Here are some of the more common service-learning projects that you may wish to engage schools in:

- **Stream cleanups:** The most basic of service learning projects, this requires minimal planning and equipment. Students may pick up trash and remove rubble or other potentially harmful human-discarded items from the stream and the riparian zone. This project has the obvious advantage of visual improvements and may leave students with a greater sense of empowerment to care for the site. The Streamkeeper’s Field Guide (Murdock & Cheo, 1996) and the Teacher’s Guide for Creating a Water Monitoring Program have some great suggestions on organizing and conducting stream clean-ups.
• **Storm drain stenciling:** In many urban areas, students have successfully stenciled “Don’t Dump. Drains to Stream” messages beside storm drains. Many urban storm drains do indeed feed directly to creeks, streams and rivers, potentially having a significant effect on water quality. It is common for residents to incorrectly assume that storm drains receive municipal treatment along with household waste water. As part of a student-led education campaign, it may be possible to prevent some pollutants from reaching the receiving stream. Once permission from the city has been obtained, few materials aside from stencils, durable paints, drop cloths, and traffic cones are needed. The Center for Watershed Protection offers some good information on planning these projects (Center for Watershed Protection).

• **Tree planting:** Another common service-learning project that is easy for schools to perform, given that the basic materials are provided. Trees such as willows and cottonwoods are planted on degraded streambanks to help stabilize the soil and prevent further erosion. Restoration specialists may also design willow-wattles or other bank stabilization structures to be used in conjunction with tree planting. Trees can be expensive so they are often donated by individuals, companies or agencies. In some cases, willow branches can be cut from nearby stands and re-planted. Students can watch and even monitor the progress of the site over time, leaving them with a sense of stewardship and accomplishment.

• **Riparian fencing:** In some cases it may be possible to work with local landowners to fence livestock out of riparian areas. Naturally, this requires cooperation on behalf of the landowner, but also a precise plan and adequate materials. If you wish to work with
individual landowners, it is very important to approach them diligently, listen to their concerns, and use a non-confrontational approach to problem-solving. Again, it may be possible to get fencing materials donated, or perhaps funding is available through state agencies or cost-sharing programs with the landowner. This can really help improve water quality if enough soil still exists and vegetation is planted or allowed to recover. This is among the more complicated restoration projects that students can become involved in.

- **Habitat improvements:** Engaging students in in-stream habitat improvement projects is potentially the most difficult type of restoration work. Restoration specialists often develop plans to reconstruct stream channels and add fish habitat improvement structures. In some cases, students may be able to provide labor and, in return, gain valuable experience by working on these fascinating projects. Schools can follow-up the project with long-term monitoring to document trends in water quality in the watershed. You may also want to explore off-stream habitat improvement projects such as building bird-boxes or revegetation with native grasses, shrubs, and trees.

**Action-Taking**

While service-learning projects aim to put students' bodies to work, action-oriented projects engage their political ideology. No doubt this is a thorny issue for many volunteer monitoring groups who purport to be educationally-oriented and politically neutral. However, if a school's data points to a specific water quality problem and source, then what can they do to fix it? Many students, especially those of high school age, will find themselves motivated to take action against the violator. The question then becomes, "how do we involve students in a constructive, fair, and meaningful political process for improving conditions in the watershed?"
First of all, the most obvious solution to a problem is to confront the violator in a pleasant, non-confrontational manner. Many times you will find that the landowner or agency is simply unaware of the problem and is not maliciously damaging the stream. In this case, students can use their data to expose the problem and work with the other party toward an amicable solution. If this does not work, then students may wish to try a different tact.

1. **Prepare data.** Make sure that they not only have adequate data to support your claims, but also evidence to prove that the methods and equipment were reliable (e.g., Is your equipment sensitive enough to detect certain pollutants? Are your methods credible such that no one can refute these claims?) Arrange the data so that it is concise and understandable to the target audience. Students should unanimously agree on how they want to present their claims.

2. **Prepare a plan of action.** Rather than simply pointing the finger at a polluter, encourage students to devise creative solutions to the problem. This can be difficult but it also gives students an idea of the real-world difficulties facing natural resource managers today. Perhaps students can offer restoration materials or labor to the landowner to facilitate the corrective process.

3. **Choose an audience.** Students should not errantly say things like “so-and-so is dumping all his cow manure into the stream and is causing massive pollution.” Statements like this can be interpreted the wrong way and lead to confrontation. It is much more productive and professional if they present this information to a local or state water quality agency who can address this issue.

4. **Attend public meetings.** If students feel strongly about a particular development plan, then
they should attend public meetings to voice their opinions. Participating in the civic process nurtures good citizen behavior and shows students that they can indeed affect political decisions.

5. *Use the media.* If students do not get satisfactory results by working directly with landowners or agencies, then it may be time to raise the attention of the media. Local newspapers, radio and tv stations can be powerful allies and might be willing to broadcast their findings. A well-orchestrated student media campaign can even raise the interest of politicians and spotlight the problem. This should be used as a last resort since it tends to bend the will of the polluter instead of encouraging voluntary compliance. Nevertheless, many school groups have successfully promoted watershed protection and, in some cases, brought about legislative improvements (Murdoch & Cheo, 1996).

A word of caution, however, about political action: your program will be judged by the action of your participants. Therefore, as watershed coordinator, if schools decide to participate in the political process based on their monitoring data, recognize that this can have far-reaching implications for your program in general. For example, if a school group dogmatically presents information to the public stating that “all ranchers pollute streams,” then prepare for your group to be typecast as an “environmental” program and not an educational one. This can have implications for your relationships within the communities of the watershed, and even your ability to raise funds. Be sensitive about the environmental issues people face today because seldom are things black-and-white with easy solutions. Students that participate in local problem-solving are more apt to understand the complexity of natural resource issues and work toward constructive solutions. For your part, try presenting watershed issues to school groups in a non-partisan
manner if you truly wish to educate and not advocate.

It might also be helpful to read Hungerford and Volk's (1990) discussion on the process of turning environmental knowledge and concern into action among students. They note that propagating responsible citizenship is not merely a function of environmental knowledge and awareness, but a more complex suite of interactions involving action skills, action strategies, and personality factors. If you assist schools that want their students to become more actively involved with watershed related issues, then this paper summarizing previous research on these complex linkages will be helpful.

**Working with the Media**

You now know that raising interest, participants and money for your program come only with hard work. You have obviously worked a great deal to get to this point so don't neglect telling people how great the program you have built really is. You might find that this is a good way to gain *more* community interest, volunteers and money. To that end, use the media as another tool for achieving your goals and to showcase the efforts of participants.

Let's face it, kids love publicity. Frankly, who wouldn't love seeing themselves on the 6 o'clock news? So take the opportunity to show-off student efforts by inviting the media to join them on a field monitoring day. Perhaps invite television crews, local newspaper, weekly magazine, and community bulletin reporters to watch an enthusiastic, well-coordinated and experienced group of students monitoring their stream. For students, this influence not only promotes meticulous data collection, but also makes them feel that they are doing something important. In addition, it "raises the bar" for other participating schools to do an equally good job at monitoring their stream. Of importance to the program, media attention alerts the broader
community about your project and helps demonstrate educational impartiality (i.e., that you are not teaching what to think about environmental issues, but rather, that you are engaging students in “real world” science and using the watershed concept to teach other subjects). Furthermore, it can help attract volunteers, inform parents about what their children are doing in school, and may even entice potential donors. School administrators will also be pleased to see that educational goals are being met and that the hard work of teachers is recognized. Partner organizations and individuals should be recognized for their contributions in the story as well.

When contacting the media it is generally most professional to submit a press release prior to telephoning directly. It is perfectly acceptable to issue a press release for nearly any action that your school groups may take, be it field monitoring, restoration projects, or a watershed congress. Although some traditional styles of press releases exist, the format that you use is not as important as that you include the following basic information (reporters will change your format anyway):

1. **Who is submitting the information and for what organization?** Include your name, your program name, and contact information for both.

2. **What are you advertising?** Provide the reporter with an event title and a brief description.

3. **Why is the event noteworthy?** Provide information about why the event is taking place or what it hopes to accomplish.

4. **When is it taking place?** Include the time and date, including information about weather contingencies if the event is outside.

5. **Where is it taking place?** Also, include information about directions to the site and alternative sites in case of bad weather.

More information about writing a press release can be found in the Volunteer Trainer’s Handbook.
Although most classroom teachers are familiar with evaluating their students by testing, quizzing, and assigning papers, many environmental educators are not as familiar with the process. This is unfortunate because a well-designed evaluation can benefit nearly every aspect of your watershed education program. Therefore, in this section we hope to encourage you to design an evaluation and an evaluation schedule for continuous appraisal. To do this, we offer the "Four W's" (what, who, when, and why) of an evaluation and use them to get you thinking about how to perform one. Chapter 4 provides results from a formative evaluation of BRWEP which may also help you in developing an effective program evaluation.

Many people wrongfully assume that an evaluation is an attempt to put you and your management under the dissecting microscope. Not true! While an evaluation can yield some beneficial information about how to perhaps do your job better, you shouldn’t fret about losing your job or being criticized. Instead, consider it an opportunity to let you know how the program is going. This information will be critical for making changes and management decisions that may ultimately protect your job by correcting problems along the way, before they become significant. In other words, if your ultimate goal is to educate students, help teachers teach more effectively, or even improve the condition of your watershed, how will you be able to prove that you’ve done it unless you perform an evaluation?

Some Background Information on Evaluation

Evaluation may seem like an intuitive concept to most, however, few practitioners and scholars agree on a universal definition, let alone prescriptions about how to perform one.
Nevertheless, for our purposes we consider evaluation to be: “the identification, clarification, and application of defensible criteria to determine an evaluation object’s value (worth or merit), quality, utility, effectiveness, or significance in relation to those criteria (Worthen et al., 1997).” Said more simply, an evaluation is a process that tells you how the program is going.

There are also some academic distinctions between the terms evaluation and assessment, although it will likely have little effect on your design. However, you should be aware that some folks may challenge your use of the term evaluation if you haven’t applied the information you’ve collected. In most cases you will probably want to make changes to the program based on your data, and not simply gather information for knowledge—that is an assessment. Also, note that this definition of evaluation loosely incorporates the numerous different types available, from the quantitative to the qualitative.

Although fundamental debates still rage about what evaluation is and how it should be done, certain “truths” within the program evaluation field do indeed exist. One such recognized concept is that most evaluations can be termed either formative or summative. Worthen and others (1997) state that a “formative evaluation is conducted to provide program staff evaluative information useful in improving the program,” while a summative evaluation “is conducted and made public to provide program decision makers and potential consumers with judgements about that program’s worth or merit in relation to important criteria.”

Whether you do a formative or summative evaluation also has much to do with timing. If the program is young and your goals are not attainable within say, 10 years, then you’ll want to conduct formative evaluations to see how you’re doing in the meantime. As in the case of the formative evaluation presented in Chapter 4, its primary function is to help you identify necessary
changes and grow the program. On the other hand, if after 10 years your funding agency wants you to demonstrate that student participation in local political affairs has increased over previous levels, then you’ll need to deploy a summative evaluation. Using this tool, you’ll then be able to make judgements about a program’s effectiveness or worth, perhaps based on the attainment of your goals or other criteria. While it may seem trivial or even a matter of academic semantics, knowledge of these concepts will really help you justify and design your evaluation.

