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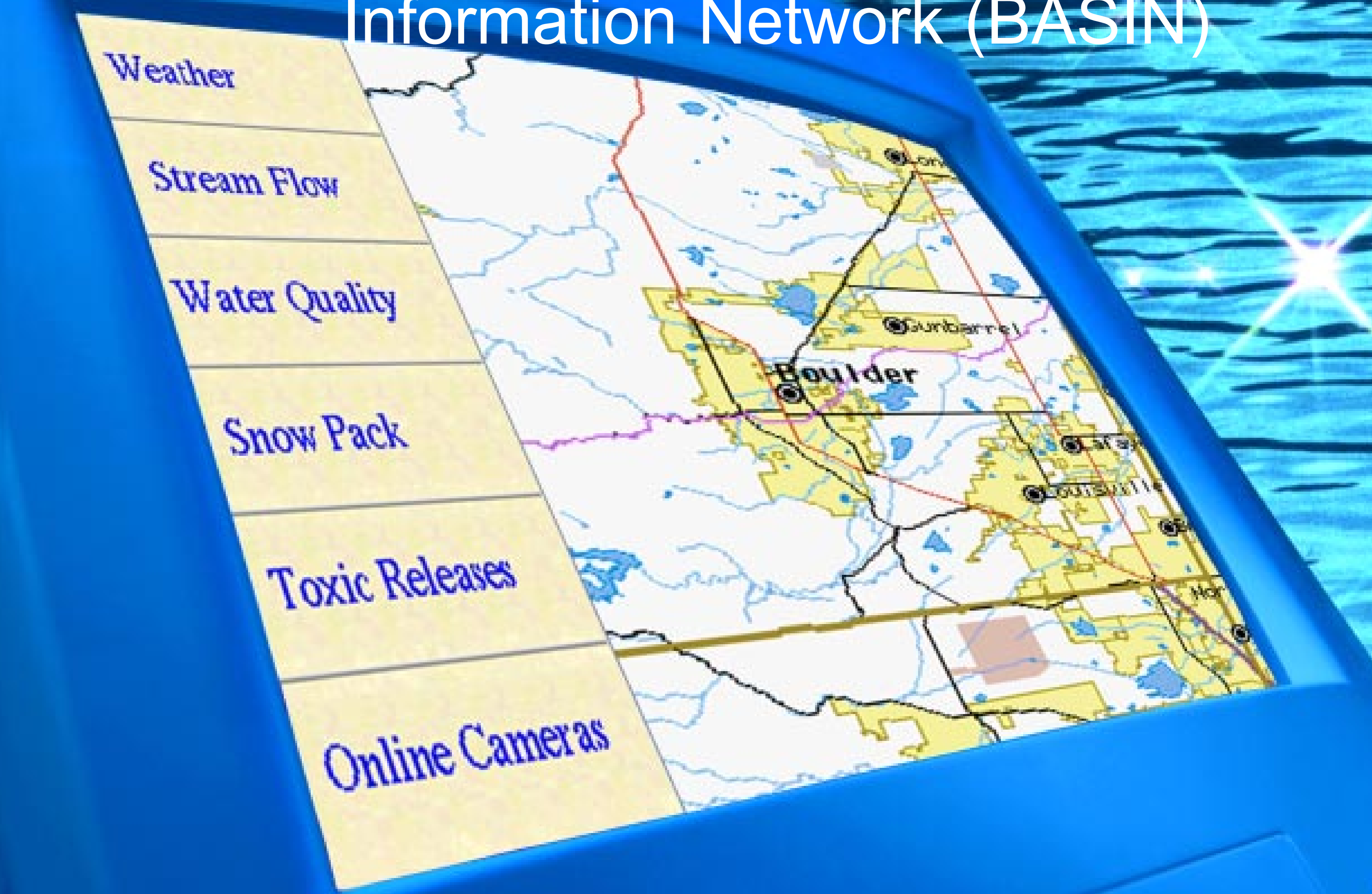
Delivering Timely Environmental Information to Your Community

The Boulder Area Sustainability Information Network (BASIN)



E M P A C T

Environmental Monitoring for Public Access
& Community Tracking

Disclaimer

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The Boulder Area Sustainability Information Network (BASIN)

United States Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
Cincinnati, OH 45268

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1. INTRODUCTION

1.1 Background

BASIN, the **B**oulder **A**rea **S**ustainability **I**nformation **N**etwork, began as a two year pilot project designed to deliver a variety of environmental information about the Boulder, Colorado area to its inhabitants. As an ongoing model for the localization of socio-ecological data and information, BASIN seeks to improve public access and understanding of environmental information by fostering a collaborative partnership between researchers, data collectors, educators and the general public and actively seeks community involvement in information development and learning and services activities. [Source: http://bcn.boulder.co.us/basin/main/about.html]

Note!

> The Colorado BASIN project should not be confused with the Environmental Protection Agency's BASINS (Better Assessment Science Integration Point and Nonpoint Sources) Modeling Course. The BASINS Modeling Course is a watershed training course offered by the EPA's Office of Wetlands, Oceans, & Watershed. Please see http://www.epa.gov/waterscience/BASINS/ for more information about BASINS.

BASIN project components include:

- **Data Providers** - agencies who either actively provided data to BASIN or had relevant environmental data available on the Web. BASIN utilized data collected by the following agencies:

  - City of Boulder, Drinking Water Program
  - City of Boulder, Storm Water Quality Program
  - City of Longmont
  - Colorado Air Pollution Control Division
  - Colorado's River Watch Program
  - SNOwpack TELemetry (SNOTEL)
  - United States Geological Survey (USGS)

- **Information Collection, Management and Delivery** - a system to maintain environmental data and to establish and maintain communication links. The key agencies responsible for this effort are as follows:

  - City of Boulder
  - enfo.com, Colorado

- **Communications** - led by the Communications Coordinator, this component of BASIN served to communicate information about environmental conditions and to facilitate community and school-based participation in new and existing environmental programs. General content and background materials on the BASIN Web site, the BASIN Newsletter, BASIN Television and CD-ROM programs, and other education and outreach materials were developed through BASIN Communications. The following agencies were responsible for developing the ECOSOURCE material:

  - City of Boulder
  - Boulder Community Network
  - Boulder Valley School District
  - Community Access TV

For the purposes of this Environmental Monitoring for Public Access and Community Tracking (EMPACT) project, the "Boulder area" is defined as the St. Vrain Watershed, a 993 square mile region that extends from the Continental Divide to the High Plains and includes over 285,000 people [Source: http://www.bococivicforum.org/indicators/people/05.html].

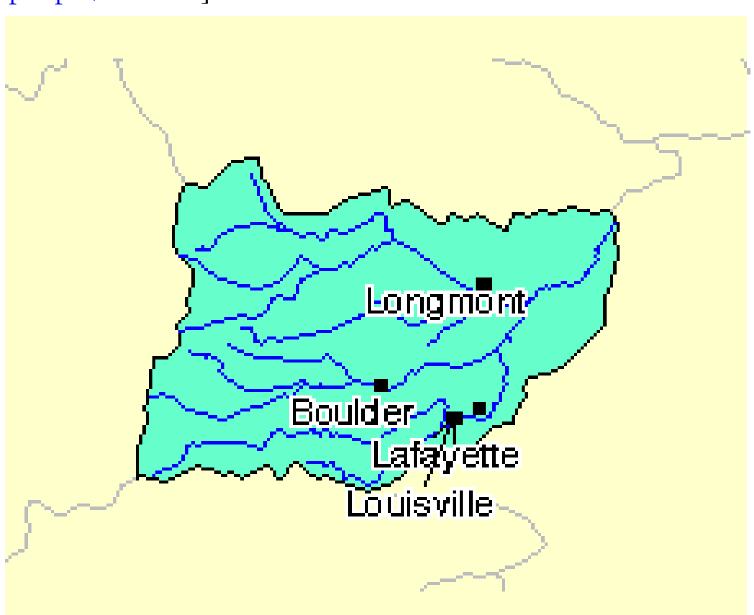


Figure 1.1 St. Vrain Watershed.
Source: http://bcn.boulder.co.us/basin/watershed/address.html

The BASIN project was one of eight EMPACT projects funded by the U.S. Environmental Protection Agency's (EPA's) Office of Research and Development (ORD) in 1998. The EMPACT program was created to introduce new technologies that make it possible to provide timely environmental information to the public.

1.2 EMPACT Overview

This handbook offers step-by-step instructions about how to provide a variety of timely environmental information including water quality data to your community. It was developed by the EPA's EMPACT program. EMPACT is working with the 150 largest metropolitan areas and Native American Tribes in the country to help communities in these areas:

- Collect, manage, and distribute timely environmental information.
- Provide residents with easy-to-understand information they can use in making informed, day-to-day decisions.

To make this and other EMPACT projects more effective, partnerships with the National Oceanic and Atmospheric Administration (NOAA) and the USGS were developed. EPA works closely with these federal agencies to help achieve nationwide consistency in measuring environmental data, managing the information, and delivering it to the public.

To date, environmental information projects have been initiated in 84 of the 150 EMPACT- designated metropolitan areas and Native American Tribes. These projects cover a wide range of environmental issues, including water quality, groundwater contamination, smog, ultraviolet radiation, and overall ecosystem quality. Some of these projects were initiated directly by EPA, while others were launched by EMPACT communities themselves. Local governments from any of the 150 EMPACT metropolitan areas and Native American Tribes are eligible to apply for EPA-funded Metro Grants to develop their own EMPACT projects. The 150 EMPACT metropolitan areas and Native American Tribes are listed in the table at the end of this chapter.

Communities selected for Metro Grant awards are responsible for building their own timely environmental monitoring and information delivery systems. To find out how to apply for a Metro Grant, visit the EMPACT Web site at http://www.epa.gov/empact/apply.htm.

One such Metro Grant recipient is the BASIN Project. The project provides the public with a variety of timely environmental information about the Boulder area including weather, stream flow, water quality, snow pack, and toxic release data, as well as an extensive compilation of supplemental information to provide interpretive context for the environmental data.

1.3 BASIN EMPACT Project

1.3.1 Overview/Approach

The primary goal of BASIN was to help Boulder area residents make meaningful connections between environmental data and their daily activities and enable involvement in the development of public policy, especially as it relates to the local environment. The BASIN project focused on critical local and regional environmental issues that pertained to the Boulder Creek Watershed.

The data provided on the BASIN Web site were selected by the BASIN Project team based on the following criteria:

- Significance of the data to the local community/environment,
- Availability of the data,
- Interest to the local community,
- Feasibility for putting the data on the Web site, and
- Sensitivity of the data (e.g., controversial data)

There are three classifications of data available on the BASIN Web site.

- Data links to other Web sites (e.g., SNOTEL, weather, toxic releases, and stream flow) where BASIN did not have any principal relations with the data providers and had no influence on the collection, analysis, or quality control of the data.

- Acquired data, where BASIN dealt with the data providers but had no direct influence on the data collection or quality control of the data (e.g., River Watch data and City of Longmont).

- Direct data, where BASIN had an interactive relationship with the data provider and had input on the data format, collection protocols, and QA/QC (i.e., City of Boulder's drinking water and storm water data and USGS data).

The BASIN approach emphasizes "timely" information over "real-time" data. Acquiring and delivering "real-time" data involves a high frequency of data sampling, transmission, and display. Costs are proportionately higher and tend to reduce other aspects of a project accordingly. Therefore, high frequency data presentation should only be incorporated when it is essential to the usefulness of the data. In many applications, "timely" data may provide the same desirable features as "real-time" data. For the BASIN project, "timely" means the most current available data set, presented with the appropriate supporting contextual information. This approach avoids the problems associated with static data sets that quickly become outdated, but avoids the higher maintenance costs associated with "real-time" data delivery.

1.3.2 BASIN EMPACT Project Team

The BASIN Project team consists of both principal and collaborative partners. The principal BASIN partners are as follows: [http://bcn.boulder.co.us/basin/adm/contributors.html]

- City of Boulder - provided overall project coordination as well as drinking water and storm water monitoring data.
- enfo.com. - directed design and development of the BASIN InformationManagement System and provided technical coordination of Web site designand development (see http://www.enfo.com).
- Mark McCaffrey - Communications Coordinator for the BASIN Project. As an environmental educator and co-founder of the Boulder Creek Watershed Initiative, Mark was involved with developing the original BASIN EMPACT proposal and, as Communications Coordinator, assisted in establishing the network of both principal and collaborative partners for the BASIN project.
- University of Colorado Department of Civil Engineering and Architectural Engineering - served as one of the initial EMPACT grant writers; developed data collection and interpretation strategies for the integrated water quality component; and studied residential water use.
- USGS/Dr. Larry Barber - provided data collection, analysis and interpretation guidance and participated in the development of the Boulder Creek Millennium Baseline data collection program.
- Michael Caplan - Community liaison and team facilitation.

Collaborative Partners include the following:

- Boulder Community Network.
- Boulder County Healthy Communities Initiative.
- Boulder County Health Department.
- Boulder Creek Watershed Initiative.
- Boulder Valley School District.
- Colorado Division of Wildlife-River Watch Network.
- Community Access Television.
- United States Geological Survey

1.3.3 Project Costs

Overall - The costs to conduct a monitoring project similar to the BASIN Project can vary significantly. Factors affecting the cost include, but are not limited to, the size and location of your study area, the types of information available from potential collaborative partners, the number and types of parameters you want to measure, the number of personnel needed to collect and analyze the data, the number of samples to collect, the amount of new equipment which will need to be purchased, etc. For the BASIN project, the BASIN team purchased a Sun SPARC Database Server Platform for $10,000.

The BASIN team originally submitted an EMPACT Metro Grant Application/ Proposal for $600,000. However, due to limited EMPACT resources, the BASIN project was funded the reduced budget of $400,000 for two years beginning in January 1999. Provided below is brief discussion of the primary project components of the BASIN project. Figure 1.2 provides the budget expenditures for the BASIN's monitoring project. [Source: BASIN Project 2000 Annual Report, dated January 30, 2001]

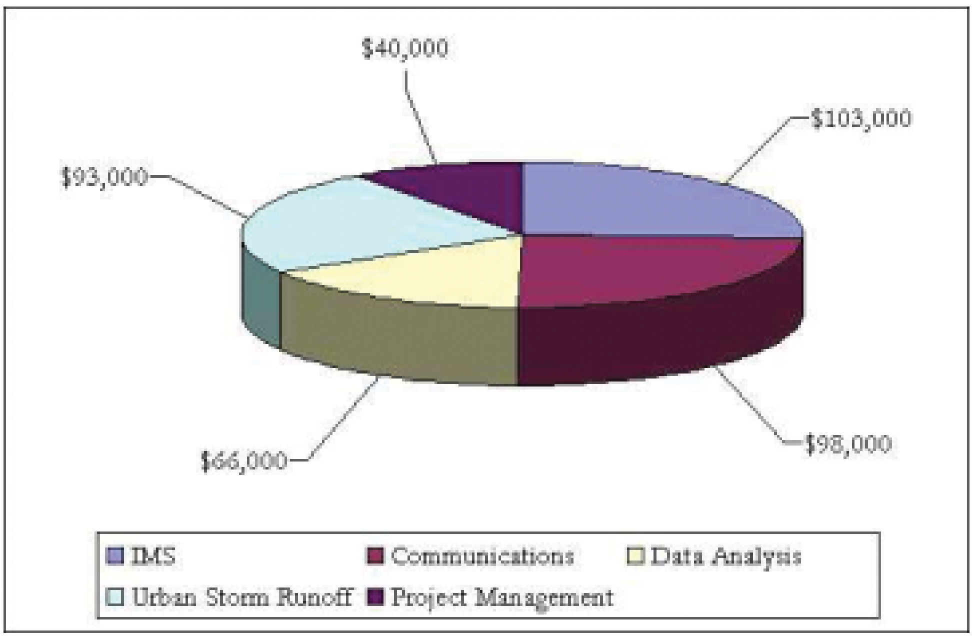


Figure 1.2 Budget Expenditures for the BASIN Project.

Information Management System (IMS) - effort included developing data provider partnerships, identifying IMS software requirements, implementing IMS system, development of the bibliographic database and supporting user interface, development of an event calendar database and user interface, development of a photograph database and user interface, maintenance of timely data acquisition and display protocols, providing e-mail forum support, and general maintenance of the BASIN Web site. This effort comprised approximately 26 percent of the $400,000 project budget.

Communications - effort included Web site design; assistance in the development of video productions about BASIN and Boulder Creek, publishing the bi-monthly *BASIN NEWS* newsletter, hosting on-line discussion regarding drought, fires, and floods, and developing specific learning activities and promoting BASIN in local schools. This effort comprised approximately 24 percent of the $400,000 project budget.

Data Analysis - effort included collecting, compiling, and analyzing existing water quality data, as well as developing a protocol to transmit the QA/QC validated data to the Web site. Monthly data for 17 parameters measured along Boulder creeks were made available on the BASIN Web site. This effort also included the compilation of a 450-item Boulder Creek Watershed Bibliography which can be queried via the BASIN Web site (see IMS) and the development of an extensive list of household hazards and environmentally benign alternatives. This effort comprised approximately 17 percent of the $400,000 project budget.

Urban Storm Runoff - effort included developing a better understanding of micro-scale runoff relationships at a small-scale urban site, developing an overall water balance model of a small urban site, and developing a process level understanding of the residential water use. This effort comprised approximately 23 percent of the $400,000 project budget.

Project Management - effort included maintaining communications with grant agency, project managers, and all BASIN participants, administering grant and subcontractor contracts and correspondence, maintaining EPA approved Grant Management Filing System, serving as a liaison between granting agency and city; providing oversite of the Environmental Index development process, and producing the *BASIN NEWS* newsletter. This effort comprised approximately 10 percent of the $400,000 project budget.

1.3.4 EMPACT Project Objectives

Overall BASIN project objectives include the following:

- Improve existing environmental monitoring to provide credible, timely and usable information about the watershed to the public.
- Create a state-of-the-art information management and public access infrastructure using advanced, web-based computer technologies.
- Build strong partnerships and an ongoing alliance of governmental, educational, non-profit and private entities involved in watershed monitoring, management, and education.

- Develop education and communication programs to effectively utilize watershed information in the public media and schools and facilitate greater public involvement in public policy formation.

1.3.5 Technology Transfer Handbook

The Technology Transfer and Support Division of the EPA's ORD National Risk Management Research Laboratory initiated development of this handbook to help interested communities learn more about the BASIN Project. The handbook also provides technical information communities need to develop and manage their own timely watershed monitoring, data visualization, and information dissemination programs. ORD, working with the BASIN Project team, produced this handbook to leverage EMPACT's investment in the project and minimize the resources needed to implement similar projects in other communities.

Both print and CD_ROM versions of the handbook are available for direct on_line ordering from EPA's ORD Technology Transfer Web site at http://www.epa.gov/ttbnrmrl. You can also order a copy of the handbook (print or CD-ROM version) by contacting ORD Publications by telephone or by mail at:

EPA ORD Publications
USEPA-NCEPI
P.O. Box 42419
Cincinnati, OH 45242
Phone: (800) 490-9198 or (513) 489-8190

Note!

Please make sure that you include the title of the handbook and the EPA document number in your request.

We hope you find the handbook worthwhile, informative, and easy to use. We welcome your comments, and you can send them by e-mail from EMPACT's Web site at http://www.epa.gov/empact/comment.htm.

1.4 EMPACT Metropolitan Areas

Albany-Schenectady-Troy, NY
Albuquerque, NM
Allentown-Bethlehem-Easton, PA
Anchorage, AK
Appleton-Oshkosh-Neenah, WI
Atlanta, GA
Augusta-Aiken, GA-SC
Austin-San Marcos, TX
Bakersfield, CA
Baton Rouge, LA
Beaumont-Port Arthur, TX
Billings, MT
Biloxi-Gulfport-Pascagoula, MS
Binghamton, NY
Birmingham, AL
Boise City, ID
Boston-Worcester-Lawrence-MA-NH-ME-CT

Brownsville-Harlingen-San Benito, TX
Buffalo-Niagara Falls, NY
Burlington, VT
Canton-Massillon, OH
Charleston-North Charleston, SC
Charleston, WV
Charlotte-Gastonia-Rock Hill, NC-SC
Chattanooga, TN-GA
Cheyenne, WY
Chicago-Gary-Kenosha, IL-IN-WI
Cincinnati-Hamilton, OH-KY-IN
Cleveland, Akron, OH
Colorado Springs, CO
Columbia, SC
Columbus, GA-AL
Columbus, OH
Corpus, Christie, TX
Dallas-Fort Worth, TX
Davenport-Moline-Rock Island, IA-IL
Dayton-Springfield, OH
Daytona Beach, FL
Denver-Boulder-Greeley, CO
Des Moines, IA
Detroit-Ann Arbor-Flint, MI
Duluth-Superior, MN-WI
El Paso, TX
Erie, PA
Eugene-Springfield, OR
Evansville-Henderson, IN-KY
Fargo-Moorhead, ND-MN
Fayetteville, NC
Fayetteville-Springfield-Rogers, AR
Fort Collins-Loveland, CO
Fort Myers-Cape Coral, FL
Fort Pierce-Port St. Lucie, FL
Fort Wayne, IN
Fresno, CA
Grand Rapids-Muskegon-Holland, MI
Greensboro-Winston-Salem-High Point, NC
Greenville-Spartanburg-Anderson, SC
Harrisburg-Lebanon-Carlisle, PA
Hartford, CT
Hickory-Morganton-Lenoir, NC
Honolulu, HI
Houston-Galveston-Brazoria, TX
Huntington-Ashland, WV-KY-OH
Huntsville, AL
Indianapolis, IN
Jackson, MS
Jacksonville, FL
Johnson City-Kingsport-Bristol, TN-VA
Johnston, PA
Kalamazoo-Battle Creek, MI
Kansas City, MO-KS
Killeen-Temple, TX
Knoxville, TN
Lafayette, LA
Lakeland-Winter Haven, FL
Lancaster, PA
Lansing- East Lansing, MI
Las Vegas, NV-AZ
Lexington, KY
Lincoln, NE
Little Rock-North Little Rock, AR
Los Angeles-Riverside-Orange County, CA
Louisville, KY-IN
Lubbock, TX
Macon, GA
Madison, WI
McAllen-Edinburg-Mission, TX
Melbourne-Titusville-Palm Bay, FL
Memphis, TN-AR-MS
Miami-Fort Lauderdale, FL
Milwaukee-Racine, WI
Minneapolis-St. Paul, MN-WI
Mobile, AL
Modesto, CA
Montgomery, AL
Nashville, TN
New London-Norwich, CT-RI
New Orleans, LA
New York-Northern New Jersey-Long Island, NY-NJ-CT-PA
Norfolk-Virginia Beach-Newport News, VA-NC
Ocala, FL
Odessa-Midland, TX Oklahoma City, OK
Omaha, NE-IA
Orlando, FL
Pensacola, FL
Peoria-Pekin, IL
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD
Phoenix-Mesa, AZ
Pittsburgh, PA
Portland, ME
Portland-Salem, OR-WA
Providence-Fall River-Warwick, RI-MA
Provo-Orem, UT
Raleigh-Durham-Chapel Hill, NC
Reading, PA
Reno, NV
Richmond-Petersburg, VA
Roanoke, VA
Rochester, NY
Rockford, IL
Sacramento-Yolo, CA
Saginaw-Bay City-Midland, MI
St. Louis, MO-IL
Salinas, CA
Salt Lake City-Ogden, UT
San Antonio, TX
San Diego, CA
San Francisco-Oakland-San Jose, CA
San Juan-Caguas-Arecibo, PR
San Luis Obispo-Atascadero-Paso Robles, CA
Santa Barbara-Santa Maria-Lompoc, CA
Sarasota-Bradenton, FL
Savannah, GA
Scranton-Wilkes Barre-Hazleton, PA
Seattle-Tacoma-Bremerton, WA
Shreveport-Bossier City, LA
Sioux Falls, SD
South Bend, IN
Spokane, WA
Springfield, MA
Springfield, MO
Stockton-Lodi, CA
Syracuse, NY
Tallahassee, FL
Tampa-St. Petersburg-Clearwater, FL
Toledo, OH
Tucson, AZ
Tulsa, OK Visalia-Tulare-Porterville, CA
Utica-Rome, NY
Washington-Baltimore, DC-MD-VA-WV
West Palm Beach-Boca Raton, FL
Wichita, KS
York, PA
Youngstown-Warren, OH

Federally recognized Native American Tribes

2. HOW TO USE THIS HANDBOOK

The remainder of this handbook provides you with step_by_step information on how to develop a program to provide timely environmental data to your community using the BASIN Project in the Boulder, Colorado area as a model. It contains detailed guidance on how to:

1. Establish partnerships with community stakeholders and data collection organizations and collect supporting information sources.
2. Prototype data management procedures and data presentation standards while formalizing data sharing partnerships.
3. Present prototype systems to partner organizations and community stakeholders and gather feedback.
4. Revise and update system to reflect feedback while expanding both data sharing partnerships and public outreach efforts.