Each different type of evaluation will yield different pieces of information. So choose an evaluation technique that is appropriate for your information needs, time considerations, logistical constraints, etc. Due to the great number of evaluation techniques, it is not possible to describe them all in this manual. Instead, this discussion offers the “Four W’s” of evaluation—what, who, when, and why. Answering these questions will prepare you to determine which evaluation type is best for you. Then you must research how by exploring amongst the many books and scholarly papers on evaluation techniques in the psychology and education fields. A few notable books that may help you decide which technique to use include Worthen and co-workers (1997), Berg (2001), and Babbie (1989). From the environmental education field, Thomas’ (1990) paper provides some good information about how to use a case study approach for evaluation. Also supported by Rakow (1985), case studies can be a particularly useful way to evaluate your program, especially during the first few years. In addition, the Sourcebook for Watershed Education (Cole-Misch et al., 1996), Guide to Program Planning and Evaluation (Andrews, 1995), and Program Organizing Guide (Behar & Dates, 1995) can provide you with some ideas and tools specific to volunteer monitoring organizations. If after reading a bit from these sources you still need more information, use their bibliographies to lead you toward other publications.
During your selection process you'll also want to develop some research questions. As in any scientific investigation, you'll need to write down those questions which you'd most like answers to. Asking these questions early-on should also influence your survey design. Once you've conducted the evaluation, you'll be able to return to these questions to measure exactly how well your program is going.

**The Four W's of Evaluation**

As the discussion above elucidates, the survey literature is awash with theories, paradigms and techniques for evaluation. So as not to confuse or dissuade you from undertaking an evaluation, here we present a pragmatic approach that should open the door for further exploration of the subject. After asking yourself some basic questions you should be ready to address implementation or how to evaluate a program. To this end, concentrate on the "Four W's:” what, who, when, and why.

1. **What?** It is important to decide exactly what information you want from your evaluation. For example, do you want to find out how well your program improves teacher's knowledge and skills, or how well it teaches watershed science concepts to students? Perhaps you want to determine if your program has had a measurable effect on water quality or raised public awareness about pollution problems? As in the case of the formative evaluation presented in Chapter 4, maybe you simply want feedback from program participants that can help you improve the program as it evolves. In any case, once you have decided what you'll measure, then it should be more obvious which group of people you'll need to address to answer your questions.

2. **Who?** After you've decided what to evaluate, determine who is the most appropriate
audience to provide answers to your questions. In the instances above, you'll focus on teachers if you want to see how much your program has helped them, students to find out what the program has taught them, or a more complex interaction in the last example. So if your program goals are to produce a measurable improvement in water quality, then you'll need to devise an experiment that not only measures the extent and location of the improvement, but also tease-out how your program is responsible for producing them.

You should also consider who is going to perform the evaluation. Sometimes it may be possible to administer it yourself and other times an outside evaluator may help reduce response bias. A nearby university or experienced organization may be able to provide information and resources to assist you.

3. When? When is the most appropriate or efficient time to conduct your evaluation? For example, in the case of a formative evaluation, you’ll want to do this rather early in the program’s development, while a summative evaluation is more appropriate after the program has been established for a number of years. Logistically, you should time your evaluation to fit best with teachers’ schedules or your own. In some cases, donors may require you to submit an evaluation plan along with your grant application. Deciding exactly when to do an evaluation will also help you allocate limited resources to maximize benefits.

4. Why? This is perhaps the most important question of all to answer. Be prepared to justify your evaluation, not only to yourself, but perhaps to the steering committee or a funding source. Again, write down this information in your evaluation plan so that it reminds you of what you’re trying to get out of this process. If you have not done so already, outline
your research questions at this point. These should be reflective of what you’re hoping to learn and why you’re doing it in the first place.

**Putting It All Together—Designing Your Evaluation**

If you’re feeling overwhelmed at this point, don’t worry. Evaluations really do not have to be “a big deal.” They are merely systematic ways of finding out how well your program is going. They also don’t require a PhD to design and deploy, only a plan, ambition, and time. With this in mind, let’s move toward putting the final evaluation together.

Consistent with Worthen’s (1997) definition of evaluation above, the results of your evaluation should be compared to defensible criteria. In other words, how will you know when you’ve been “successful?” If you want to evaluate how successful your program has been at getting teachers to integrate the watershed concept into their classroom, then how many teachers will constitute success? Exactly how much of an improvement in student knowledge would suggest that your program is working? Even in a basic formative evaluation you’ll need to decide how many responses necessitates changing a component of the program. Many groups experience difficulty in determining success because they define their criteria too broadly. Be specific. These criteria will be particularly helpful if you need to demonstrate success to donors or wish to show school administrators that the program is beneficial. Proven success can also help in “selling” the program to schools in other watersheds.

There are some extremely variable professional opinions about not only what evaluation is, but how it should be done. To illustrate this point, consider this statement about designing evaluations by Worthen and co-workers (1997): “Few come with careful step-by-step instructions practitioners can follow, and even fewer are useful in settings and circumstances beyond those in
which they were created.” In other words, there are usually few rules to designing an evaluation as long as it clearly yields the information you need. Some authors believe that it should produce information useful to decision makers, some think that evaluation is merely professional judgement about a program's worth, while others maintain that it should utilize experimental research procedures with appropriate controls (Worthen et al., 1997). By looking at several different examples of evaluations, you should begin to form ideas about designing your own survey. Thoroughly investigate the rules for your chosen evaluation (if there are any) and design accordingly. In all honesty, you will find that many surveys are built not from a particular design template, but organically to meet the information needs of the evaluator. If the survey clearly yields answers to your questions, then most any format is acceptable.

Some Closing Thoughts

This chapter has presented a great deal of information, all of which is encapsulated in the process model for watershed education (Figure 2). In summary, a coordinator must first develop the infrastructure of the program (e.g., funding, monitoring protocol) and select an appropriate watershed for implementation. After administrative participants (i.e., local coordinator, steering committee) are chosen, watershed specific goals and objectives are created. Next, teachers and other program participants (e.g., mentors) are selected to participate in a training workshop. Once the program is implemented, coordinators must continue to provide assistance, both in the field and in the classroom. Finally, a program evaluation is conducted to determine its effectiveness and worth.

The best models are dynamic, flexible, and adaptable to different circumstances. Unfortunately, knowing exactly when and how to apply this information is not something that is
easily taught; it is best learned through experience. Remember, if you encounter a difficult situation, consult with other educators, the steering committee, and other watershed education groups, some of which may have experienced the same scenario before. Be open to new opportunities and ideas as they can help turn good programs into great programs. Although it may be many years before you are able to measure progress or attainment of your goals, we believe that dedication, hard work, creativity, and cooperation are the cornerstones of success.
CHAPTER 4
TEACHER EVALUATION

Introduction

The Bear River Watershed Education Project (BRWEP) is a school-based watershed education program created in 1999. Its goal is to nurture an empowered citizenry through problem-solving, scientific inquiry and analysis, as well as cooperation and understanding. Most of the 18 teachers currently participating attended a 3-day summer, 1999, workshop where they were trained in the use of a standardized monitoring protocol. With their teachers, some 600 students measure and learn about the physical, chemical, and biological properties of the Bear River (Utah, Wyoming, and Idaho) and its tributaries, participate in service-learning activities, and work with professional mentors. A web page serves as a clearinghouse for project news and water quality information, displays student writings and history projects, and contains a central repository for storage and retrieval of data. After its first year of existence, program administrators deployed a formative survey to evaluate the program. This paper presents the results of this evaluation and discusses its implications for the future of BRWEP.

Chapters 2 and 3 have already covered much of the literature relevant to environmental education (EE) and evaluation thereof. In brief, we concur with Wade (1996) that EE should not be purely content-based but process-based. EE, and in particular, watershed education, is not a subject per se. Rather, it is a teaching model that offers educators new and creative ways to facilitate learning using environmental themes at its core. As a unit, watersheds provide an excellent opportunity to connect any school subject and address topics of local, and therefore, personal relevance to students. Truthfully, watershed education is nothing new—systems
education has been around for quite some time. However, few schools seem to have embraced this integrated strategy despite calls for such reforms throughout the education field. We hope that BRWEP will encourage more schools to adopt their watershed as a core unit around which to structure their curricula.

Although we advocate a systems approach to environmental education, a serious paucity of rigorous scientific information exists to confirm our belief in the value of this learning mechanism. Additionally, EE in general seems to be awash with practitioners who decry the lack of evaluative materials inherent in most programs, particularly teacher in-service programs. Thomas (1990, p. 3) asserts that evaluations are not a common program component unless they are undertaken as part of an accreditation process or funding agreement. Furthermore, he suggests that several compounding factors, including insufficient funds, a lackadaisical attitude toward evaluation, and the perceived non-utility of results, often lead to the omission of this critical step in program development. While BRWEP has not designed a rigid evaluation schedule, a formative evaluation was initiated at the end of the first year to determine how the program can be improved. This process will be repeated in the future to again provide administrators with information for changing the program to meet the needs of participants. Ultimately, a summative evaluation should be conducted to determine its quality and long-term effectiveness.

Methods

A quasi-case-study approach to evaluating BRWEP was used to provide information useful in changing the program. Case studies have been called many different things, though they are typically used to generate understanding, rather than knowledge, and are most appropriate to
answer the "how" and "why" (Yin, 1994, p. 17). Although we did indeed want to know how the program is going, we consider our tactic to be a quasi-case study approach because we also sought some descriptive information about "who" and "what;" those elements are more commonly addressed by a traditional survey-statistical approach.

This method was chosen because of its adaptability and the inherent flexibility it offers evaluators. Thomas (1990, p. 5) states that "there is no one strategy for its application."

Therefore, when we combined some elements of a traditional case study (we examined only BRWEP and did not compare it to other organizations) and some survey questions (to provide quantitative data), our evaluation gleaned the ideal blend of information for our needs. It was also selected because it would not consume significant program resources (i.e., administrative time and money) or place considerable burdens on teachers.

A case study is a quasi-experiment because it lacks random assignment of subjects to experimental and control groups (Babbie, 1989, p. 333). Yin (1994) defines three classes of case studies: exploratory, explanatory, and descriptive. In our case, an exploratory approach was used because the program was initiated prior to determining research questions. By their very nature, exploratory case studies do not use comparative or correlative methods to determine value as compared to predetermined criteria for "success," nor do they attempt to test a hypothesis or theory (Yin, 1994). Thus, an exploratory case study lacks true objectivity and replicability. Nonetheless, this approach can provide evaluators with rich, descriptive information about a program and is a necessary precursor for future summative evaluations. While the results of the evaluation are not necessarily applicable to groups other than BRWEP, they provide some practical knowledge about how to improve our program in its developmental stages.
In the design stages, a formative evaluation was deemed most appropriate because BRWEP has not yet reached maturity, whence it could prove its merit, value or worth. Thus, our research questions were twofold: 1) what has BRWEP done well thus far, and 2) what can be improved in the future? This data can be used to provide BRWEP administrators with suggestions for improving this emergent program in the next 1-2 years.

A peer-reviewed survey was designed using the quasi-case-study approach and was distributed to all participating teachers (N=19). A 100% response rate allowed us to assert our conclusions based on the entire BRWEP population. Each individual question will not be discussed here; instead, a copy of the survey is presented in the Appendix of this paper.

Responses were categorized using manifest content analysis techniques (those elements that are physically present and countable; Berg, 2001, p. 242) although some latent content (meaning and symbolism inferred from data or written responses; Berg, 2001, p. 242) was derived from descriptive answers. All different responses were first listed, then later grouped into categories dictated by the breadth of answers. Except for a few questions where “yes-no” or Likert Scale questions were asked, response categories were not determined until after the completed surveys were read. While this coding technique has some obvious disadvantages, largest of which being its subjectivity, this was most useful given our personal relationship with each respondent and our ability to identify with specific aspects of the program (i.e., I am inextricably linked to the program). Therefore, responses were sometimes categorized by considering the answer in conjunction with descriptive answers and personal interactions with teachers; without personal familiarity with teachers and many of their field experiences, some responses would have been difficult to code. Obviously, this imparts considerable bias in terms of
data interpretation, however, subjectivity and intimacy with participants is the only way to usefully apply the survey information.

Results

To paint a picture of the program, we can discuss the first series of survey questions that sought to ascertain who exactly are the BRWEP teachers, and why they are participating (Table 1). It appears that our teachers are quite experienced, given that they have spent an average of nearly 18 years educating students. Most are middle-aged (mean=47.5 yrs.) and within such an age range (36-58 yrs.) that suggests the program has not attracted those who are new to the profession, nor those about to retire. There were 13 males and only 6 females involved, few of whom (5.5% of responses) listed previous water quality monitoring experiences as a reason why

<table>
<thead>
<tr>
<th>Question</th>
<th>n</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. years teaching?</td>
<td>19</td>
<td>17.5 yrs</td>
</tr>
<tr>
<td>Avg. teacher age?</td>
<td>17</td>
<td>47.5 yrs</td>
</tr>
<tr>
<td>Age range?</td>
<td>17</td>
<td>36-58 yrs</td>
</tr>
<tr>
<td>Male/female ratio?</td>
<td>19</td>
<td>13:06</td>
</tr>
<tr>
<td>What was your initial interest in participating?</td>
<td>54</td>
<td>%</td>
</tr>
<tr>
<td>previous WQ monitoring experience</td>
<td>3</td>
<td>5.5</td>
</tr>
<tr>
<td>personal interests</td>
<td>17</td>
<td>31.5</td>
</tr>
<tr>
<td>convenience</td>
<td>6</td>
<td>11.1</td>
</tr>
<tr>
<td>professional interests</td>
<td>22</td>
<td>40.7</td>
</tr>
<tr>
<td>concern for WQ</td>
<td>5</td>
<td>9.3</td>
</tr>
<tr>
<td>Ø</td>
<td>1</td>
<td>1.9</td>
</tr>
<tr>
<td>What are your specific educational objectives?</td>
<td>47</td>
<td>%</td>
</tr>
<tr>
<td>to produce specific student outcomes</td>
<td>18</td>
<td>38.3</td>
</tr>
<tr>
<td>meet standards/personal knowledge</td>
<td>3</td>
<td>6.3</td>
</tr>
<tr>
<td>desire to teach concepts, subjects</td>
<td>23</td>
<td>48.9</td>
</tr>
<tr>
<td>Ø</td>
<td>3</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Ø= inconclusive data
they were attracted to the program. Instead, most teachers joined BRWEP because of the professional opportunity it afforded (40.7% of responses). These folks wanted to teach concepts that they believe to have significance for students, and also because of the opportunity to integrate science and community issues with their existing curriculum. Approximately 31% of responses were indicative of teachers’ personal motivations (love of the outdoors, opportunity for learning, interest in environmental issues), while interestingly, 11% claimed that conveniences such as having proximity to a stream and happenstance recruitment by colleagues were important factors in their decision to participate. Curiously, only one respondent listed their concern for water quality (WQ) in the Bear River basin as being a strong reason for joining the project.

Table 1 also shows that of the total responses (n=47), nearly half (48.9%) indicate a strong professional desire to teach about watershed-related concepts, while 38.3% hope to produce outcomes in students (e.g., sense-of-place connections, enjoyable field experiences, increase awareness, teach scientific processes).

Table 2 shows the level of program adoption by teachers at the end of the first year. Of the 19 teachers originally participating, 17 conducted monitoring with their students the first year. Of the two that did not, one has indicated no further interest in participating, while the last teacher still considers himself involved. Among the 17 teachers who have adopted BRWEP, all have done field sampling at least once, 88% have also used the program in the classroom, and two (11%) have involved students in monitoring after-school. It appears that most (53%) are monitoring streams in both the spring and fall sampling windows, while some are only able to visit the field in either spring or fall (17.6% and 29.4%, respectively).

Additionally, with regard to interdisciplinary teaching, 100% of teachers (n=17) are using
TABLE 2. Level of Program Adoption

<table>
<thead>
<tr>
<th>Question</th>
<th>n</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you sample in 1999 or 2000?</td>
<td>19</td>
<td>%</td>
</tr>
<tr>
<td>Yes</td>
<td>17</td>
<td>89.5</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>10.5</td>
</tr>
<tr>
<td>In which settings did you use the program?</td>
<td>17</td>
<td>%</td>
</tr>
<tr>
<td>Field</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>Classroom</td>
<td>15</td>
<td>88.2</td>
</tr>
<tr>
<td>After-school</td>
<td>2</td>
<td>11.8</td>
</tr>
<tr>
<td>What time of year did you conduct monitoring?</td>
<td>17</td>
<td>%</td>
</tr>
<tr>
<td>Spring only</td>
<td>3</td>
<td>17.6</td>
</tr>
<tr>
<td>Fall only</td>
<td>5</td>
<td>29.4</td>
</tr>
<tr>
<td>Spring &amp; Fall</td>
<td>9</td>
<td>53</td>
</tr>
</tbody>
</table>

BRWEP to teach biological science, 47% for humanities, 41% physical science, and 35% reported using it for math lessons (data not presented in Tables). Furthermore, 47% said that they have or are currently collaborating with other educators as part of their watershed studies (either intra- or interschool partnerships). Thus, it appears that a considerable number of teachers recognize the program's value to teach across the curriculum, and consider it an opportunity to work with colleagues.

It comes as little surprise that the most common perceived barrier to participating in BRWEP is a lack of time (Figure 4). In most schools, particularly at the high school level where school days are broken into short time periods, the ability to take field trips or conduct monitoring during class time is indeed limited. Somewhat surprisingly, 14% of responses (n=50) listed a lack of student content knowledge as a significant hurdle, and yet only 10% listed safety as a continual concern. It also appears that quite a few teachers feel overwhelmed on their monitoring
days—12% of responses cited a lack of parental or extra help as an issue they face. Fortunately, student interest and administrative support appears high, although few teachers reported no barriers to participation at all.

Lastly, the survey asked questions to find out how well the current program structure appears to be supporting teachers. As they are important program objectives, a five-point Likert Scale (2 to -2) was used to determine how effective educators perceive BRWEP to be at teaching various science concepts, social connectivity, stewardship, and promoting cooperation and teamwork among students. The results suggest that the current program structure is most utile for exploring water quality concepts but is somewhat less adept at teaching aquatic biology, ecological connectivity, scientific data analysis, stewardship, cooperation/teamwork and about the watershed concept itself (Table 3). Although these thresholds are purely arbitrary (<1.0 = poor, 1.0 - 1.5 = good, 1.51 - 2.0 = excellent), it is nonetheless dismaying to see that the mean
perception of BRWEP’s ability to teach historical/cultural connectivity to rivers (mean=0.41), the scientific method (mean=0.88) and encourage political action (mean=0.13) is low.

The last data presented in Table 3 can be interpreted as a rough measure of program “success” thus far (i.e., Has participation been worthwhile?). As determined by all actively participating teachers (n=17), for themselves and students alike, the program was considered moderately to very worthwhile (mean=2.56), and 100% of those who have sampled thus far would recommend participation to other educators. In context however, the potential for substantial response bias exists because teachers were all acutely aware that administrators would be analyzing the results, thereby making them more inclined to rate the program higher than they might if an independent evaluator was used.

Discussion

The demographic portion of our results suggest that experienced teachers constitute much of BRWEP, many of whom are somewhere in the middle part of their career. Not a surprising result, this is probably due to the fact that our initial recruitment efforts were done through personal relationships with other educators and subsequent word-of-mouth recommendations. Thus, this recruitment method would seem to select those who are indeed experienced. This has implications for long-term program adoption because none of them are imminently nearing retirement age. While it is conceivable that teachers who are more accomplished and comfortable in their classroom are best-suited for watershed education programs, it would be nice to tap into the enthusiasm often exuded by younger teachers (i.e., those not far out of college).

The results also indicate that most folks have joined the project for professional interests and very few had any previous water quality monitoring experience. However, additional data
### TABLE 3. Value of Program as Perceived by Teachers

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How effective is BRWEP at teaching: (n=17)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water quality</td>
<td>1.</td>
<td>excellent</td>
</tr>
<tr>
<td>Aquatic biology</td>
<td>1.47</td>
<td>good</td>
</tr>
<tr>
<td>Ecological connectivity</td>
<td>1.18</td>
<td>good</td>
</tr>
<tr>
<td>About watersheds themselves</td>
<td>1.18</td>
<td>good</td>
</tr>
<tr>
<td>Scientific data analysis</td>
<td>1.31</td>
<td>good</td>
</tr>
<tr>
<td>Land/river stewardship</td>
<td>1.12</td>
<td>good</td>
</tr>
<tr>
<td>Cooperation/teamwork</td>
<td>1.47</td>
<td>good</td>
</tr>
<tr>
<td>Historical/cultural connectivity</td>
<td>0.41</td>
<td>poor</td>
</tr>
<tr>
<td>Scientific method</td>
<td>0.88</td>
<td>poor</td>
</tr>
<tr>
<td>Political action/advocacy</td>
<td>0.13</td>
<td>poor</td>
</tr>
<tr>
<td>(for ranking, &lt;1.0 = poor, 1.0 - 1.5 = good, 1.51 - 2.0 = excellent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Has your participation been worthwhile: (n=17)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For you?</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>For your students?</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>(based on a four-point Likert Scale where: 3 = very worthwhile,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 = moderately worthwhile, 1 = slightly worthwhile, 0 = not at all worthwhile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Would you recommend participation to other teachers?</strong></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Yes</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maybe</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Undecided</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

revealed that 84.2% of teachers (n=19) have conducted some sort of field-based science projects or lessons before. This is significant as we look toward recruiting additional teachers in the Bear River basin and others around the State of Utah. We might surmise that experienced teachers (>8-10 years) who have been involved with field-based projects, environmental education workshops (e.g., Project WET), and skills-based (e.g., map and compass) activities may be the group most appropriate for initial recruitment efforts.
A closer look at teacher objectives reveals that the majority only aspire to teach concepts (i.e., professional interests), while a lesser number hope to create positive student outcomes. This is significant because many of BRWEP’s objectives are to produce not only cognitive knowledge, but affective changes among students. If teachers do not share or are even aware of the objectives of the larger program, then the administration should take appropriate action. It would be useful to know if teachers share the goals of the administration, and what additional steps can be taken to work together for attaining mutual benefit? Interpretation of written responses also suggests that many teachers have not yet clarified and explicitly stated their curriculum goals. These important issues should be addressed by the BRWEP steering committee.