- Chapter 3 provides information about gathering environmental monitoring data. The chapter begins with an overview of the BASIN watershed and discusses the importance of sustainability. The chapter then focuses on the types of data provided on the BASIN Web site and the environmental parameters that are monitored in the BASIN watershed.

- Chapter 4 provides information on how to collect, transfer, and manage timely environmental data. This chapter discusses the sources of the timely environmental data (i.e., who or which organization collects the data for the BASIN project) and the data transfer and management process. In particular, this chapter provides detailed information on collecting, transferring, and managing the data.

- Chapter 5 provides information about using data presentation tools to graphically depict the timely environmental monitoring data you have gathered. The chapter begins with a brief overview of data presentation. It then provides a more detailed introduction to selected data presentation tools utilized by the BASIN team. You might want to use these software tools to help analyze your data and in your efforts to provide timely environmental information to your community.

- Chapter 6 outlines the steps involved in developing an outreach plan to communicate information about environmental data in your community. It also provides information about the BASIN Project's outreach efforts. The chapter includes a list of resources to help you develop easily understandable materials to communicate information about your timely environmental monitoring program to a variety of audiences.

This handbook is designed for decision-makers considering whether to implement a timely environmental monitoring program in their communities and for technicians responsible for implementing these programs. Managers and decision_makers likely will find the initial sections of , and most helpful. The latter sections of these chapters are targeted primarily at professionals and technicians and provide detailed "how to" information. Chapter 6 is designed for managers and communication specialists.

The handbook also refers you to supplementary sources of information, such as Web sites and guidance documents, where you can find additional guidance with a greater level of technical detail. The handbook also describes some of the lessons learned by the BASIN team in developing and implementing its timely environmental monitoring, data management, and outreach program.

3. BASIN EMPACT PROJECT

This chapter provides information about the BASIN watershed area, the importance of "sustainability," and important parameters for measuring the health of a watershed. Understanding your area and knowing what it must provide is the first step in the process of generating timely environmental information and making it available to residents in your area.

The chapter begins with a broad overview of the "Boulder Area" watershed characteristics and discusses why sustainability is important. The chapter then discusses the various parameters which are monitored to measure the condition of the watershed.

Readers primarily interested in learning about watersheds and environmental sustainability should read Sections 3.1 and 3.2. Readers primarily interested in an overview of the types of environmental data that are available for a community should read Section 3.3.

3.1 Boulder Creek Watershed Characteristics

A watershed is the entire drainage area or basin feeding a stream or river. It includes surface water, groundwater, vegetation, and human structures. Watersheds vary in size from just a few acres to hundreds of square miles - and everyone lives in one. One of the main functions of a watershed is to temporarily store and transport water from the land surface to a water body (e.g., stream or river) and ultimately (for most watersheds) onward to the ocean. In addition to moving the water, watersheds and their water bodies also transport sediment and other materials (including pollutants), energy, and many types of organisms. Watersheds also recharge drinking water reservoirs within the watershed. [Source: http://www.epa.gov/owow/watershed/wacademy/acad2000/ecology/ecology18.html]

Boulder Creek is a small watershed located in the Front Range of the Rocky Mountains, east of the Continental Divide in central Colorado. Boulder Creek is part of the Mississippi River Basin, and reaches the Mississippi River by way of the St. Vrain, South Platte, Platte, and Missouri Rivers. The watershed encompasses about 1100 km^2 (440 sq. mi.) and consists of two physiographic provinces. The upper basin, defined on the west by the Continental Divide, is part of the Southern Rocky Mountain Province. The lower basin, defined on the west by the foothills of the Rocky Mountains, is part of the Colorado Piedmont Section of the Great Plains Province. These regions differ significantly in topography, geology, and hydrology. The upper basin is composed primarily of Pre-Cambrian Age metamorphic and granitic rocks, which are very weather resistant, while the lower basin is dominated by sedimentary rocks, which are more easily eroded. In addition to the physiographic province delineations, land use has imprinted such a strong signal on the watershed that it can be further divided into five regions: mountains, transportation corridor, urban, wastewater-dominated, and agricultural (Source: S.F. Murphy, P.L. Verplanck, and L.B. Barber, "Chemical Data for Water Samples Collected from Boulder Creek, Colorado, During High-Flow and Low-Flow Conditions, 2000," to be submitted as a USGS Open File Report).

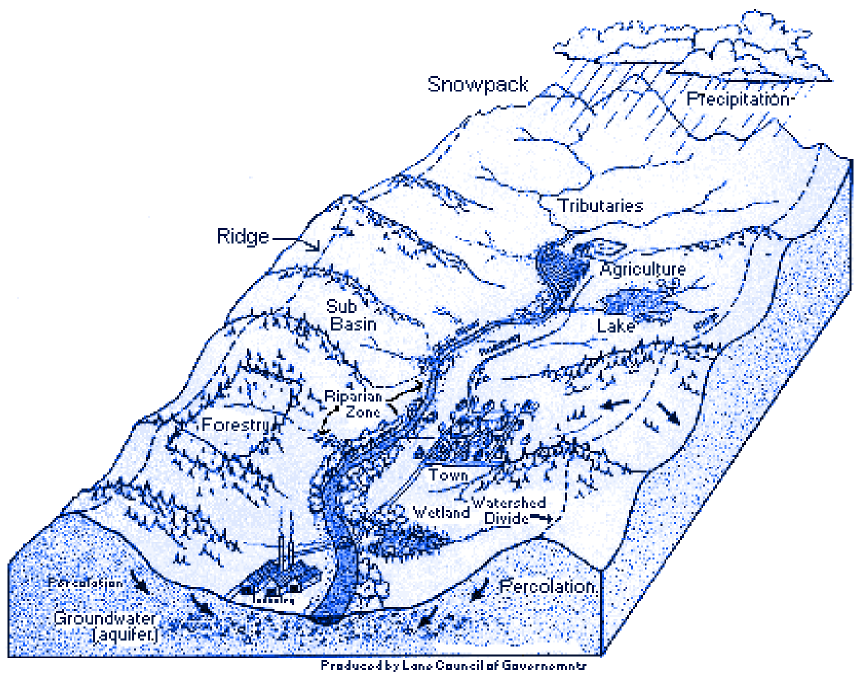


Figure 3.1. Schematic of a Watershed.
[Source: http://www.epa.gov/OWOW/win/what.html]

For the purposes of the EMPACT project, the "Boulder Area" is the St. Vrain Watershed. It encompasses a 993 square mile region that extends from the Continental Divide to the High Plains and includes approximately 285,000 people. The City of Boulder is the largest metropolitan area within the Boulder Creek Watershed. Other communities in the Boulder Creek Watershed include Nederland, Longmont, Louisville, and Lafayette.

West of Boulder there are prime snowmelt water supplies adjacent to abandoned and active mines, recreation areas, growing mountain communities and forest fire zones. Steep canyons above Boulder make it one of the state's primary flood areas. Runoff from these canyons causes erosion and transports pollutants into Boulder's creeks. East of the City, the land topography changes to a plains environment where there are dramatic changes in the water flow patterns and ecosystem. At this point, Boulder Creek becomes heavily impacted by the city's Wastewater Treatment Plant. [Source: 1998 EMPACT Grant Application]

Several creeks and tributaries exist in the Boulder Creek Watershed. These include Boulder Creek, St. Vrain Creek, Rock Creek, Coal Creek, Four Mile Creek, Sunshine Creek, Goose Creek, and Lefthand Creek.

The Boulder area, particularly the eastern portion of Boulder, are "semi-arid" plains while the mountains to the west are wetter and receive most of their precipitation in the form of snow during the late spring months. However, after the snow has melted and the summer rains have come and gone, even the mountains can become parched and dry, becoming ripe for forest fires.

Through extensive waterworks, such as a complex systems of ditches, reservoirs, pipelines and dams, the Boulder area has to some extent buffered itself from the seasonal flux of the water cycle. Nevertheless, the area is still vulnerable to droughts, flashfloods, forest fires, pollution and breakdown of the infrastructure that delivers water and removes waste.
[Source: http://bcn.boulder.co.us/basin/main/whywater.html]

3.2 Sustainability

The key word in the BASIN acronym is "sustainability." The term "sustainability" is derived from the word "sustainable" which means to maintain or prolong necessities or nourishment. When it comes to the sustainability of the environment, as well as the communities that are a part of that environment, many people agree that providing citizens with relevant environmental information that will allow them to make appropriate personal actions and help determine present and future public policy is of paramount importance. The "sustainability" of future communities will be, in part, determined by the actions of citizens today. [Source: http://bcn.boulder.co.us/basin/main/about.html#Sustain]

Since 1960 the Boulder area has quadrupled in population, outpacing the global population explosion with high-impact development and growth. To support such a substantial growth in population and industry, more water was needed for the Boulder area. As a result, the Boulder area implemented large-scale water projects, such as the Colorado Big Thompson and Windy Gap projects, which imported water from the other side of the Continental Divide. According to the Boulder County Health Communities Indicator Report of 1998, on average some 67,000 acre feet of water per year enters Boulder County from the Colorado Big Thompson project, a Federal "trans-basin" project begun in the 1950s.

Even with today's relatively high compliance standards, this tremendous growth impacts the quality of the water in the region. For example, waste from municipal sewage and individual septic systems impacts the waterways, air pollution from cars transports into the high mountain lakes and streams, and ground water is contaminated by leaking underground storage tanks. Aside from environmental impacts, rivers are sometimes literally drained dry due to Colorado's prior appropriations doctrine which historically has not supported leaving water in the river to support the aquatic habitat.

Although the issues are complex and the solutions are difficult, there are signs of progress in the Boulder area. For example, the City of Boulder has implemented a practice called "in-stream flow" which leaves some water in Boulder Creek at certain times during the year to protect the fish and macroinvertebrates. Also, water-conserving landscape design is becoming more popular in the region and water education is becoming an integral part of children's school curriculum.

However, the question remains: Can a community be sustainable? One step towards addressing sustainability is to monitor the community's impact (or ecological footprint) on the environment to reveal the difficult questions and tough choices it must face to minimize its impact on the environment. By focusing initially on water in the Boulder area, the BASIN project provided timely monitoring data, as well as background information and links to other resources that enabled the inhabitants of the region to better understand and to take steps to protect the Boulder area environment. [Source: http://bcn.boulder.co.us/basin/main/sustain.html] For more on sustainability, see "Toward a Stewardship of the Global Commons: Engaging "My Neighbor" in the Issue of Sustainability: http://bcn.boulder.co.us/basin/local/sustainin0.html. The Web site of the EPA Office of Water (http://www.epa.gov/owow/monitoring) is a good source of background information on water quality monitoring.

3.2.1 Establishing Community Partnerships

BASIN seeks to communicate the significance of timely environmental data to the general public. To maximize the effective communication of existing environmental information and improve the public relevance of ongoing data monitoring programs, BASIN established partnerships with environmental researchers currently collecting data in the watershed and solicited the active participation of the public in the design and development of BASIN's data management system and presentation of information. To develop these partnerships BASIN proceeded as follows:

- sought community input on both community information needs and outreach program design,
- established partnerships for both data access and community outreach,
- gathered references to existing environmental data,
- gathered access to supporting environmental information,
- established data management procedures in consultation with existing and new data collection programs,

- established prototype Web site design and development procedures,
- evaluated data and designed outreach channels, particularly for data presentation,
- developed data interpretation and supporting materials,
- released the initial Web site prototype within the first year,
- actively gathered partner, stakeholder and public feedback on the Web site prototype,
- continued to revise and update Web site during the second year, and
- established procedures to continue data updates and solicit additional data and information sources.