Although not every teacher took part in watershed education activities, it appears that BRWEP did an admirable job at mobilizing participation in its rookie year. Two of the nineteen teachers did not participate in the first year after the training workshop, one has since withdrawn from the program, and an additional teacher (uncounted in the survey) has recently come onboard. It is also encouraging that 88% are not only conducting field monitoring activities, but reported using it in the classroom. Naturally, there is bound to be a wide variance in terms of what content they’ve taught, but nonetheless they are either preparing beforehand or conducting follow-up activities in the classroom as we would hope. Additionally, we would like to increase the number of teachers monitoring in both the spring and fall sampling windows so that they have greater opportunities to compare student data between seasons and from one year to the next.

Solutions for the common response “lack of time,” as one of the barriers teachers face to implementing this program have been addressed in Chapter 3. A more surprising finding however, is the perception that a lack of student content knowledge is a significant problem. Is
this not what an education program is *supposed* to alleviate? We are also concerned that more teachers did not consider safety to be a big issue—indeed it should be foremost on everyone’s minds. At the summer, 2001 workshop it would be useful to include discussion of safety issues and hazard mitigation on the agenda. Furthermore, Figure 2 shows that certain logistical issues such as extra help, transportation and group size, are of moderate concern (>8%). We counter with the belief that all of these can be surmounted with a modicum of planning and creativity on behalf of the BRWEP administration and teachers.

Nearly half of all teachers reported using BRWEP as part of writing, English, art and music lessons, although fewer (11%) have yet incorporated the program into their history and social studies curricula. The scientific components of the program are quite obvious, however, the considerable level of interdisciplinary teaching, in spite of the relatively weak emphasis put forth by the BRWEP administration thus far, is encouraging. We speculate that the number of teachers and the depth of interdisciplinary watershed studies will rise as greater effort is made to train and work with schools on building such curricula.

The results in Table 3 lend credence to the notion that the program is successful at teaching many scientific subjects. It is alarming, however, to see how poorly BRWEP teaches both social connectivity to watersheds and scientific methodology, and to a lesser extent, the definition of a watershed. We can take to heart these judgements and place greater emphasis on these subjects in the future.

When asked whether they would recommend the program to colleagues in other watersheds, all teachers said they would (many of them emphatically). Written elaborations offer us insight into the perceived benefits of the program as well. More than a few cited the value of
doing "real science" with their students, suggesting that BRWEP is a valuable alternative or addition to existing science curricula. We speculate that future adoption of an integrated watershed curriculum model at the school level may yield similar positive experiences.

**Conclusions**

These results suggest that BRWEP is making progress toward achieving its goals and is perceived as valuable to both teachers and students. Overall, the program is doing a good job at supporting teachers in those areas where we have focused the bulk of our efforts thus far (e.g., providing water quality content) but is deficient in others. From this study, I offer several recommendations to improve the program in the near future: 1) work closely with the teacher who has not yet participated in the program; 2) encourage more schools to sample streams in both monitoring seasons; 3) encourage greater use of BRWEP in after-school settings; 4) increase classroom support to address the perceived lack of student and teacher content knowledge; 5) develop creative solutions to address the lack of time for participation; 6) work with schools to adopt an interdisciplinary watershed education program.
CHAPTER 5

RECOMMENDATIONS

We believe the model presented in Chapter 3 represents the best available plan for conducting a school-based watershed education program. This Chapter contains specific recommendations for BRWEP and future watershed monitoring efforts, particularly in Utah. If these recommendations are found to be beneficial, this knowledge should be incorporated into future revisions of the model.

These recommendations are based primarily upon observational evidence, program experience, discussions with educators, the literature, and examination of other programs. For usage by different audiences, this information has been grouped into several categories: BRWEP administrative needs and program development, recommendations for technological and workshop improvements, advice for coordinators in other watersheds, teaching improvements, and finally, some general suggestions. Readers should note that the recommendations are not necessarily listed in order of priority. Implementation of specific changes to BRWEP should not commence without first discussing them amongst the steering committee.

BRWEP: Administrative Needs

1. *Find a permanent locus of control.* BRWEP currently is managed by the Utah State University Extension, Water Quality Program, and the College of Natural Resources. While these two entities should certainly be included as partners, a more permanent “home” and staff should be sought. Neither group currently has the resources to adequately support BRWEP, let alone future statewide efforts. There are currently efforts underway to develop a statewide task force for watershed education. I believe it would be
best if this new entity were not nested within an agency. After reviewing the
organizational structure of many large, apparently successful national watershed education
groups, a separate entity that receives agency support seems ideal. These groups may
operate autonomously, apart from many of the regulations and constraints that typically
bind agency-affiliated groups. To be sure, participation, funding, and administrative
support from agencies and universities is desirable—indeed, power lies in partnerships. To
be more adaptable, however, the locus of power should exist within a non-profit or other
sovereign group.

2. Enhance stability and sustainability. BRWEP and future watershed education projects
should make every effort to enhance their long-term stability and sustainability. By this,
we are referring primarily to funding sources. Those soft-money grants are usually
ephemeral; seek consistent funding that is appropriated from a legislature, an agency, or a
foundation and engage in contractual obligations for its use. To become sustainable a
program must also retain a consistent "cast of characters." People that are hired into a
permanent position, as opposed to a one- or two-year appointment, feel as though they
belong to a permanent organization. Create employee incentives that will keep a good
coordinator around for many years. Too often when energetic individuals leave a
program, so too does the program's momentum. Committed participation through
sampling contracts (see: BRWEP: Program Development no. 7) among teachers and
mentors will also help sustain your program.

3. Expand BRWEP to additional schools within the basin. While 17 schools currently
participate, additional schools within the basin could expand data collection and learning
opportunities. In particular, the towns of Woodruff and Randolph (UT), Montpelier (ID), Preston (ID), Smithfield (UT), Hyrum (UT), Wellsville (UT), and Brigham City (UT) should be targeted. Already, interest by a teacher (Randy Stacey) at Mountain Crest High School (Hyrum, UT) has been expressed but not thoroughly pursued.

4. **Better align teachers’ goals with those of the program.** The information presented in Chapter 4 suggests that teachers’ goals are somewhat different than those of the administration. If the program is to succeed in the long-run, teachers must be working toward the same goals. Therefore, the next coordinator should seek better understanding of these discrepancies (e.g., Ask teachers if they’re even aware of the program goals. Do they aspire to create an active, informed citizenry? Do they want to teach concept knowledge or help improve watershed condition?). Teachers will certainly have their own classroom goals and objectives, however, they should also be working toward achieving those of the larger program. If consistent differences are found, the steering committee should adjust them to meet the needs and desires of participants.

5. **Provide a broader support network for teachers.** Teachers should have multiple options for seeking help and information. I have found that list-servers, e-groups, and volunteer monitoring newsletters are all excellent ways to provide additional help. Currently, BRWEP teachers are subscribed only to *The Volunteer Monitor* (EPA) newsletter. They might feel a greater sense of involvement if they were aware of national watershed education programs and were subscribed to list-servers. I recommend providing materials with different formats; these could include written materials, electronic resources and personal contacts so that teachers may choose the information medium most comfortable
to them.

6. **Purchase more kits.** Money in the existing EPA grant (administered by Dr. Chris Call) is earmarked for purchasing additional monitoring kits. I recommend that Thatcher Elementary School (Thatcher, ID), Preston High School (Preston, ID), The School for Natural Learning (Mendon, UT), Logan High School (Logan, UT), and Adele C. Young Intermediate School (Brigham City, UT) receive the next five kits. Evanston High School (Evanston, WY), Cokeville Elementary/High School (Cokeville, WY), A.J. Winters Elementary School (Montpelier, ID), Hooper Elementary School (Soda Springs, ID), and Bear River High School (Garland, UT) currently have monitoring trunks. Future money should prioritize schools within Cache Valley and new program recruits for receiving equipment.

7. **Keep safety records.** Evidence from the survey shows that safety issues are of significant concern to teachers. It would be useful to keep track of project-related injuries so that we can work toward minimizing these factors in the future. If the program maintains an excellent safety record, show new teachers this information to allay some of their fears. The next workshop should help teachers evaluate potential safety hazards at a field site and discuss ways to mitigate them.

8. **Challenges for BRWEP?** The future presents several interesting short-term (1-2 years) challenges for the next program coordinator.
   a. Challenges in data interpretation and reporting because of BRWEP’s broad participant age-range and differing abilities of teachers.
   b. Helping students make connections between their data and ecological condition
will be a formidable task.

c. Helping students make connections between cultural/historical components and how these situations have contributed to present ecological condition.

d. Priority should be given to working with one school in thoroughly adopting a watershed education theme and curriculum (a great case study, complete with pre- and post-data).

e. Increase classroom and field support. This will consume lots of administrative time and energy if one full-time person is available to visit schools.

**BRWEP: Program Development**

1. *Greatly increase computer training for teachers.* To this point, I suspect that teachers have not made greater use of available technology (i.e., on-line database, web site for updated information) because of their general unfamiliarity with computers. Even those teachers that are already comfortable using the Internet and Microsoft Excel would benefit from increased computer training, particularly, assisting with use of the database and graphical options. One-on-one training should take place in the classroom, although efforts should be made to include computer training as a standard part of all future workshops. New technologies such as G.P.S. and GIS can be presented then as well. Do not offer teachers any new gadgets without training! It is also important to provide follow-up help and assistance with technology during the data collection and analysis stages. In this regard, I believe that BRWEP has thus far not helped teachers to the extent that we should.

2. *Implement an interdisciplinary program.* As this paper continually advocates, adoption of
an interdisciplinary watershed education program by schools should be of paramount concern to the next BRWEP coordinator. However, an interdisciplinary program can only be used to enhance subject connectivity within the classroom if teachers are shown how to do this. Some written materials may help as well: curriculum guides exist that have been specifically written around the watershed theme. In particular, the Illinois Rivers Project (http://www.siue.edu/OSME/river/RPCur_Guides.html) has published an excellent series of curriculum workbooks complete with activities, lesson plans, service-learning projects, and other resources for teachers. Their series includes books on biology, chemistry, earth science, geography, language arts, math, and others. Using an existing curriculum will reduce time and money spent developing your own while providing teachers with proven materials. This helps reduce their planning time and instills confidence by demonstrating that interdisciplinary watershed education has been done many times before.

3. Offer service-learning projects. As discussed in Chapter 3, service-learning projects can be a powerful way to engage students within their communities. BRWEP has thus far done little to facilitate these projects, and many more opportunities can be explored. See Chapter 3 for more information.

4. Consider encouraging participation in action projects. BRWEP has not yet assisted schools with turning their data or desires into action. BRWEP could encourage greater participation not only in restoration activities and service-learning projects, but also political action based on students' results. This may be a sticky subject for some, especially donors who do not like to see advocacy mixed with education in any form. Therefore, if BRWEP chooses to pursue this tactic, you must work closely with the
steering committee to determine the most appropriate way to get involved. The forthcoming (Fall, 2001) Watershed Protection Guide from GREEN (http://www.earthforce.org/green/) will contain information for educators who wish to facilitate action projects.

5. Plan a watershed congress. As was advocated in Chapter 3, participation in a “watershed congress” is a great way to finish the monitoring season. Students can present their findings, share recommendations and stories, and get to know about some of the other schools throughout the watershed. Students can give presentations, have opportunities to participate in restoration projects and optional monitoring sessions. This day-long gathering is a good way to engage students, teachers, administrators and mentors alike. Make sure to invite professional scientists, educators, university students and the media to round-out the event. Your “celebration” should be held in a central location during the spring and will require adequate facilities for student presentations. The Montana Volunteer Water Monitoring Project hosts an excellent “Water Summit” every year.

6. Develop a Quality Assurance Project Plan. One problem that volunteer monitoring organizations commonly face is that of data credibility. Skeptics often raise questions about the validity of a group’s sampling process, their equipment, data analysis, and reporting of water quality information. One way to assuage these concerns is to develop a Quality Assurance Project Plan (QAPP) filed through the EPA. First, a group must decide exactly why they want to undergo this potentially lengthy and complex process. Is it to allay concerns about credibility within the community? Do they want their data to be accepted by a water quality agency for use in management purposes? Perhaps they want
to encourage students to collect better data. There are many different levels of a QAPP and BRWEP should consider writing one to at least ensure the quality of it’s data for educational purposes. Specific information on developing a QAPP can be found at: http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm. For BRWEP, this process could open up new avenues for applying volunteer data, improve credibility within the community, and impart quality control standards among schools.

7. Develop a participant contract. A participant contract is a useful way of ensuring long-term program adoption among schools. This contract may be formal or informal (i.e., written or spoken), but it should include detailed information about the time requirements necessary for different levels of data collection (stream cleanups vs. basic WQ monitoring vs. advanced WQ monitoring) and outline a sampling schedule (e.g., fall only, spring only, both seasons). The coordinator should discuss these considerations with each new teacher. For busy teachers, this provides them with written expectations and will help them prioritize monitoring during the school year. For administrators, this helps clarify the level of participation by each school and can be the first step toward developing a QAPP.

8. Create a hardship form. If a participant contract is developed, it may also be useful for the program administrator to create a hardship form. This allows a school to report sampling difficulties or information about why they could not complete their monitoring schedule. Rivers Of Colorado Water Watch Network (ROCWWN) http://riverwatch.state.co.us/Contents/hardship%20form.asp has made their form available on-line and should be used as a template for developing such a document. Somewhat of a mini-evaluation, this helps keep program administrators abreast of monitoring problems
throughout the watershed. A sampling schedule form may also be a useful way to keep track of who’s going into the field and when—this helps trainers coordinate visits. Make all of these forms available and submittable from your web site. For coordinators, this can be another important communication link with participants. For teachers, it is simply more convenient than a telephone call.

9. **Have students write a book on their findings and experiences.** A student-written book can be an educationally valuable way to display data, maps, photos, creative writings, and other experiences. If students know that their information and work is to be used in a book about their watershed, they will take great pride in their studies and ultimately have a significant product to show for it. Books also help to get information out to the community and attract potential donors. Although creating a book is a substantial undertaking, with sufficient money and time to organize, this can be a rich and rewarding educational experience for students, especially if they are involved as editors.

10. **Development of additional after-school programs.** Recently, there has been a substantial increase in funding for after-school education programs. After-school is an excellent time to develop a watershed education program because it often allows more time for monitoring, restoration activities, and action-taking programs. GREEN is currently developing an after-school program for students aged 10-15 which will allow them to work on environmental problems within their own watershed. At present, only students at Adele C. Young Intermediate School and Logan High School have used BRWEP as part of after-school activities. Effort should be made to increase the number of students participating after-school.
11. *Receive direction from the steering committee.* Additional recommendations should be solicited from the steering committee members since they are integral to the program's success. Be sure to involve them in all major decisions effecting the direction of the project. The steering committee should be re-organized after I leave, and new contributors sought.

**Technology**

1. *Development of individual school web pages.* The BRWEP steering committee has moved to support the creation of web pages for each participating school. These web pages can each be unique and should involve as many schools as possible. Many schools are already teaching web page development to students, and BRWEP fits nicely into this part of their curriculum. Here, they may post raw data, graphs, conclusions, maps, photos, videos, creative writing, and other related experiences. A watershed coordinator or consultant with HTML experience will probably have to spend considerable time visiting schools and assisting with this project.

2. *Better links with existing professional data.* The current BRWEP web page does not contain direct links to state or federal water quality data sites. Ideally, it should provide not only links, but a more user-friendly interface with Department of Environmental Quality and EPA STORET data. If this information was readily available and interpretable on the BRWEP web page, participants would be more likely to use it for comparing their own data. This helps students look for similarities, inconsistencies, errors and gaps within the professional data, as well as their own. Be forewarned, however, considerable effort will be required to aid students in understanding these voluminous and
often complex professional datasets.

3. *Determine the effectiveness of web-based information dissemination.* A short survey or other means of gathering information about the comfort-level of teachers with computer technology would be very useful. At present, not all participating teachers have entered their old data into the BRWEP database. Before additional efforts to expand web-based information dissemination (e.g., newsletters, results, interactive help for schools) are pursued, a survey that determines computer literacy should be performed. If it is found that teachers are either not comfortable or have inadequate access to electronic formats, changes to the program should be made. While the computer is an easy way for many of us to share information, for others it is not. In rural areas especially, Internet connections can be slow and frustrating for students. If you determine that the Internet and e-mail is too difficult for many schools, then significant changes should be made to the information-sharing and communication format.

4. *Produce “student wizards.”* A student wizard is simply a tool posted on your web page to provide “how-to” information. For example, you might post a video clip for each component of the monitoring protocol so that students can visualize how it is done before entering the field. Or a wizard could provide students with information on indicators of watershed condition or highlight common sampling mistakes. These programs should be simple-to-use, yet engaging and interactive. Simple lists are seldom eye-catching, especially to modern students—so make the wizards dynamic and fun. The idea is to provide students with additional information that their teachers may not have or aren’t able to graphically present.
5. **Help page.** An interactive link or tutorial should be developed for the BRWEP web page that helps schools interpret data more effectively. The graphs presented in the Appendix of this paper would be one way to help students, as is the student wizard mentioned above. A help page should certainly not be developed in lieu of classroom visits—they are probably more effective at aiding schools in data interpretation.

6. **Add Power point slides to BRWEP web page.** I would suggest that the Power Point presentation we have developed be added to the BRWEP page for helping schools interpret data (see Nancy Mesner). This would be one more interpretive resource available to students and teachers.

7. **Author an on-line newsletter.** Several monitoring groups have found that a periodic newsletter can be a useful way of sharing information, ideas, creative works, and success stories (see: [http://riverwatch.state.co.us/Contents/newsletters.html](http://riverwatch.state.co.us/Contents/newsletters.html) or [http://nris.state.mt.us/wis/volwatmon.htm](http://nris.state.mt.us/wis/volwatmon.htm)). While BRWEP has a current news web page, this could be greatly expanded to help participants keep abreast of changes.

8. **Create videos.** Creation of two training videos could help improve some aspects of the program. For students, teachers, and parent/community volunteers, a detailed video that describes how to do each of part of the sampling protocol could be shown before going into the field. Another film for school administrators, donors, the media and the public could offer a general program introduction and serve to encourage collaboration and generate excitement. Copies can be made and given to all teachers for them to show each new class.

9. **Use of student quotes.** Take note of positive student quotes during your field and
classroom excursions. Once you have received permission from students or their parents, post these on your web page or include them in the student-designed book. These are not only interesting to share with others, but help display your successes to the public.

**Workshops**

1. *Schedule regular teacher training workshops.* It would be useful to hold annual training sessions for teachers, both new and experienced. They serve as refreshers, present new information, allow you to distribute educational materials, offer time for reflection and suggest improvements, and are good times to conduct program evaluations. This is also a form of sampling QAQC and helps reconnect teachers with the broader project. Stable funding will greatly help you plan and host regular workshops every year.

2. *Model interdisciplinary teaching at next workshop.* Since BRWEP teachers thus far have little experience with comprehensive interdisciplinary studies, future workshops should explain and model how to do this. An entire workshop could focus on subject integration, lesson planning, and even begin to design a program of study. Once back in their classrooms, educators often revert to teaching how they were shown at in-service workshops. Take advantage of this by conducting your workshop in a subject-integrated manner to demonstrate how powerful an interdisciplinary approach can be.

3. *Invite several teachers from one school to attend workshops together.* If your goal is for entire schools to adopt a watershed-based, interdisciplinary approach to education, then you’ll need to train teachers at the same time. Teachers with similar training will all understand basic watershed concepts and have the same experience to draw upon. What’s more, if you nurture collegial relationships among teachers, they will come to rely on one
another in creating their lessons. For example, if social studies teachers know how science teachers use monitoring in their lessons, they can build upon these experiences to teach about water law and policy in their class.

Advice for Coordinators in Other Watersheds

1. Initially target Beaver, Sevier, Uinta basin, and Jordan River watersheds. Resource Conservation & Development (RC&D) groups currently exist within these basins and can serve as ushers into local communities. As citizen groups with agency connections, RC&D's can be powerful allies for gaining local trust and support and may know teachers that would be interested in participating. These basins represent four of the eight major physiographic provinces in Utah. With BRWEP already operating, only the Great Salt Lake, Weber, and Colorado River watersheds would be without organized volunteer monitoring programs. Because of their burgeoning population, the Ogden and Weber River watersheds would also be good candidates for recruitment. I believe that because Utah has such scarce water resources, managers should make every effort to involve citizens in watershed protection efforts.

2. Identify strategic differences between rural and urban watersheds. The inherent difficulties of program implementation typically vary from one watershed to the next. Significant differences often exist between rural and urban schools, even within the same watershed. Access to streams, availability of buses and funding, and local knowledge of WQ topics usually differ from one locale to another. It is important for coordinators to identify and document these differences so that barriers can be reduced with each new program. The model presented in Chapter 3 should also be changed to incorporate these
3. *Make the information in the model available and relevant to participating teachers.*

Chapter 3 presents a model based on our experience with BRWEP. Future regional watershed education coordinators will benefit from BRWEP’s experience and can offer the pertinent model information to teachers. For example, teachers would find our ideas for more successful field days, data analysis and reporting helpful. As in the case of student data, information is most powerful when it is communicated to the appropriate audience—use this information! I would suggest presenting these findings during teacher visits and at future workshops.

4. *Develop performance criteria and school evaluations.* A steering committee may wish to consider developing written performance criteria and school evaluations. Performance criteria can define several levels of monitoring, allowing schools to participate at different grades depending on their motivations and constraints. Some schools may only wish to participate in stream cleanups while others may do basic WQ monitoring and others advanced. Offer schools a chance to participate at any level. Evaluations that assess how well schools meet performance criteria would then provide them with valuable feedback to make changes. I have found that teachers often appreciate this professional, constructive criticism because it helps them improve teaching and monitoring techniques for the following year. Although this is a time consuming affair, it can improve the quality of your program, and also provide supporting material to bolster your QAPP.