BASIN found that an iterative design process with active involvement of the community is essential to insure that data presentations are effective and relevant and that sufficient contextual information is provided to make these data meaningful to the general public.

3.2.2 Water Quality Monitoring: An Overview

Water quality monitoring provides information about the condition of streams, lakes, ponds, estuaries, and coastal waters. It can also tell us if these waters are safe for swimming, fishing, or drinking. Water quality monitoring can consist of the following types of measurements:

- *Chemical* measurements of constituents such as dissolved oxygen, nutrients, metals, and oils in water, sediment, or fish tissue.
- *Physical* measurements of general conditions such as temperature, conductivity/salinity, current speed/direction, water level, water clarity.
- *Biological* measurements of the abundance, variety, and growth rates of aquatic plant and animal life in a water body or the ability of aquatic organisms to survive in a water sample.

You can conduct several different types of water quality monitoring projects. For example water quality monitoring can be conducted as follows:

- at fixed locations on a continuous basis,
- at selected locations on an as-needed basis or to answer specific questions,
- on a temporary or seasonal basis (such as during the summer at swimming beaches), or
- on an emergency basis (such as after a spill).

Many agencies and organizations conduct water quality monitoring including state pollution control agencies, tribal governments, city and county environmental offices, the EPA and other federal agencies, and private entities, such as universities, watershed organizations, environmental groups, and industries. Volunteer monitors - private citizens who voluntarily collect and analyze water quality samples, conduct visual assessments of physical conditions, and measure the biological health of waters - also provide increasingly important water quality information. The EPA provides specific information about volunteer monitoring at http://www.epa.gov/owow/monitoring/vol.html.

Water quality monitoring is conducted for many reasons, including

- characterizing waters and identifying trends or changes in water quality over time;
- identifying existing or emerging water quality problems;
- gathering information for the design of pollution prevention or restoration programs;
- determining if the goals of specific programs are being met;
- complying with local, state, and Federal regulations; and
- responding to emergencies such as spills or floods.

EPA helps administer grants for water quality monitoring projects and provides technical guidance on how to monitor and report monitoring results. You can find a number of EPA's water quality monitoring technical guidance documents on the Web at: http://www.epa.gov/owow/monitoring/techmon.html. The EPA's Office of Water has developed a Watershed Distance Learning Program called the "Watershed Academy Web." This program, which offers a certificate upon completion, is a series of self-paced training modules that covers topics such as watershed ecology, management practices, and analysis and planning. More information about the Watershed Academy Web can be found on the Web at: http://www.epa.gov/

watertrain/. The EPA also has a Web site entitled "Surf Your Watershed" which can be used to locate, use, and share environmental information on watersheds. For more information about the resources available on Surf Your Watershed, please see the following Web site: http://www.epa.gov/surf3. The EPA also has a collection of watershed tools available on the Web at: http://www.epa.gov/OWOW/watershed/tools/. The watershed tools available on the Web deal with topics such as data collection, management and assessment, outreach and education, and modeling.

In addition to the EPA resources listed above, you can obtain information about lake and reservoir water quality monitoring from the North American Lake Management Society (NALMS). NALMS has published many technical documents, including a guidance manual entitled *Monitoring Lake and Reservoir Restoration*. For more information, visit the NALMS Web site at http://www.nalms.org. State and local agencies also publish and recommend documents to help organizations and communities conduct and understand water quality monitoring. For example, the Gulf of Mexico Program maintains a Web site (http://www.gmpo.gov/mmrc/mmrc.html) that lists resources for water quality monitoring and management. State and local organizations in your community might maintain similar listings.

In some cases, special water quality monitoring methods, such as remote monitoring, or special types of water quality data, such as timely data, are needed to meet a water quality monitoring program's objectives. Timely environmental data are collected and communicated to the public in a time frame that is useful to their day-to-day decision-making about their health and the environment, and relevant to the temporal variability of the parameter measured. Monitoring is called *remote* when the operator can collect and analyze data from a site other than the monitoring location itself.

3.3 Timely Environmental Data

When deciding what data to make available to communities in the Boulder area, the BASIN team considered several factors. These factors included the following:

- significance of the data to the local community/environment,
- availability of the data,
- the public's ability to interpret the data,
- the various methods to allow the public to view the data in perspective,
- interest to the local community,
- feasibility of putting the data on the Web site, and
- sensitivity of the data (e.g., controversial data).

Since the focus of the BASIN EMPACT project was to provide data about the Boulder Creek Watershed, the BASIN team decided that water quality data was significant to the Boulder area. The City of Boulder already conducted two water monitoring programs (drinking water and storm water) which measured a variety of water quality parameters so there was data readily available. This program included an existing collaboration between the City of Boulder and the USGS, to provide an integrated data set on total organic carbon (TOC). The team also searched for other sources of data that was available for distribution to the public. Such sources included USGS, the Colorado Air Pollution Control Division, and SNOTEL. The team also considered the feasibility of putting the data on the BASIN Web site (e.g., was the data in a format that could be displayed easily?).

After considering the various factors and conducting research to identify the types of data that were available in an acceptable format, the team identified three classifications of data that it made available on its Web site. These classifications are as follows:

- data links to other Web sites (e.g., SNOTEL, weather, and stream flow),
- acquired data (e.g., River Watch data and City of Longmont water data), and
- direct data (i.e., City of Boulder's drinking water and storm water data and USGS TOC data).

3.3.1 Data Links to Other Web sites

The BASIN team searched the World Wide Web and identified available environmental data that would be of interest to the local community. BASIN identified SNOTEL data, weather data, toxic releases data, and stream flow data. The BASIN Web site (http://www.basin.org) was designed to provide links to these data, which provided the local community with centralized access to a wide variety of relevant timely environmental monitoring activities. It is important to note that BASIN did not have any principal relations with the data providers and had no influence on the collection, analysis, or quality control of the data - the data were simply made available on the BASIN Web site. A brief description of the external data which the BASIN Web site links to is provided below.

SNOTEL Data. There are three SNOTEL (for SNOwpack TELemetry) snowpack monitoring sites in the Boulder area watershed. SNOTEL is an extensive, automated system operated and maintained by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) to measure snowpack in the mountains of the west and forecast the water supply. Data from the SNOTEL sites are plotted by the Western Regional Climate Center. The user can access the SNOTEL data and create plots of the cumulative precipitation, snow water content, and temperature data. [Source: http://bcn.boulder.co.us/basin/data/SNOTEL/SNOTEL.html]

Weather. The BASIN Web site has a link to weather data for six locations in the Boulder area. The weather data are maintained by a variety of government agencies and private individuals. The user clicks on the "weather" link (http://bcn.boulder.co.us/basin/data/WEATHER/WEATHER.html) which takes them to a Spatial Data Catalog, a BASIN map showing the six weather monitoring sites. The user can select any of the monitoring sites and obtain the near real-time weather at that site (the information is updated every five minutes). Such weather data includes temperature, dewpoint, humidity, barometric pressure, aeronautical pressure, wind speed, peak gust, wind chill, and wind direction. In addition to receiving current weather data, the user can also obtain minimum and maximum values for each of the parameters over the previous 24-hour period.

Toxic Releases. The BASIN Web site provides direct access to the Environmental Defense Fund's (EDF) Scorecard Internet site which catalogs 23 facilities in the Boulder area that release toxic substances into the environment. [Source: http://bcn.boulder.co.us/basin/data/TRI/TRI.html] The data on the EDF Scorecard is not "real-time" because it reflects the environmental releases that each facility reported on its annual EPA Toxic Release Inventory forms. The user can click on the various facilities highlighted in the Spatial Data Catalog and learn about the toxic chemicals that each facility is releasing to the environment in the Boulder area.

Stream Flow. The BASIN Web site has a link to data collected from 21 stream flow gauging sites located in the Boulder area. Shown here is a stream stage gauge mounted in the North Boulder Creek diversion flume. The data from the stream flow gauging sites are obtained from State and Federal (USGS) sources. The user clicks on "stream flow" (http://bcn.boulder.co.us/basin/data/STREAMFLOW/STREAMFLOW.html) which takes them to a Spatial Data Catalog, a map showing the 21 stream flow gauging sites (see discussion of Spatial Data Catalog in Chapter 5). The user can obtain the stage (or stream depth) in feet as well as the stream flow in ft^3/sec or cubic feet per second (cfs). Depending upon the site selected, the data can be viewed in either a tabular or graphical format.

Air Quality. The BASIN EMPACT Web site posts the current air quality status for the Denver-metro area. The information is obtained from the Colorado Air Pollution Control Division (APCD). The air quality advisories are issued each day at 4 P.M., MST. The advisories are categorized as either **BLUE** or **RED**. If the user wants to know what action to take based on the advisory, they click on the link which transfers them to an APCD Web site (http://apcd.state.co.us/psi/o3_advisory.phtml). This Web site provides practical suggestions to reduce summertime air pollution.

Ultraviolet Exposure Index. In addition to posting the air quality status, the BASIN EMPACT Web site also posts the current EPA/NOAA ultraviolet (UV) exposure index. The index is based on a numerical scale from 0 - 10+, with "0" indicating "minimal" exposure and "10+" indicating "very high" exposure. If the user wants to know more about the index or what they should do to protect themselves against UV exposure they can click on the link which takes them to an EPA "SunWise" Web site (http://www.epa.gov/sunwise/uvindex.html).

3.3.2 Acquired Data

The BASIN team solicited data provider partnerships with existing Boulder area environmental monitoring programs. BASIN established successful data provider partnerships with the City of Longmont, the Denver Water Board, and the State of Colorado's River Watch Program. Data sets (water quality monitoring data) received from these data providers were integrated into the BASIN Information Management System (IMS) and were used to develop information products currently available on the BASIN Web site (http://www.basin.org). It is important to note that with the data provider partnerships, BASIN had no direct influence on the data collection or quality control of the data. [Source: 2000 Annual Report, BASIN Project, EMPACT Grant, January 30, 2001]

3.3.3 Direct Data

The BASIN team partnered with the City of Boulder to obtain data collected by its Storm Water and Drinking Water Programs. BASIN had an interactive relationship with the City of Boulder and had input on the data format, collection protocols, and QA/QC. Water quality monitoring data is provided by a cooperative program between the City of Boulder's Public Works Department and Dr. Larry Barber of the USGS Laboratory located in Boulder. Source water quality is monitored by the City of Boulder's Drinking Water Monitoring Program at several locations in the headwaters of the basin. Stream Water Quality is monitored by the city's Storm Water Monitoring Program throughout the lower basin.

Drinking water quality can only be conserved to the extent that source waters are protected, water treatment is optimized, and the water quality in the distribution system is maintained. Boulder's three watersheds (i.e., North Boulder Creek, Middle Boulder Creek/Barker Reservoir, and Boulder Reservoir) are increasingly vulnerable to point and non-point contamination due to development in the area. Water treatment is subject to increasing stresses from pathogens and other contaminants, as well as to increasing public expectations for drinking water quality. Distribution system water quality is receiving increased public attention as outbreaks of waterborne disease are connected with biofilms, backflow incidents, and other hard-to-quantify contaminant vectors. [Source: 1998 EMPACT Grant Application]

As for storm water, non-point source pollution is a critical environmental issue in the Boulder Creek Watershed. Pollutant sources include highway runoff, urban drainage, mining, logging, erosion, and agriculture. The City of Boulder recognizes the need to protect water through pollution abatement of non-point sources and through watershed management.

Monthly readings of 17 primary water quality parameters are accessible through the BASIN Water Quality data access page (http://bcn.boulder.co.us/basin/data/COBWQ/index.html). The importance of each of the parameters which can be viewed at the BASIN Web site is discussed below.

Alkalinity refers to how well a water body can neutralize acids. Alkalinity measures the amount of alkaline compounds in water, such as carbonate (CO_3^{-2}), bicarbonate (HCO_3^-), and hydroxide (OH^-) ions. These compounds are natural buffers that can remove excess hydrogen ions that have been added from sources such as acid rain or acid mine drainage. Alkalinity mitigates or relieves metals toxicity by using available HCO_3^- and CO_3^{-2} to take metals out of solution, thus making it unavailable to fish. Alkalinity is affected by the geology of the watershed; watersheds containing limestone will have a higher alkalinity than watersheds where granite is predominant.

Ammonia, Nitrate, and Nitrite are sources of nitrogen. Nitrogen is required by all organisms for the basic processes of life to make proteins, to grow, and to reproduce. Nitrogen is very common and found in many forms in the environment. Inorganic forms include ammonia (NH_3), nitrate (NO_3^-)and nitrite (NO_2^-). Organic nitrogen is found in the cells of all living things and is a component of proteins, peptides, and amino acids. These compounds enter waterways from lawn fertilizer run-off, leaking septic tanks, animal wastes, industrial waste waters, sanitary landfills and discharges from car exhausts.

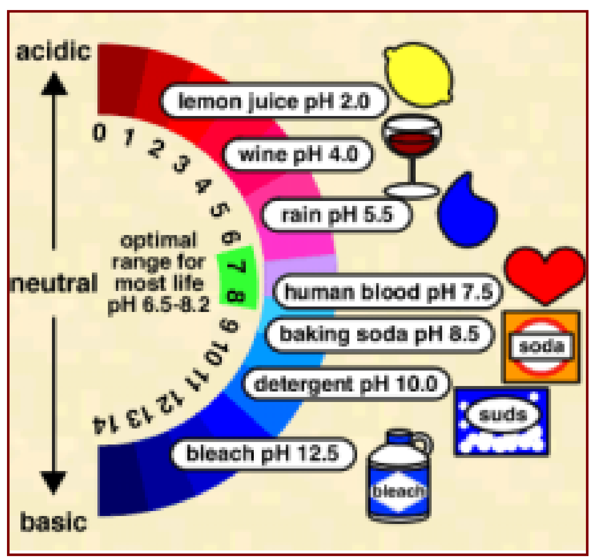
Excessive concentrations of ammonia, nitrate, or nitrite can be harmful to humans and wildlife. Toxic concentrations of ammonia in humans may cause loss of equilibrium, convulsions, coma, and death. Ammonia concentrations can affect hatching and growth rates of fish and changes may occur during the structural development of tissues of fish gills, liver, and/or kidneys. In humans, nitrate is broken down in the intestines to become nitrite. Nitrite reacts with hemoglobin in human blood to produce methemoglobin, which limits the ability of red blood cells to carry oxygen. This condition is called methemoglobinemia or "blue baby" syndrome (because the nose and tips of the ears can appear blue from lack of oxygen). High concentrations of nitrate and/or nitrite produces a similar condition in fish and is referred to as "brown blood disease." Nitrite enters the bloodstream through the gills and turns the blood a chocolate-brown color. Brown blood cannot carry sufficient amounts of oxygen, and affected fish can suffocate despite adequate concentration in the water. The EPA has established a maximum contaminant level of 10 mg/l for nitrate and 1 mg/l for nitrite. [Source: http://bcn.boulder.co.us/basin/data/COBWQ/info/NH3.html]

Dissolved Oxygen (DO) is the amount of oxygen dissolved in the water. DO is a very important indicator of a water body's ability to support aquatic life. Fish "breathe" by absorbing dissolved oxygen through their gills. Oxygen enters the water by absorption directly from the atmosphere or by aquatic plant and algae photosynthesis. Oxygen is removed from the water by respiration and decomposition of organic matter. The amount of DO in water depends on several factors, including temperature (the colder the water, the more oxygen can be dissolved); the volume and velocity of water flowing in the water body; and the amount of organisms using oxygen for respiration. The amount of oxygen dissolved in water is expressed as a concentration, in milligrams per liter (mg/l) of water. Human activities that affect DO levels include the removal of riparian vegetation, runoff from roads, and sewage discharge.

Fecal Coliform Bacteria are present in the feces and intestinal tracts of humans and other warm-blooded animals, and can enter water bodies from human and animal waste. If a large number of fecal coliform bacteria (over 200 colonies/100 ml of water sample) are found in water, it is possible that pathogenic (disease- or illness-causing) organisms are also present in the water. Pathogens are typically present in such small amounts it is impractical to monitor them directly. High concentrations of the bacteria in water may be caused by septic tank failure, poor pasture and animal keeping practices, pet waste, and urban runoff.

Hardness generally refers to the amount of calcium and magnesium in water. In household use, these divalent cations (ions with a charge greater than +1) can prevent soap from sudsing and leave behind a white scum in bathtubs. In the aquatic environment, calcium and magnesium help keep fish from absorbing metals, such as lead, arsenic, and cadmium, into their bloodstream through their gills. Therefore, the harder the water, the less easy it is for toxic metals to absorb into their gills.

pH measures hydrogen concentration in water and is presented on a scale from 0 to 14. A solution with a pH value of 7 is neutral; a solution with a pH value less than 7 is acidic; a solution with a pH value greater than 7 is basic. Natural waters usually have a pH between 6 and 9. The scale is negatively logarithmic, so each whole number (reading downward) is ten times the preceding one (for example, pH 5.5 is 100 times more acidic as pH 7.5). The pH of natural waters can be made acidic or basic by human activities such as acid mine



drainage and emissions from coal-burning power plants and heavy automobile traffic. pH can interact with metals and organic chemicals making them more or less toxic depending on the type of chemical.

Specific Conductance is a measure of how well water can pass an electrical current. It is an indirect measure of the presence of inorganic dissolved solids, such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron. These substances conduct electricity because they are negatively or positively charged when dissolved in water. The concentration of dissolved solids, or the conductivity, is affected by the bedrock and soil in the watershed. It is also affected by human influences. For example, agricultural runoff can raise conductivity because of the presence of phosphate and nitrate.

Stream Flow is the volume of water moving past a point in a unit of time. Flow consists of the volume of water in the stream and the velocity of the water moving past a given point. Flow affects the concentration of dissolved oxygen, natural substances, and pollutants in a water body. Flow is measured in units of cubic feet per second (cfs) or ft^3/sec.

Total Dissolved Solids (TDS) refers to matter dissolved in water or wastewater, and is related to both specific conductance and turbidity. TDS is the portion of total solids that passes through a filter. High levels of TDS can cause health problems for aquatic life.

Total Organic Carbon (TOC) - Organic matter plays a major role in aquatic systems. It affects biogeochemical processes, nutrient cycling, biological availability, and chemical transport. It also has direct implications in the planning of wastewater treatment and drinking water treatment. Organic matter content is typically measured as total organic carbon and dissolved organic carbon, which are essential components of the carbon cycle.

Total Phosphorus is a nutrient required by all organisms for the basic processes of life. Phosphorus is a natural element found in rocks, soils and organic material. Its concentrations in clean waters is generally very low; however, phosphorus is used extensively in fertilizer and other chemicals, so it can be found in higher concentrations in areas of human activity. Phosphorus is generally found as phosphate (PO_4^{-3}). ***Orthophosphorus*** is a form of inorganic phosphorus and is sometimes referred to as "reactive phosphorus." Orthophosphate is the most stable form of phosphate, and is the form used by plants. Orthophosphate is produced by natural processes and is found in sewage. High levels of orthophosphate, along with nitrate, can overstimulate the growth of aquatic plants and algae, resulting in high dissolved oxygen consumption, causing death of fish and other aquatic organisms. The primary sources of phosphates in surface water are detergents, fertilizers, and natural mineral deposits.

Total Suspended Solids (TSS) refers to matter suspended in water or wastewater, and is related to both specific conductance and turbidity. TSS is the portion of total solids retained by a filter. High levels of TSS can cause health problems for aquatic life.

Turbidity is a measure of the cloudiness of water - the cloudier the water, the greater the turbidity. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water. Turbidity is closely related to TSS, but also includes plankton and other organisms. Turbidity itself is not a major health concern, but high turbidity can interfere with disinfection and provide a medium for microbial growth. It also may indicate the presence of microbes. High turbidity can affect the natural algal productivity of the stream and can affect other organisms such as fish and invertebrates that use algae as a food source. High turbidity can be caused by soil erosion, urban runoff, and high flow rates.

Water Temperature is a very important factor for aquatic life. It controls the rate of metabolic and reproductive activities. Most aquatic organisms are "cold-blooded," which means they can not control their own body temperatures (e.g., certain trout and salamanders require cold water). Their body temperatures become the temperature of the water around them. Cold-blooded organisms are adapted to a specific temperature range. If water temperatures vary too much, metabolic activities can malfunction. Temperature also affects the concentration of dissolved oxygen and can influence the activity of bacteria in a water body. Too much light caused by reduced stream side vegetation can increase the stream temperature. [Source: BASIN Water Quality Terms, http://bcn.boulder.co.us/basin/natural/wqterms.html]

3.4 The Boulder Creek Millennium Baseline Study

BASIN served to strengthen an existing collaboration among local USGS water quality scientists and the City of Boulder (COB) source and storm water quality monitoring programs. The formal collection and public release of the COB's water quality information lead to a more ambitious water quality monitoring effort called the Boulder Creek Millennium Baseline Study which was designed to clarify water quality concerns in the Boulder Creek Watershed.

The Boulder Creek Millennium Baseline Study was performed during the summer and fall of the year 2000 as a collaborative effort of the USGS Water Resources Division, the City of Boulder, and the BASIN to provide an in-depth analysis of Boulder Creek water quality. This study measured several parameters not normally regulated or considered to be problematic in Boulder Creek but which would assist in the formulation of a conceptual model of the processes at work in the creek system. Detailed synoptic water quality sampling of Boulder Creek, including the main stem and major tributaries, allows the identification of the sources of chemical constituents. Boulder Creek offers an excellent opportunity to measure the impact of natural and anthropogenic processes on a small river system because it flows from pristine source waters, through an urban corridor, and is transformed into a sewage-dominated stream below Boulder's sewage treatment plant (STP) outfall, and finally flows through agricultural areas. Water quality sampling of Boulder Creek during high-flow (June) and low-flow (October) conditions, from upstream of the town of Eldora to the confluence with the St. Vrain River, was carried out to determine influences on water chemistry. The relative importance of different sources varies seasonally, and therefore high- and low-flow sampling is an important step in characterizing the watershed. The study also provided a baseline data set from which future water quality changes can be observed. (from S.F. Murphy, P.L. Verplanck, and L.B. Barber, "Chemical Data for Water Samples Collected from Boulder Creek, Colorado, During High-Flow and Low-Flow Conditions, 2000," to be submitted as a USGS Open File Report).

The Millennium Baseline Study measured additional parameters including the following:

- Major Ions
- Metals
- Pesticides
- Pharmaceuticals
- Hormones
- Other organic wastewater compounds

4. COLLECTING, TRANSFERRING, AND MANAGING TIMELY ENVIRONMENTAL DATA

A centralized collection of timely environmental data can be beneficial to your community in several ways. Such information raises the public's awareness of environmental issues that pertain to them, it serves as a valuable learning tool to increase their understanding of actions that affect their environment, and it serves as an avenue for them to express their concerns and questions.

Using the BASIN Project as a model, this chapter provides you and your community with instructions on how to collect and maintain data to post on your Web site. If you are responsible for or interested in collecting water samples, you should carefully read the technical information presented in Section 4.2. If you are interested in analyzing water samples, you should read the information presented in the Section 4.3. This section provides detailed information on the type of equipment and procedures used to analyze water samples. Details on data transfer and management are discussed in Section 4.4 and quality assurance is discussed in Section 4.5. Readers interested in an overview of the system should focus primarily on the introductory information in Section 4.1 below.

4.1 System Overview

The BASIN project sought to leverage the activities of existing environmental monitoring programs and develop public environmental information resources derived from timely environmental data collection. BASIN developed partnerships with various organizations to gather pertinent environmental information about the Boulder area. As discussed earlier, the BASIN project provided three types of data to the Boulder community: (1) Web links to external data sources, (2) acquired data, and (3) direct data (see discussion in Section 3.3). This data can be accessed through links from the BASIN Web site at http://bcn.boulder.co.us/basin/.

The remainder of this chapter discusses the collection, analysis, transfer and quality control of the storm water and drinking water quality data (direct data) provided to BASIN by the City of Boulder. BASIN interacted closely with the City of Boulder to develop sample collection protocols, determine data format, and to develop QA/QC procedures.