5. *Seek beneficial users for monitoring data.* Whether you have developed a QAPP or not, it may be worthwhile to find uses for your data outside the classroom. For example, find out
if there is a WQ agency that wants to use student data in their management plans. Do citizens or watershed groups have interest in your findings? While education should still be your primary concern, you may discover that student data has application beyond the school environment. This helps students feel that their participation is valued and may encourage them to be more precise in their data collection.

6. **Hold public open houses.** Extensive public participation can benefit many aspects of a watershed education program. As you work with the steering committee to identify watershed issues of concern, solicit ideas or suggestions from the public as well. This is also a good way to raise interest in the program and deepen support upon a broad structural foundation. Students can also utilize public open houses to present their data and findings to the community.

7. **Classroom presentations.** Coordinators can enhance learning by presenting information to students prior to field monitoring. An initial slide show, presentation or lesson to individual classrooms provides students with background information on watersheds and helps teach sampling techniques. It is also an opportunity to show them the broader project and generate excitement. This requires considerable travel, preparation, and classroom time, however, our experience suggests that students benefit greatly.

8. **Expanded citizen monitoring programs in Utah.** The effort to forward student-based monitoring programs within Utah should also include development of citizen monitoring projects. Citizen groups can utilize many of the existing sampling protocols and often collect high-quality data. They are also good resources for providing school groups with additional help and information.
9. **Greater involvement of the media and communities.** As was suggested in Chapter 3, publicity by the media can enhance public exposure and attract potential donors or volunteers. Greater participation by local citizens, watershed groups, and civic groups will help to broaden a program’s support network. This will involve considerable time writing press releases, meeting with volunteers, and coordinating meetings and events within local communities.

10. **Create a “buddy system” among teachers.** Pair up existing teachers so that they have a fellow teacher to contact for help and advice on lesson planning and curriculum development. Teachers may also find it helpful to sample streams and give class presentations together. This helps teachers and students alike to feel that they are part of a larger program with purpose and meaning.

11. **Improve communication of complex scientific information.** Students and teachers can be turned off by dense scientific information on topics such as water quality, hydrology or riparian vegetation. Coordinators can mitigate this problem by visiting classrooms to help them understand these topics. Oftentimes, it will only be a matter of defining terminology, but sometimes you may have to re-teach the scientific circle of logic and assist with interpreting data. During these visits, present information in a way that is easy for non-professionals to understand, yet challenge them with advanced concepts and theories. Classroom visits are especially important when participants are interpreting their own data and trying to compare it to professional data (e.g., EPA STORET data).

**Improvement of Teaching in Watershed Education**

1. **Have students identify WQ issues and design their own monitoring/educational program.**
Concurrent with constructivist teaching practices, a coordinator can help schools identify the WQ issues in their area. Students can then design their own monitoring schedule and determine which parameters to measure for obtaining this information. They may also develop ideas for related interdisciplinary studies throughout the year. In essence, this process puts students in charge of their own learning. Teacher-coordinator preparation would have to begin in late-summer or fall, thereby allowing teachers enough time to incorporate changes into their curriculum.

2. **Student-developed plans for watershed restoration, management.** Once students have completed their water quality investigations, teachers may assign team-projects to develop restoration and management plans for their basin. A constructivist approach to these projects would provide excellent closure for a year-long investigation of water quality.

**General**

1. **Future graduate research projects.** Numerous graduate project ideas have been spawned from BRWEP thus far. Here is a brief summary of those deemed most important:
   a. Determine the educational, social, and ecological benefits of interdisciplinary studies.
   b. Develop and perform a summative evaluation for BRWEP in 2-5 years.
   c. To what extent are the various technologies effective at disseminating information among teachers? Among students? Among the public?
   d. Research to better understand the linkages between student knowledge [of environmental concepts] and taking-action. In other words, what program actions yield the greatest interest in student restoration projects? What forces lead students
to take political action? Research should build upon the work of Hungerford and Volk (1990) and others who are still exploring these questions.

e. Why do teachers perceive this project as being “real science,” as compared to what they do in the classroom (as stated in several survey responses)? Identifying the unique learning enhancements in field science could help improve classroom instruction.

2. *Hire a statewide coordinator.* Efforts are currently underway to establish the first full-time, devoted watershed education/volunteer monitoring coordinator in Utah. Similar positions are also desirable in the adjacent states of Wyoming and Idaho. A statewide manager who trains watershed-specific coordinators should deploy programs that are compatible with one another. Most importantly, if similar monitoring protocols are used within each watershed, data is then comparable from one to the next. Thus, a well-coordinated effort and single organization must be at the heart of its management.

3. *Development of monitoring protocols for issues of urban concern.* As watershed education programs move into urban areas such as the Wasatch Front, procedures for monitoring non-point source pollution, storm water runoff, and construction sites will be needed. Many groups such as Streamkeeper’s (http://www.streamkeeper.org/), the Illinois Rivers Project (http://www.siue.edu/OSME/river/river.html), and Save Our Streams (http://www.saveourstreams.org/) have already developed these materials.

4. *Avoid taking “soft money.”* For future projects in other watersheds (e.g., starting a watershed education program in a new watershed, Internet development and maintenance), try to avoid taking “soft money.” Soft money is one-time funding from a group or agency.
and typically comes with considerable limitations. It is often just as time consuming to write and manage small grants as it is larger sums. To maximize your efficiency and resources, limit the amount of soft money you will accept. While smaller, one-time needs such as equipment may be satisfied this way, it is easiest to seek long-term funding from more consistent sources such as through agency or legislative appropriations.

5. **Need for better field kits.** GREEN has begun working with chemical test kit manufacturer LaMotte to develop easier, more accurate kits for volunteer and student organizations. While BRWEP may not work with manufacturers, if possible, try to find better testing apparatus—particularly for nitrates and phosphates. Existing protocols should also be expanded to include conductivity, coliform bacteria, TSS/TDS, BOD, and chlorine since these are parameters of known concern within the Bear River basin.

6. **Don’t reinvent the wheel.** There are so many volunteer monitoring and watershed education groups nowadays that it is seldom necessary to create original curriculum materials. For example, as coordinator, do not feel that you should develop a monitoring protocol from scratch—borrow or modify an existing one. If you encounter difficulties, remember that many other groups have probably already been through the same situations. Join list-servers and newsgroups (e.g., http://www.earthforce.org/green/, http://www.epa.gov/OWOW/monitoring/volunteer/vm_index.html) to search for educational materials or to find out how other groups have dealt with similar problems. Often there is little to be gained by reproducing materials that are already freely available.
REFERENCES


Center for Watershed Protection. *Teacher’s guide for creating a water monitoring program*. Ellicott City, MD: Center for Watershed Protection.


Roundtable.
Rivers of Colorado Water Watch Network. (2000). [Internet]. Available: [http://riverwatch.state.co.us/About%20RW/about.html](http://riverwatch.state.co.us/About%20RW/about.html) [2001, 04/08].
environmental education program for schools (11th ed.). Dubuque, IA: Kendall/Hunt Publishing.


APPENDICES

BRWEP Summer, 2000 Teacher Evaluation

Evaluation Ideas for Classroom Teachers

Press Releases to Professional Mentors

Mentor Agreement

Sample Graphs to Interpret Data

Internet References

Sample Grant Proposal and Budget
1. Teacher Background Information

A. School: ____________________________
Grade(s) you currently teach: ____________________________
Subject(s) you currently teach: ____________________________
Years spent teaching: __________
Your age: ________ Your Gender: ________

B. Please list three reasons why you were initially interested in participating in the Bear River Watershed Education Project with your students.

• ______________________________________
• ______________________________________
• ______________________________________

C. Have you ever conducted field-based science projects or lessons with students prior to this project?

☐ Yes ☐ No (go to question D below)

If yes, please list or describe them below:

• ______________________________________
• ______________________________________
• ______________________________________

D. If you answered "No" to question C above, then list the primary reason why you have never participated in such projects with your students before?

• ______________________________________
• ______________________________________
• ______________________________________
E. What are the specific educational objectives you hope to accomplish by participating in this project?

<table>
<thead>
<tr>
<th>Your Educational Objectives</th>
<th>Did you meet them?</th>
<th>Why or why not?</th>
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<tbody>
<tr>
<td></td>
<td>Yes or No</td>
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2. Participation in Bear River Watershed Education Project

A. Did you conduct water quality monitoring activities in 1999 or 2000 using the Bear River Watershed Education Project sampling protocol?

  □ Yes [ ] □ No (go to question B below)

Please check the areas where you utilized any component of the program below.

  □ Classroom lessons

  □ Field activities (list month(s), year)

  □ After-school/extracurricular activities or clubs

  □ Other

B. If you answered "No" to question A above, then list two reasons why you did not conduct field monitoring activities in 1999 or 2000.

  •

  •
3. Challenges and Barriers to Participation

A. Please check any of the following problems that you face in participating in the Bear River Watershed Education Project with your students. Briefly explain any box that you check.

- Liability issues: ______________________________________________________________________

- Safety concerns: ______________________________________________________________________

- Lack of administrative support: ______________________________________________________________________

- Transportation issues: ______________________________________________________________________

- Lack of student content knowledge: ______________________________________________________________________

- Lack of personal content knowledge: ______________________________________________________________________

- Lack of student interest: ______________________________________________________________________

- Lack of adult supervision or extra help on field days: ______________________________________________________________________

- Lack of parental support for project: ______________________________________________________________________

- Conflicts with state education standards: ______________________________________________________________________

- Lack of congruence with classroom curriculum: ______________________________________________________________________

- Lack of time: ______________________________________________________________________

- Others: ______________________________________________________________________

B. Please give two suggestions for overcoming these challenges or barriers.

- ______________________________________________________________________

- ______________________________________________________________________
C. Please list three difficulties you have experienced during field monitoring activities.

*** Only answer this question if you have conducted field monitoring activities using the Bear River Watershed Education Project protocol.

- 
- 
- 

4. Integration with Existing School Curriculum

A. Does this program fit within your state educational standards?

- Yes  
- No  
- I'm not held to state standards

If yes, then please list standard # and objective title.

<table>
<thead>
<tr>
<th>Standard #</th>
<th>Objective Title</th>
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</table>
B. Please list up to four subject areas that you have taught using the Bear River Watershed Education Project.

- 
- 
- 
- 

C. Have you collaborated with teachers in other subject areas as part of the Bear River Watershed Education Project?

☐ Yes  ☐ No

If yes, please list the subject areas that they teach:______________________________________

5. Program Evaluation

A. Based on personal assessment or observations of your students, please rank how effective the Bear River Watershed Education Project is at each of the following:

- Teaching aquatic biology
- Teaching water quality
- Teaching ecological connectivity
- Teaching historical/cultural connectivity of rivers and humans
- Teaching the scientific method
- Teaching about watersheds
- Teaching scientific data analysis
- Encouraging land/river stewardship
- Encouraging political action/advocacy
- Promoting cooperation/teamwork


Go to question B below
B. If you answered "Somewhat Ineffective" or "Very Ineffective" to any questions above, then please list why you feel this is so? *Be sure to mention which question you're addressing.*

- 
- 
- 

C. Please rate how worthwhile you feel that participation in the Bear River Watershed Education Project has been:

<table>
<thead>
<tr>
<th>Very Worthwhile</th>
<th>Moderately Worthwhile</th>
<th>Slightly Worthwhile</th>
<th>Not At All Worthwhile</th>
<th>Undecided</th>
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</table>

- for you? 
  - 
  - 
  - 

Reason why? ________________________ 

- for your students? 
  - 
  - 
  - 

Reason why? ________________________ 

D. Would you recommend participation in this program to teachers in other watersheds?

- Yes 
- Maybe 
- No 
- Undecided 

Why or why not? ________________________ 

______________________________
EVALUATION IDEAS FOR CLASSROOM TEACHERS

Have you met your goals?
A general format for teachers to evaluate the efficacy of their participation in a watershed education project

Research Problem:
- How do I measure student knowledge gained through the water quality monitoring program?
- How can I determine if my goals for participation in this program have been met, even if I am hoping for long-term or attitudinal changes?
- Is the watershed theme a practical and beneficial means of teaching?
- Is my continuing participation in this program worthwhile?

Data Collection:
- An attitudinal test is given at the beginning of the unit or the year to determine the current political ideas, behavioral attitudes, connectivity with place, and level of interest toward the Bear River watershed. A post-instruction test is given to identify attitudinal changes in students.
- A “quiz” is given at the beginning of the unit or the year to determine the extent of current student knowledge of watershed-related concepts. This will also help direct the course objectives and content areas to be taught. A post-instruction test is given to determine the effectiveness of the program on student content knowledge. This test should be repeated again to determine knowledge retention over time.
- Observational data is collected throughout the process (in the form of detailed field notes) to note significant experiences, events, or interactions. This will help to chart progress and contextualize events as they pertain to program evaluation.
- Explicitly define educational and personal goals for participation in the program prior to beginning instruction. Create objectives to measure attainment of these goals.

Data Analysis:
- Compare pre- and post-results from content knowledge tests.
- Compare pre- and post-results from attitudinal tests.
- Revisit all field notes and categorically analyze. Group in terms of positive and negative experiences/comments, and program evaluation notes (how to improve instruction, learning).
- Determine whether or not goals have been achieved by examining specific objectives.
- Based on all available evidence, determine whether the watershed theme is valuable to students as a curriculum locus.
- Based on all available evidence, determine how worthwhile participation in BRWEP has been.

Report Results:
Results should be reported to the students, faculty, school administrators, and the BRWEP program coordinator. It is very important to communicate the results of the examination, positive or negative, in order to share these experiences and the knowledge gained through participation in this project so that changes can be made in the future. Results can be used to change future instruction by
the teacher/evaluator, the program coordinator, and by other teachers participating in the program.

**Action Planning:**

Implementation of changes made evident by the research is imperative if this process is to have been useful. These should help guide future instruction, changes in the monitoring protocol, cooperation with teachers in other subjects, and a refinement of the action research process. Most important, teachers should revisit their individual goals to determine their appropriateness within their own educational situation. Teachers should also create a plan to revisit the evaluation process at some point in the future. The BRWEP program coordinator should also use this information to provide other participating teachers with advice and examples on how to conduct their own watershed education lessons. It may also be appropriate to share this information with the public, the media, funding agencies, and cooperating groups.


2Program goals can be found at: [http://www.ext.usu.edu/bearrivered/project/vision.html](http://www.ext.usu.edu/bearrivered/project/vision.html)
Who we are: A River Runs Through Us: The Bear River Watershed Education Project

What we’re seeking: We are searching for professional mentors to share their interest and knowledge of water quality, biology, agriculture, hydrology, cultural history or other related fields. You will be working with 5th - 12th grade students and their teachers throughout the Bear River basin, primarily during the spring and fall.

Project description: The goal of this project is to encourage students and teachers to become more knowledgeable citizens and caretakers of the Bear River watershed. We do this by promoting skills in problem-solving, scientific inquiry and analysis, as well as cooperation and understanding. To do this we: 1) train and support teachers as they undertake long-term monitoring activities with their students; 2) teach students the scientific method and how it is used in the collection and interpretation of data, as well as concepts in aquatic/riparian ecology and water quality; 3) help students think on a watershed scale, with emphasis on the interconnectedness of the scientific, historical, political, and cultural aspects of river systems; 4) offer opportunities for students to participate in restoration projects, work with professional mentors, and present data to interested parties- agencies, organizations, municipalities and schools.

On each field day students use Hach water quality kits to measure chemical properties of streams, take flow and other physical measurements, assess riparian vegetation, examine stream insects and look for signs of wildlife. Upon returning to the classroom, students enter data into an Internet database, look for trends or differences throughout the watershed, and prepare reports on their findings.

What you can do: We would like each participating school to have at least one professional mentor. If you have expertise in any scientific or socio-cultural field you can partner with a nearby school. Most schools monitor water quality in the spring and fall, one day per season. Field days usually last ½ to a full day on tributary streams close to the school. You can also give a presentation in the classroom or possibly help with analyzing data. We also hope to involve students with restoration projects (tree planting, fencing, trash clean-up, etc.) and could provide you with lots of energetic labor if you need it. We wish to establish long-term relationships with mentors who are willing to provide help to teachers each monitoring season. Time commitments are flexible and should be arranged with individual teachers.

Contact: Robes Parrish, (435) 797-2570, rparrish@cc.usu.edu
      Nancy Mesner, (435) 797-2465, nancym@ext.usu.edu

or see: http://www.ext.usu.edu/bearrivered
MENTOR AGREEMENT

A River Runs Through Us
Bear River Watershed Education Project

January 29, 2001

Marie E. Owens
Metropolitan Water District of Salt Lake & Sandy
9000 South Danish Rd.
Sandy, UT 84093-2102

Dear Marie;

Thank you for your interest in becoming a mentor for the Bear River Watershed Education Project (A River Runs Through Us). I hope that working with this project will be as rewarding for you as it will be to the teachers and students you work with.

Your level of involvement with a school should be arranged to meet your schedule and the needs of the individual teacher. Our hope is that mentors will team up with a school at least once per-season (i.e., spring and fall). We leave it up to you and the teacher you work with to decide how you will interact with the group – for example, participating on a field monitoring trip or coming to the classroom to talk about your work or some facet of watershed science. Perhaps your arrangement could also include e-mail or telephone support to answer student or teacher questions about water quality, data analysis, etc.

Below is a list of teachers and schools in Box Elder County who would be relatively close to you. If you would like contacts in other parts of the watershed please let us know. I have also sent a copy of this letter to them to let them know of your interest.

- Donna Capasso (contact information enclosed) works with an after-school group called “Friends of the Bear River Bird Refuge” in Brigham City. She also sometimes works with biologists from the Bird Refuge.
- Eldon Petersen (contact information enclosed) teaches at Bear River High School in Tremonton. Eldon does not yet have any mentors working with his class.

Again, thank you very much for expressing interest in mentoring a school group in our program. If you and a teacher decide to work together, please contact Nancy Mesner or me to discuss how we can help you make this a successful relationship.
Sincerely,

Robes Parrish  
Bear River Watershed Education Project

enclosure

cc: Donna Capasso  
Eldon Petersen  
Nancy Mesner
Bear River Watershed Education Project Contact Information:

**Teachers:**

Donna Capasso  
Adele C. Young Intermediate School  
830 Law Dr.  
Brigham City, UT 84302  
(435) 734-4940  
dcapasso@boxelder.k12.ut.us

Eldon Petersen  
Bear River High School  
1450 South Main  
Garland, UT 84312  
(435) 257-2512  
eldon@brhsoffice.boxelder.k12.ut.us

**Mentor:**

Marie E. Owens  
Metropolitan Water District of Salt Lake & Sandy  
9000 South Danish Rd.  
Sandy, UT 84093-2102  
(801) 942-1391 x1208  
mowens@mwdsls.org

**Program Contacts:**

Robes Parrish  
Bear River Watershed Education Project  
Rangeland Resources Dept.  
Utah State University  
5230 Old Main Hill  
Logan, UT 84322-5230  
(435) 797-2570  
rparrish@cc.usu.edu

Nancy Mesner  
Water Quality Specialist  
Dept. of Geography and Earth Resources  
Utah State University  
5240 Old Main Hill  
Logan, UT 84322-5240  
(435) 797-2465  
nancym@ext.usu.edu
Thatcher

Amalga Barrens

Brigham City

Evanston

above Bear Lake

der below Bear Lake

Bugs of polluted water

Bugs of good water

Bugs of excellent water
Nitrate nitrogen concentrations
(\(\text{NO}^3\)-N in ppm)

Samples collected March, 2000

\[
= 0.05 \text{ ppm}
\]
By looking at the width of the Bear River, can you tell where is the most phosphorus? Which tributary is contributing the most phosphorus?
Water temperature
September 20, 2000
(degrees F)

Why does it increase as the river moves downstream?

Why does it decrease as the river passes through Bear Lake?
Nitrogen Load in Bear River, Jan. 20th, 2000

The graph shows the nitrogen load in kg/day for different locations along the Bear River. The locations are labeled as Evanston, Randolph, above Bear Lake, below Bear Lake, Soda Springs, Thatcher, Amalga Barrens, and Brigham City. The load increases significantly from left to right, indicating a higher nitrogen concentration as one moves downstream.
INTERNET REFERENCES

School Home Pages for Watershed Education/Monitoring

Calloway County Schools Environmental Research Project (Kentucky):
   http://www.state.ky.us/agencies/nrepc/water/sip/cchs/10cchs.htm
Coon Rapids High School Great River Project (Minnesota):
   http://www.cards.anoka.k12.mn.us/projects/grp/mrp.html#menu
Corvallis High School Riparian Monitoring Project (Montana):
   http://www.corvallis.k12 mt.us/chsrmp/default.htm
Crooked River Project (Ohio):
   http://www.lerc.nasa.gov/Other_Groups/K-12/fenlewis/Cuyahoga_River.html
Marquette High School River Studies (Wisconsin):
   http://muhs.edu/links/riverstudies/index.html
Hillsdale-Lenawee-Monroe Math/Science Center Water Quality Studies (Michigan):
   http://imec.lisd.k12.mi.us/water.html
Silver Springs Elementary School River Wranglers (Nevada): http://sses.lyon.k12.nv.us/rwrangler.htm
Strongsville High School River Project (Ohio):
   http://www.grc.nasa.gov/WWW/k-12/fenlewis/homepage.html
Washington Park High School Root River 2000 Project (Wisconsin):
   http://parkhs.racine.k12.wi.us/Root2k/index.html
Watershed Studies at Horizons High School (Michigan):
   http://server.horizons.k12.mi.us/~eda/water/water/waterq.htm