As mentioned in Chapter 3, BASIN did not have any contact with the providers of the SNOTEL, weather, toxic releases, stream flow, air quality, or UV exposure index data posted on the BASIN Web site. As a result, this Handbook does not discuss the collection, analysis, management, or quality control of these types of data. If you are interested in learning more about such topics, please refer to the following Web sites:

- For SNOTEL data, see http://www.wcc.nrcs.usda.gov/factpub/sntlfct1.html and http://www.wcc.nrcs.usda.gov/factpub/sect_4b.html

- For weather data, see http://www.atd.ucar.edu/weather.html

- For toxic releases, see http://www.epa.gov/tri/general.htm

- For stream flow data, see http://water.usgs.gov/co/nwis/sw

- For air quality data, see http://apcd.state.co.us/psi/o3_advisory.phtml

- For UV exposure data, see http://www.epa.gov/sunwise/uvindex.html

Similarly, BASIN did not have any input as to how the data provided by the City of Longmont or River Watch (the acquired data) was collected, analyzed or controlled. As a result, this Handbook does not discuss the collection, analysis, management, or quality control of the City of Longmont or River Watch data.

4.2 Data Collection

BASIN and the City of Boulder collaborated to obtain results from the city's Drinking Water and Storm Water Programs. The data collection techniques for each program are described below.

4.2.1 Drinking Water Program

The Drinking Water Program collects monthly water quality samples from 30 locations such as the Lakewood Reservoir, Barker Reservoir, Middle Boulder Creek, and Boulder Reservoir. The following procedures are used to prepare sample collection bottles:

- Total Organic Carbon (TOC) bottles are obtained from the USGS, where the bottles are washed with hot, soapy water, rinsed with tap and distilled water, and heated for 8 hours at 250 degrees C. For the remaining bottles, each set of sample bottles is cleaned and reused for one particular sample site.

- Sample bottles are rinsed with tap water immediately after the sample has been analyzed. All sample bottles (except those used for chlorophyll, metals, and bacteria) are soaked for at least one hour in a 5% hydrochloric acid (HCl) bath. These bottles are then rinsed twice transported to the field. Clean field equipment is used to fill a clean churn with this blank water. All field blank bottles are then filled from this blank water churn. Shown here is a technician obtaining field blank samples from the water churn.

[Source: http://bcn.boulder.co.us/basin/data/COBWQ/SourceWater.html]

4.2.2 Storm Water Program

The Storm Water Quality Program conducts monthly water quality monitoring to assess the impacts of point and non-point sources of pollutants on Boulder Creek and to help develop mitigation measures to reduce these impacts. The water quality samples are collected from North Boulder Creek at Boulder Falls to below the confluence of Boulder Creek with Coal Creek. The following procedures are used to prepare sample collection bottles as well as collecting samples:

- Total Organic Carbon (TOC) bottles are obtained from the USGS, where the bottles are washed with hot, soapy water, rinsed with tap and distilled water, and heated for 8 hours at 250 degrees C. The remaining bottles are cleaned in a dishwasher, which involves a hot water and detergent wash, steam cycle, and deionized water rinse. Bottles used for metals are also soaked in 3% HNO_3, rinsed with deionized water three times, and then air-dried.

- Sample are collected in accordance with procedures outlined in Standard Methods for the Examination of Water and Wastewater, 20th Edition (section 1060).

- In the field, sample bottles are rinsed two times with water from where the sample will be collected, unless a preservative or dechlorinating agent has been added to the bottle prior to use. Various types of sample bottles are used depending on the pollutant to be analyzed and the method of analysis.

- The sample location is either mid-channel of the flow or the area in the channel which best represents the flow. At that point, sample bottles are submerged to approximately 60% of the water depth to obtain the sample. The sample bottle is capped and shaken. One to two inches of head space is left in the sample bottle to allow for thermal expansion (unless sample analysis technique requires that the sample to not have any head space).

- Sample preservative is added after sample collection as prescribed by each analytical method (unless a preservative or dechlorinating agent has been added to the bottle prior to use). Samples which will be analyzed for metals are filtered in the laboratory before being acidified.

- Samples labels are completed and applied to the sample bottles. The sample bottles are placed in a cooler with blue ice. The samples are transported to the laboratory and placed in a refrigerator for storage at 4 °C (39 °F). [Source: http://bcn.boulder.co.us/basin/data/COBWQ/StormWater.html]

4.3 Data Analysis

4.3.1 Drinking Water Program

The Drinking Water Program measures some parameters in the field with portable meters and other parameters in the laboratory. The following parameters are measured in the field:

Water temperature is analyzed with a portable YSI 600 XL multi probe (http://www.ysi.com/lifesciences.htm). The temperature probe is checked annually.

Dissolved oxygen is analyzed with a portable YSI 600 XL multi probe. Calibrations are conducted in the field at the sample site with a moist-air saturated bottle.

Specific conductance is analyzed with a portable YSI 600 XL multi probe. The probe is calibrated in the drinking water laboratory the day of sampling. A potassium chloride solution of 1412 micromhos/cm at 25 °C is used in the calibration. Standards are replaced at least monthly.

The following parameters are measured in the laboratory:

Nitrate, nitrite, sulfate, orthophosphorus, and total phosphorus are measured using a Genesis spectrophotometer. For colorimetric analyses (*nitrate + nitrite, sulfate, orthophosphorus, and total phosphorus*), all collection bottles and spectrophotometer cuvettes are HCL-washed and/or cleaned with phosphate-free soap. The instrument is zeroed with the sample or with lab millipore water depending on the procedure. Two standards are run, and bracket the sample value. New standards are prepared monthly. New high- and low-range 5 point curves are constructed for the spectrophotometer when necessary.

Alkalinity is measured using Standard Method 2320B (American Public Health Association, 1998). The sample is stirred, and temperature and pH are monitored, as 0.02N sulfuric acid (H_2SO_4) is slowly added to the sample. The amount of acid necessary to lower the pH to 4.5 is proportional to the total alkalinity in the sample. This method assumes that the entire alkalinity consists of bicarbonate, carbonate, and/or hydroxide.

Ammonia is measured by the wastewater laboratory. Total ammonia (ammonium ion (NH_4+) plus unionized ammonia gas (NH_3)) is often measured in a laboratory by titration. Ammonia and organic nitrogen compounds are separated by distillation, then an acid (the titrant) is added to a volume of the ammonia portion. The volume of acid required to change the color of the sample reflects the ammonia concentration of the sample. The more acid needed, the more ammonia in the sample. Ammonia is the least stable form of nitrogen, so it can be difficult to measure accurately. The proportion of unionized ammonia can be calculated, using formulas that contain factors for pH and temperature [Source: http://bcn.boulder.co.us/basin/data/COBWQ/info/NH3.html].

Hardness is measured using Standard Method 2340C. A small amount of dye is added to the sample, and buffer solution is added until the pH of the sample reaches 10. If calcium and magnesium are present in the sample, the sample turns red. Ethylenediaminetetraacetic acid (EDTA) is then added until the sample turns blue. The amount of EDTA required to turn the sample blue represents the hardness of the sample.

Nitrate + Nitrite is measured using a Hach DR2000 spectrophotometer (http://www.hach.com) and Method 8192 (low range cadmium reduction). Cadmium metal reduces nitrate present in the sample to nitrite. The nitrite ion reacts in an acidic medium with sulfanilic acid to form an intermediate diazonium salt which couples to chromatic acid to form a pink-colored product. The pink color is then analyzed with a spectrophotometer; the more intense the pink color, the more nitrate + nitrite is in the sample.

Total phosphorus is measured using Standard Method 4500-P B.5 and 4500 - PE. In these methods, phosphorus present in organic and condensed forms is converted to reactive orthophosphate before analysis. Sulfuric acid (H_2SO_4) and ammonium persulfate ($[NH4]_2\ S_2O_8$) are added to 50 ml of the sample, and the sample is then boiled. The acid and heating causes hydrolysis of condensed phosphorous to convert to orthophosphates. After boiling down the sample to approximately 10 ml, the sample is cooled and phenolphthalein indicator is added. The sample pH is adjusted to 8.3 using sodium hydroxide (NaOH) and sulfuric acid. The sample is then brought back up to volume and analyzed for orthophosphorus as discussed below.

Orthophosphorus is measured using Standard Method 4500 - PE. Sulfuric acid, potassium antimonyl tatrate, ammonium molybdate, and ascorbic acid are added to the sample.

The potassium antimonyl, tatrate and ammonium molybdate react in the acid with the orthophosphate to form phosphomolybdic acid. The phosphomolybdic acid is then reduced to a blue color by the ascorbic acid. The blue color is then analyzed with a spectrophotometer. The darker the blue color, the more orthophosphate in the sample. The detection limit for this method is approximately 0.002 mg of orthophosphorus/liter. [Source: http://bcn.boulder.co.us/basin/data/COBWQ/SourceWater.html]

4.3.2 Storm Water Program

Similar to the Drinking Water Program, the Storm Water Program measures some parameters in the field with portable meters as shown here and other parameters in the laboratory.

Portable field instruments are used to measure *pH* and *DO*. The Orion Model 1230 multi-parameter meter has ion-selective probes which measure these parameters (http://www.thermo.com). pH is calibrated using pH buffers 7 and 10 in the wastewater laboratory before each sampling event. The probe has automatic temperature compensation for temperature-corrected buffer values. A calibration sleeve is used to calibrate DO in the wastewater laboratory before each sampling event. The instrument automatically measures and compensates for temperature and total atmospheric pressure.

The Orion Model 130 conductivity meter is used to measure *specific conductance (SC)* and *water temperature* (http://www.thermo.com). The probe is calibrated before each sampling event with a potassium chloride (KCl) solution of 1,412 micromhos/cm at 25 °C.

The Orion Model 840 DO meter and the Orion Model 140 conductivity meter (http://www.thermo.com) are used as backups if a problem with the main meter occurs in the field.

Flow velocity is measured using the Marsh-McBirney Flo-Mate 2000 portable flowmeter (http://www.marsh-mcbirney.com/Model%202000.html). USGS midsection methods, as described in the Water Measurement Manual, are followed. Calibration is performed at the factory.

4.3.3 Laboratory Analysis

Water samples are collected in bottles and taken to the City of Boulder's laboratory where various parameters are measured. Shown here are samples ready for analysis. *Alkalinity* is measured using Standard Method 2320B (American Public Health Association, 1998). The sample is stirred and the temperature and pH are monitored as 0.02 N sulfuric acid (H_2SO_4) is slowly added to the sample. The amount of acid required to lower the sample pH to 4.5 is proportional to the total alkalinity in the sample. This method assumes that the entire alkalinity consists of bicarbonate, carbonate, and/or hydroxide.

Ammonia is measured using Standard Methods 4500-NH_3 B and 4500-NH_3 C. Both the ammonium ion (NH_4^+) and unionized ammonia (NH_3) are included in the measurement. Sodium borate buffer is added to the sample, and the pH is adjusted to 9.5 with sodium hydroxide (NaOH). The sample is then distilled into a flask that contains a boric acid/color indicator solution. The distillation separates ammonia (which goes into the distillate) from organic nitrogen compounds. The distillate is titrated with H_2SO_4 until the solution turns a pale lavender. The volume of acid required to change the color of the sample reflects the ammonia concentration of the sample.

Hardness is measured using Standard Method 2340C. A small amount of dye is added to the sample, and buffer solution is added until the pH of the sample reaches 10. If calcium and magnesium are present in the sample, the sample turns red. Ethylenediaminetetraacetic acid (EDTA) is then added until the sample turns blue. The amount of EDTA required to turn the sample blue represents the hardness of the sample.

Nitrate + Nitrite is measured using a Hach DR2000 spectrophotometer, Method 8039 (high range cadmium reduction). Cadmium metal reduces nitrates present in the sample to nitrite. The nitrite ion reacts in an acidic medium with sulfanilic acid to form an intermediate diazonium salt. This salt then couples to gentisic acid to form an amber-colored product. The amber color is then analyzed with a spectrophotometer; the more intense the amber, the more nitrate + nitrite in the sample. The detection limit for this method is approximately 0.1 mg/liter. The analysis is performed on filtered samples to eliminate turbidity interferences.

Total phosphorus is measured using a Hach DR4000 spectrophotometer and Method 8190. In this method, phosphorus present in organic and condensed forms is converted to reactive orthophosphate before analysis. Sulfuric acid (H_2SO_4) and potassium persulfate ($K_2S_2O_8$) are added to the sample, and then the sample is boiled. The acid, heating, and persulfate causes organic phosphorous to convert to orthophosphate. After boiling, the sample is cooled, and sodium hydroxide (NaOH) is added, along with a solution of ascorbic acid and molybdate reagent which turns the sample blue. The intensity of the blue in the sample is proportional to the orthophosophate concentration.

Orthophosphorus is measured using a Hach DR4000 spectrophotometer and Method 8114. This method is based on Standard Method 4500 - P.C. Molybdovanadate reagent is added to the sample. The molybdate reacts in the acid with the orthophosphate to form a phosphomolybdate complex. In the presence of vanadium, yellow vanadomolybdophosphoric acid is formed. The yellow color is then analyzed with a spectrophotometer; the more intense the yellow, the more orthophosphate in the sample. The detection limit for this method is approximately 0.09 mg PO_4/liter. [Source: http://bcn.boulder.co.us/basin/data/COBWQ/StormWater.html]

4.4 Data Transfer

The BASIN IMS is distributed across two Internet connected servers: the private Environmental Data Network Association (EDNA) database server and the public BASIN Web site server. A SUN E250 Unix Server, which is networked through the Boulder Community Network, hosts the private EDNA database server which generates and delivers public data products to the BASIN Web server upon receipt of updates from the data providers.

The BASIN IMS has been implemented using the object oriented features of Practical Extraction and Report Language (PERL) programming in a UNIX environment and utilizes several freely available supporting software libraries. The system is a combination of independent L modules which access a common set of PERL object definitions and operate on a common database structure. Additional programming support has been obtained from the extensive resources of CPAN (Comprehensive PERL Archive Network). In particular two primary graphics libraries - GD and GIFGraph were employed to dynamically construct plot images and merge images with background gif map images.

The EDNA IMS server is configured to receive and process updated data, preprocess input data, update the database, and regenerate a static Web-based hierarchy. The EDNA server also provides a non-public Web site for prototyping information products by BASIN content developers. Figure 4.1 presents the relationship of the EDNA database and BASIN information servers.

Data updates supplied by EDNA data providers are received through e-mail and are preprocessed through a series of routines prior to storage in the EDNA database. Input data are received in a variety of provider defined formats and each is submitted to a provider specific preprocessor pipeline. These preprocessors execute a variety of unit and data format conversions and map each provider's spatial and temporal identifiers to the global identifier set.

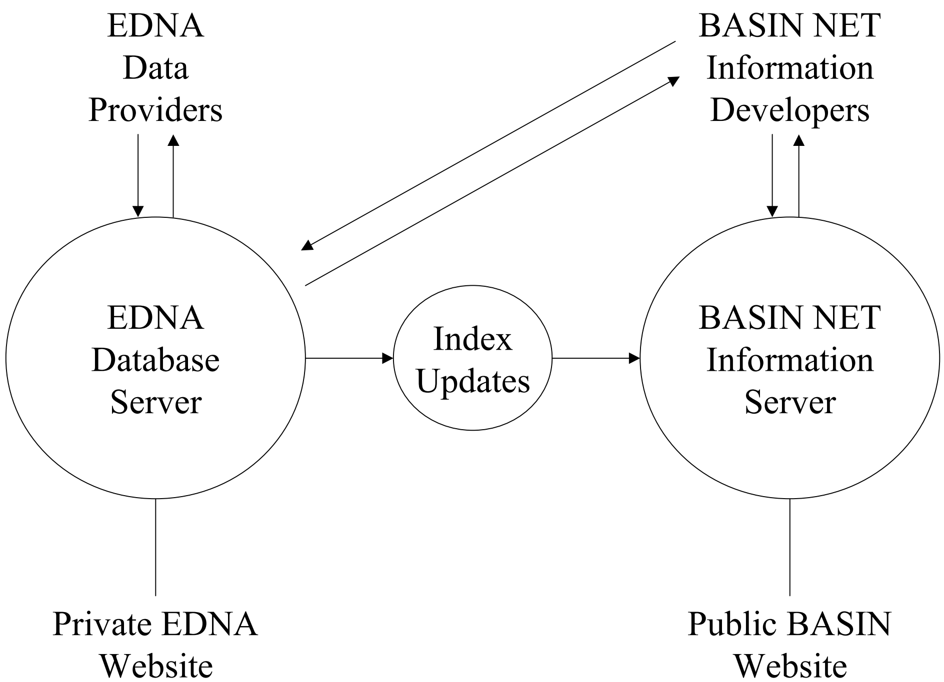


Figure 4.1 Database Servers

Once stored in the EDNA database, a series of batch routines are executed to generate static Web site elements (plot files and per parameter time series, profiles and image maps). To ensure data integrity, EDNA database files are exported read only to the public Web server. Figure 4.2 presents the general data flow for water quality data sent by the data providers and principle components of the BASIN IMS. [Source: BASIN FINAL Report, February 2001, Section D, 3.1]

The EDNA Database

BASIN information resources are retained on the server as a series of relational database files. The relationship of database tables and keys is outlined in Figure 4.3.

The BASIN data model handles each data set as a separate entity with a full set of meta-data properties. Sets are composed of a vector of parameters representing grab samples measured periodically at a series of stations. In practice, data sets are defined by the data providing agent or program. Each set is defined by a record in the main catalog table (catalog/classes.rdb).Each parameter is defined by a set of general characteristics (label, units, definition) and a set specific meta-data set containing collection and analysis procedures, detection limits, global maximum scale). Each parameter set is maintained in a set specific table catalog/SET.rdb.

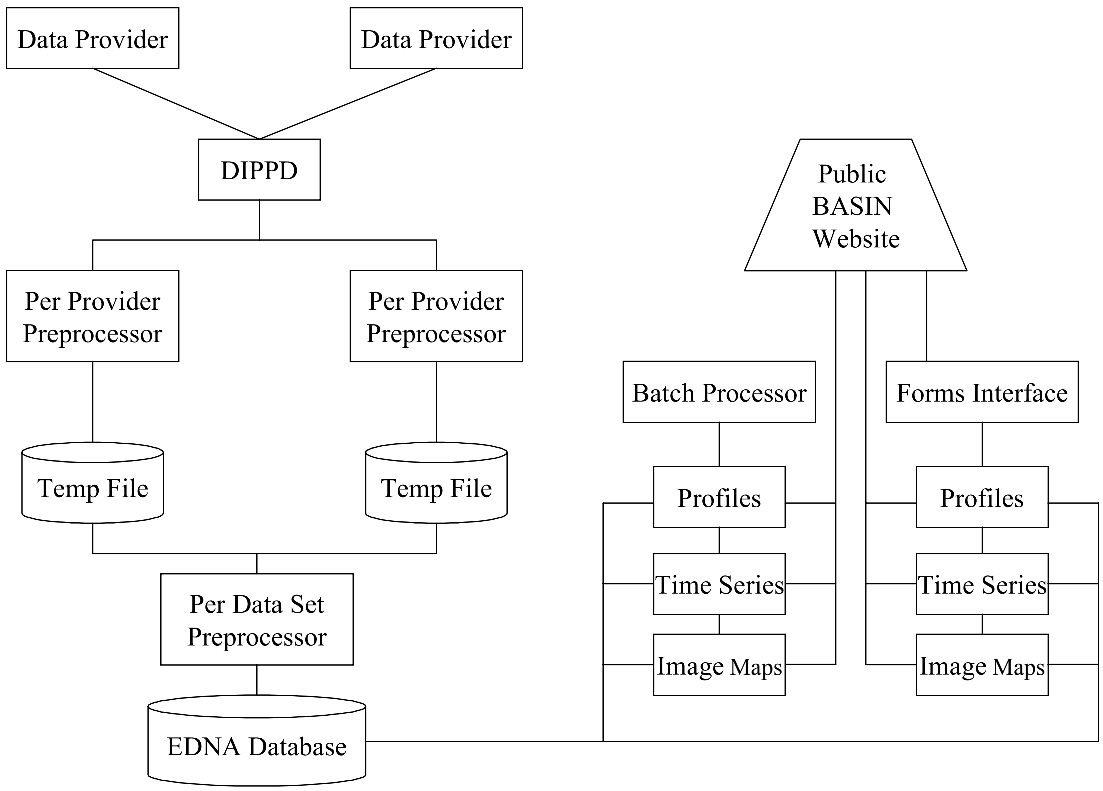


Figure 4.2 Data Flow for Water Quality Data.

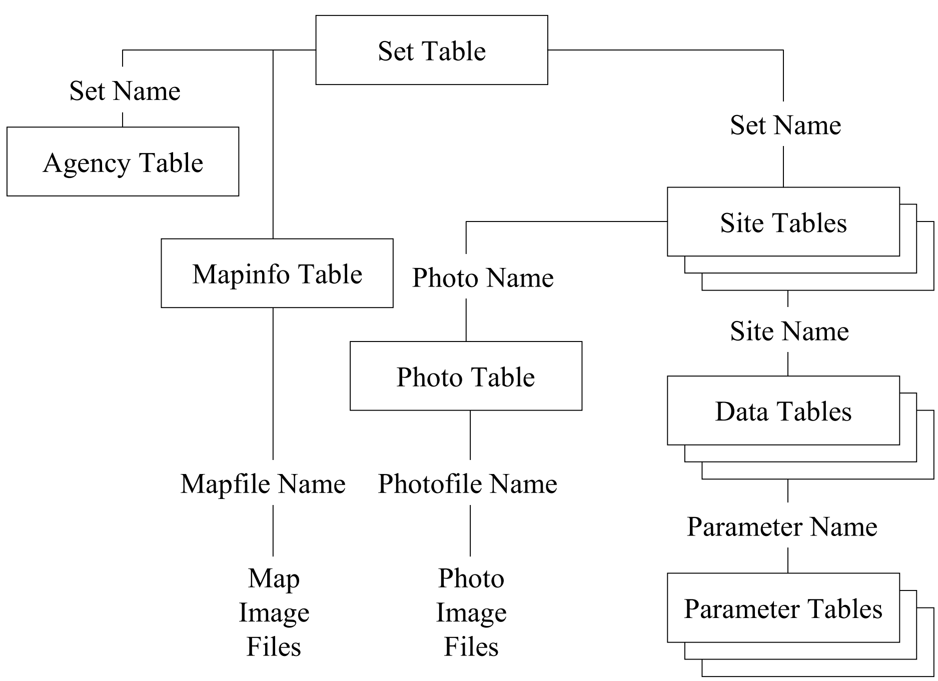


Figure 4.3 EDNA Database Structure.

Each set also defines a series of stations, defined by a set of identification parameters (labels, photo index, map index) and physical characteristics (longitude, latitude, elevation). Site data are maintained in a site/SET.rdb database table.

> **TIGER**
>
> Topically Integrated Geographic Encoding and Referencing
>
> TIGER is the Census Bureau's digital mapping system used to produce maps for its Census programs. MAPS may be requested from the TIGER MAP Service at http://tiger.census.gov/cgi-bin/magpen .
>
> Web developers can obtain instructions for requesting maps at http://tiger.census.gov/instruct.html

Dynamic image map construction is supported by combining spatial data contained in the database site table with a background gif map image obtained from the Census Bureau's Topically Integrated Geographic Encoding and Referencing (TIGER) Map Server (http://tiger.census.gov/cgi-bin/mapsurfer). Background maps are defined by a record in the database map image table which contains images as used in the formatting of the Water Quality Index grade signposts used in the WQI display. The system is designed to overlay data plots and images on any arbitrary gif file to support future enhancement of background context maps from locally developed geographic information systems (GIS) resources. More information about BASIN data presentation approaches is available in Chapter 5 of this manual.

The primary data model employed assumes each parameter is defined by a two dimensional surface over time and space. While this model is generally applicable to all anticipated data sets, the primary prototype example sets are composed of monthly water quality data measured at a series of stations. The above structure is maintained in a hierarchy of datafile tables composing a relational database. Each database table is maintained in a tab delineated ASCII file. While the database design is compatible with more formal database application, the limited resources of the BASIN project combined with several internal design objectives motivated the choice of a simpler, more portable approach.

4.5 Quality Assurance/Quality Control

For the City of Boulder's drinking water and storm water sampling effort, field blanks are used for every sampling event. Field blanks are filled with deionized water and are treated in the same manner as other sample bottles. Duplicate samples are also collected for each sampling event.