State and Community Monitoring Organizations

Alabama Water Watch: http://www.auburn.edu/aww/
Alliance for the Chesapeake Bay Monitoring Program: http://www.acb-online.org/
Bear River Watershed Education Project: http://www.ext.usu.edu/bearrivered
Calloway County Schools Environmental Research Project (Kentucky):
   http://www.state.ky.us/agencies/nrepc/water/sip/cchs/10cchs.htm
Delaware River Basin Education Page: http://www.state.nj.us/drbc/edweb/edweb.htm
Flathead Basin Commission (Montana): http://www.digisys.net/fbc/
Fox/Wolf Rivers Environmental History Project (Wisconsin): http://www.foxwolf.org/
Georgia Adopt-A-Stream Program: http://www.riversalive.org/aas.htm
Georgia River Network: http://www.garivers.org/
Grand Lake St. Mary’s Watershed Project (Ohio): http://www.mercercountyohio.org/glsm/
Hoosier Riverwatch (Indiana): http://www.hoosierriverwatch.com/
Kentucky Water Watch: http://www.state.ky.us/nrepc/water/wwhomepg.htm
Maryland Save-Our-Streams Program: http://www.saveourstreams.org/
Mississippi Headwaters River Watch Project (Minnesota):
   http://www.mhbriverwatch.dst.mn.us/watch/watchindex.html
Missouri Stream Team: http://www.rollanet.org/~streams/
Montana Volunteer Water Monitoring Project: http://nris.state.mt.us/wis/volwatmon.htm
Montana Watercourse Program: http://www.montana.edu/wwwwater/
Montana State University Students and Teachers as Resources Project (STAR):
   http://www.math.montana.edu/~star/
Project del Rio (New Mexico, Texas, Mexico): http://www.econet.apc.org/green/delrio.html
Raccoon River Watershed Project (Iowa): http://www.rrwp.org/about.htm
River Watch Network (Vermont): http://www.riverwatch.org/index_noiframe.htm
Rivers of Colorado Water Watch Network: http://riverwatch.state.co.us/
San Marcos River Rangers (Texas): http://www.riverrats.net/smrr/ranger01.htm
Student Watershed Research Project (Oregon): http://www.swrp.org/
Testing the Waters Program (Wisconsin): http://muhs.edu/links/riverstudies/ttw.html
Texas Watch Environmental Monitoring Program: http://www.texaswatch.geo.swt.edu/
The Friends of the Chicago River (Illinois): http://www.chicagoriver.org/
The Friends of Casco Bay (Maine): http://www.cascobay.org/
Thorton Creek Project (Washington): http://nsccux.sccd.etc.edu/~tcp/
University of Rhode Island Watershed Watch: http://www.edc.uri.edu/uriww/
Upper Chattahoochee River Keepers (Georgia): http://www.ucriverkeeper.org/
Utah's Stream Connections: http://www.uen.org/stream/
Vermont Rivers Project: http://dauntless.smcvt.edu/vt_rivers/splash.html
Virginia Save-Our-Streams:
Watersheds Unite (Iowa): http://hometown.aol.com/watershedsunite

National Watershed Monitoring Organizations

Adopt-A-Stream Foundation: http://www.streamkeeper.org/
Izaak Walton League Save-Our-Streams Program: http://www.iwla.org/SOS/index.html
Global Rivers Environmental Education Network (GREEN): http://www.earthforce.org/green/

International Watershed Education and Monitoring Programs

Global Rivers Environmental Education Network (GREEN): http://www.earthforce.org/green/
Global Water Sampling Project: http://k12science.ati.stevens-tech.edu/curriculum/waterproj/
Global Learning and Observations to Benefit the Environment (GLOBE): http://www.globe.gov/
International Rivers Network: http://www.irn.org/
UK Rivers Network: http://www.ukrivers.net/

National Watershed Protection Groups

American Rivers Council: http://www.americanrivers.org
Center for Watershed Protection: http://www.cwp.org/
Environmental Support Center: http://www.envsc.org/
Rivers Network: http://www.rivernet.org/

Environmental Education Organizations

Cuyahoga Valley Environmental Education Center (Ohio): http://www.cveec.org/
The Institute for Conservation Leadership: http://www.icl.org/
Colorado Discovery Science Center Museum: http://www.dcsrm.org/
North American Association for Environmental Education (NAAEE): http://www.naeee.org/
Project Learning Tree: http://www.hcs.ohio-state.edu/ODNR/Education/infolnt.htm
Project WET: http://www.projectwet.org/
Project WILD: http://www.projectwild.org/
Utah Society for Environmental Education: http://www.usee.org/

Education Departments

EPA Office of Environmental Education http://www.epa.gov/enviroed/
Idaho Department of Education: http://www.sde.state.id.us/Dept/
Utah State Office of Education: http://www.usoe.k12.ut.us/
Wyoming Department of Education: http://www.k12.wy.us/

Education Standards

Idaho Education Standards: http://www.sde.state.id.us/osbe/exstand.htm
Utah Education Standards: http://www.uen.org/cgi-bin/websq1/utahlink/CoreHome.hts
Wyoming Education Standards: http://www.k12.wy.us/publications/standards/
**Bear River Watershed Education Project Related**

Bear River Watershed Education Project: [http://www.ext.usu.edu/bearrivered](http://www.ext.usu.edu/bearrivered)
Bear River Migratory Bird Refuge: [http://www.northernutah.com/brefuge.htm](http://www.northernutah.com/brefuge.htm)
Bear River RC&D: [http://www.bearrivercd.org/](http://www.bearrivercd.org/)
Utah Education Network (UEN), UtahLink Weather Reports: [http://www.uen.org/utahlink/weather/](http://www.uen.org/utahlink/weather/)
Utah’s Stream Connections: [http://www.uen.org/stream/](http://www.uen.org/stream/)
Utah SURWEB Media Shows: [http://www.surweb.org/Search/MS_Classroom.asp](http://www.surweb.org/Search/MS_Classroom.asp)

**Publications and Other Resources**

Education Gateway: [http://edgateway.net/](http://edgateway.net/)
EPA Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers:
EPA Guide to Developing a Quality Assurance Project Plan (QAPP):
  [http://www.epa.gov/OWOW/monitoring/volunteer/qappcovr.htm](http://www.epa.gov/OWOW/monitoring/volunteer/qappcovr.htm)
Library of Congress: Appalachia On-line Slide Show:
  [http://memory.loc.gov/ammem/cmnshome.html](http://memory.loc.gov/ammem/cmnshome.html)
National Service Learning Clearinghouse: [http://www.nicsl.coled.umn.edu/default.html](http://www.nicsl.coled.umn.edu/default.html)
National Directory of Volunteer Environmental Monitoring Programs:
State Education and Environment Roundtable: [http://www.seer.org](http://www.seer.org)
The Volunteer Monitor On-line Newsletter:
  [http://www.epa.gov/OWOW/monitoring/volunteer/vm_index.html](http://www.epa.gov/OWOW/monitoring/volunteer/vm_index.html)
The Volunteer Monitor: Issue on School-Based Monitoring:
  [http://www.epa.gov/volunteer/spring93/index.html](http://www.epa.gov/volunteer/spring93/index.html)
SAMPLE GRANT PROPOSAL & BUDGET

The Bear River begins high in the Uinta Mountains of Utah, flows through three states (WY, ID, UT), and ends its 500-mile journey in the Great Salt Lake, a mere 80-miles from its source. Historically, agricultural, domestic, recreational, industrial, and municipal demands have been placed on the river, which cumulatively have led to a serious decline in water quality along certain reaches. As these demands grow, it is increasingly important to implement monitoring programs which educate and inspire citizens to take a more active role in maintaining this vital ecosystem.

The Bear River Watershed Education Project was created to allow 5th - 12th grade teachers in all three Bear River basin states to monitor water quality with their students, and to cooperatively share data regarding the condition of the river. Besides fostering an interest in scientific investigation, it affords teachers the unique opportunity to integrate several non-science subjects (e.g., history, art, writing) into their monitoring program. The program has the following five objectives: 1) to train and support teachers as they undertake long-term monitoring activities with their students; 2) to teach students the scientific method and how it is used in the collection and interpretation of data, as well as concepts in aquatic/riparian ecology and water quality; 3) to help students think on a watershed scale whereby the interconnectedness of the scientific, historical, political, and cultural aspects of river systems is emphasized; 4) to offer opportunities for students to participate in restoration projects, work with professional mentors, and present data to interested parties- agencies, organizations, municipalities and schools; 5) to develop a process model that can be used by other schools and communities to investigate and monitor river systems at the watershed scale.

This program is being administered by the College of Natural Resources at Utah State University (USU), the Water Quality Extension Program at USU, and the Allen and Alice Stokes Nature Center, Logan, Utah. This unique relationship among University Extension, faculty, graduate students, a local nature center, and public schools throughout the three Bear River basin states provides benefit to a great many people. Since the program’s inception in August 1999, twenty teachers and approximately 450 students have been trained in the use of a water quality monitoring protocol developed specifically for the Bear River watershed. In addition, an online database has been created to allow students to remotely enter and analyze data throughout the watershed. Five equipment trunks were also purchased to allow several participating schools to conduct monitoring activities.

Our program seeks to move forward by expanding the scope of the project within the Bear River basin. A full-time graduate student/coordinator will provide advanced training with existing teachers and students participating in the project. Additional teachers throughout the watershed will be enlisted and trained in the sampling protocol. With training from a graduate student, teachers will help students to analyze data in the classroom using a variety of tools, such as spreadsheets, graphical programs, and GIS. The coordinator will also assist teachers in developing an interdisciplinary curriculum to bring English, math, chemistry, geography, and history concepts together into an educational framework based around the Bear River. This person will also be responsible for coordinating restoration projects between federal, state, and local agencies, private citizens, and school groups when appropriate. The coordinator will develop a process model and program evaluation that will outline how future watershed scale monitoring projects can be organized and implemented in other basins.
## PROPOSED BUDGET

### Personnel
Graduate Student/ Program Coordinator @ $1200/mo.

### Travel
- Field Monitoring visits @ $0.30/mi.  
  \[ \times 3000 \text{mi/yr} \]  
  \[ 900 \]  
- Classroom training @ $0.30/mi.  
  \[ \times 1500 \text{mi/yr} \]  
  \[ 450 \]  
- Per diem @ $25/day  
  \[ 750 \]  

### Technology
Web/Database maintenance (contracted) @ $12/hr  
\[ 600 \]  

### Monitoring Equipment*
- Equipment trunks: 5 @ $300/ea  
  \[ 1500 \]  

### Miscellaneous
- Office supplies, copying, etc.  
  \[ 250 \]

### TOTAL DIRECT COSTS
\[ 18,850 \]

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*Monitoring trunks include:
1. Sampling Protocol
2. 2 pairs of chest waders with straps and belt
3. 4 hand lenses
4. 4 250mL plastic squirt bottles
5. 10 plastic pipettes w/petri dishes
6. 5 glass bug sample jars
7. 1 pair of tweezers
8. 4 plastic bug trays
9. 2-3 bug identification keys
10. 1 kick net
11. 1 D-net
12. 1 ocular tube
13. 1 roll of colored flagging tape
14. 1 100-foot tape measure
15. 1 wooden meter stick
16. 1 pkg ping pong balls
17. 1 box of pH strips
18. 1 metal thermometer
19. 1 turbidity tube
20. 1 dissolved oxygen kit
21. 1 nitrate kit
22. 1 phosphorous kit
23. 1 box latex gloves
24. 2 pairs of safety glasses
25. 1 disposable camera
26. 1 First Aid kit
27. 1 calculator
28. 3 clipboards