As for the IMS, BASIN manages the delivery and display of data obtained from existing environmental monitoring programs which are subject to their own internal QA/QC procedures (i.e., the City of Boulder's Drinking Water and Storm Water Quality monitoring). The BASIN IMS does not generate data and therefore relies on the existing quality control and quality assurance procedures of the participating data providers. However, since BASIN combines information from several water quality monitoring programs, reformats that information in both graphical and spatial context, and subjects raw data to scientific interpretation, it can rapidly identify data inconsistencies and incompatibility. All BASIN data projects are subject to a three step QA/QC process including QA at the data source, during data transfer, and through final data analysis. Also, all water quality data QA/QC complies with Standard Methods for Analysis of Wastewater and Water and USGS laboratory standards. [Source: BASIN Project, 2000 Annual Report]

5. DATA PRESENTATION

Once your environmental monitoring network is in place and you have begun to receive data, you can begin to provide your community with timely information using data presentation tools to both graphically depict this information and place it in a geographic community context.

Using data visualization tools, you can create graphical representations of environmental data that can be downloaded onto Web sites and/or included in reports and educational/outreach materials for the community. The types of data visualization utilized by the BASIN EMPACT team include annotated watershed maps, time series and profile bar graphs, and a water quality index.

In a similar vein, data presentation must address the overall context which may identify significant factors impacting data values. Often variations in data values are most directly explained by the locationof the monitoring site in the watershed, particularly in a watershed with significant variation in elevation, climate, geology, and human activities such as locations found in the Boulder Creek watershed.

Section 5.1 provides a basic introduction and overview to data presentation and is useful if you are interested in gaining a general understanding of data presentation. Section 5.2 provides an overview of the BASIN spatial data catalog used to provide an interactive map-based interface to a variety of Boulder area environmental data. Section 5.3 details the specific data presentation tools used to organize and present Boulder Creek water quality data including data visualization procedures used on the BASIN EMPACT project. You should consult Section 5.2 and Section 5.3 if you are responsible for designing and developing output pages for your environmental data. Section 5.4 discusses the calculation and presentation of a Water Quality Index which provides a quick overview of the health of the Boulder Creek watershed.

5.1 What is Data Presentation?

Data presentation is the process of converting raw data to images or graphs so that the data are easier to visualize and understand. Data presentation also includes providing supporting meta-data and interpretative text to make the data meaningful to the general population. Displaying data visually enables you to communicate results to a broader audience, such as residents in your community; while providing data interpretation can help the community to understand how it impacts the health of the surrounding environment.

In addition to offering several data visualization approaches BASIN stresses the importance of both explanation and interpretation of environmental data. Visual representation of the data is extremely useful to a knowledgeable professional and helpful to the general public but must be supported by additional explanatory material. For instance a time series plot of DO is only slightly more meaningful to the general public than a table of DO values; a crucial element is to supplement each data set with both general tutorial material on each parameter and dataset-specific, narrative interpretation developed by a qualified analyst.

In addition, it is important to provide specific details of collection and analysis methods for each parameter so that similar values from independent data sets can be compared and so that the moresophisticated user can obtain specific details of exactly how the parameter is measured; which is often useful when results appear to vary from expectations.

5.2 BASIN Spatial Data Catalog

BASIN has sought to create a general portal site to water and environmental information for the Boulder Creek watershed in an effort to provide a comprehensive overview of the watershed. As discussed in Chapter 3, BASIN provides access to data from three distinct sources; remote data already available on the Web, data obtained from cooperating sources that is collected independent of the BASIN project and data provided by active BASIN partners whose collection, analysis and management procedures are coordinated with BASIN personnel.

In addition to presenting water quality data provided by active data partners, BASIN sought out any Boulder area environmental data available on the Web and cataloged this information through a common map-based user interface. Many EMPACT sites will find that other government agencies may be collecting and posting data for their local area; particularly through national efforts such as the USGS stream gage network and the EPA Toxic Release Inventory, each which provides nationwide coverage of their monitoring and data maintenance efforts. Other local, state and regional resources may be available in a particular area.

By developing basic meta-data for these resources EMPACT sites can provide a common user interface to these data resources and supplement the data collected by the EMPACT team and participants. The BASIN project located and identified several supplemental resources in the Boulder Creek watershed and assembled URLs, geographic coordinates and responsible agency information and stores this meta-data in a format common to that used for internal data resources. This allows BASIN to provide users with access to this data through a common map based interface. These resources include USGS stream flow measurements, several local weather stations, snow pack monitoring in the higher elevations, all of the sites listed in the EDF/EPA toxic release inventory and a set of online cameras which provide real-time images from around the watershed. An example of the BASIN data catalog is shown below in Figure 5.1 (water quality data).

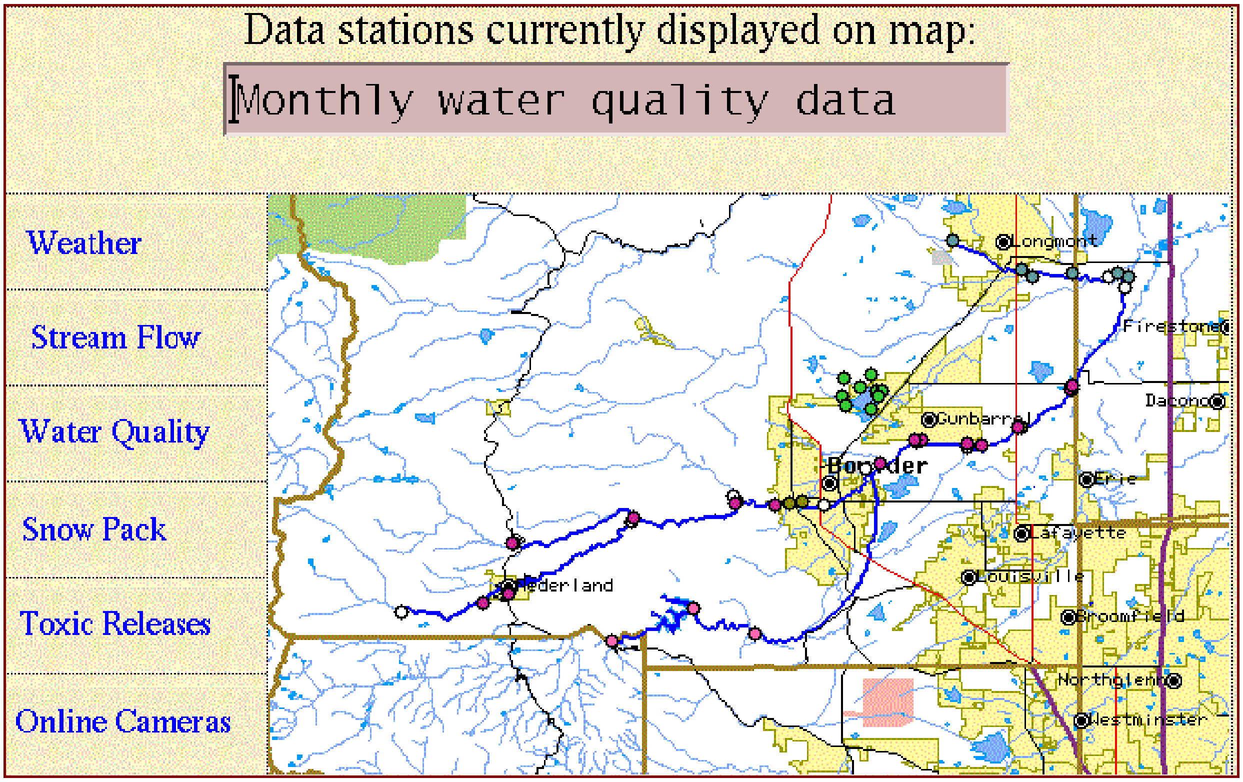


Figure 5.1 Example of BASIN's Spatial Data Catalog

In addition, in several cases data available through existing Web sites was deemed of significant interest and has been integrated directly into selected BASIN Web pages. Stream flow is a significant factor in the Boulder Creek watershed, particularly during early spring and late summer flood hazard seasons. These values are maintained on BASIN Web pages by automated processes that periodically obtain the current Web page from the source site and extracts essential values. For instance, the BASIN home page is regenerated every 5 minutes to update stream flow, air quality and UV exposure values. These automated processes are implemented in the PERL programming language and periodically executed by native UNIX cron procedures. When such external data is presented within an EMPACT site it is essential that access to the specific source site be readily apparent to the user, to insure the responsible agency is identified.

BASIN also includes several data sets provided by independent agencies. This data has been made available to the public through the BASIN Web site, but its collection is administered independent of the BASIN project. These data sets are accessed through the common BASIN spatial data catalog and presented in graphical format similar to those used for BASIN data sets; but collection, analysis and quality control procedures are not influenced by BASIN standards. These data sets include water quality data for South Boulder Creek collected by the Denver Water Board; Saint Vrain River water quality data collected by the City of Longmont and historic Boulder Creek water quality data collected by local high school students through the State of Colorado River Watch program. While one must exercise care comparing these data sets to those collected by cooperating agencies, such integration can enhance the compatibility of these data collection programs. For instance, the personnel from the City of Longmont have made voluntary efforts to coordinate data collection on the Saint Vrain River with that of the City of Boulder, resulting in a more comprehensive view of water quality in the larger Saint Vrain system.

Geographic presentation formats

In all three of the above data set types BASIN provides a uniform user interface to the available data by developing a common set of basic meta data stored in a common format such that a common set of processing tools can be employed to generate a user interface to all the datasets. BASIN provides access to all these data resources through a geographically oriented map interface using Web site image-map standards.

The most powerful visualization approaches to geographic distributed data are developed using formal GIS. However, GIS development is a resource intensive task; requiring sophisticated software applications, powerful computing resources and extensive human resources to develop basic mapping data and to integrate the available environmental data into the spatial data context. BASIN sought to stress a comprehensive data context and concluded the resources required to develop a formal GIS exceeded those available to the project. BASIN is currently working on an integration project with EPA Region 8, the USGS and the Denver Regional Council of Governments (DRCOG) to integrate formal GIS data resources with the current BASIN system.

BASIN used an alternative approach to develop procedures to manage and display spatial information. A series of procedures were developed to programmatically annotate static gif map images using graphical manipulation procedures. BASIN combines a series of publically available graphics libraries available within the PERL programming environment with background map images available in the public domain from the Census Bureau's TIGER Map Server (http://tiger.census.gov).

PERL is a widely used interpretative programming language distributed under a general public license (GPL) on a wide variety of operating systems. PERL is widely used in the Web site development community and extensive PERL programming resources are available on the Internet. PERL is particularly powerful due to the extensive set of freely available programming libraries (i.e., packages) available through the "Comprehensive PERL Archive Network" (CPAN). CPAN ftp sites are distributed throughout the Internet. PERL's Web site (http://www.perl.com) can provide the most convenient site for your locality. These libraries provide a rich set of well documented programming libraries to address a wide range of functionalities. These libraries are distributed in source code so sophisticated developers are free to enhance the basic procedures.

BASIN uses numerous CPAN PERL library packages as detailed in Chapter 4. Two specific PERL packages are used to provide graphics programming support to develop the BASIN spatial data catalog. The GD package provides standard graphic primitives (DrawPoint, DrawPolygon FillArea, etc) to dynamically annotate background GIF images. The GIFgraph package provides a higher level of abstraction to generate many standard data plot types including the bar charts used extensively in the BASIN data catalog. Each of the PERL packages are freely available on any of the CPAN ftp sites.

A set of base Boulder Creek watershed maps have been obtained from the TIGER map server and manually annotated to highlight the specific stream systems of interest. Geometric transform procedures have been developed to convert global monitoring site longitude and latitude parameters to map specific image coordinates. These procedures, combined with the GD graphics library routines, are used to generate annotated gif images integrated with HTML image map code and JAVA script to develop interactive Web-based image-maps interfaces. Users can identify and select monitoring sites using the mouse through standard Web browsers. These procedures rely on a small common set of meta data assembled for both local and remote data resources. Meta-data is maintained on the BASIN server as discussed in Chapter 4; as additional resources are added to the catalog the data catalog can be quickly regenerated to update the available resources.

5.3 Generating Data Presentations

The remote data resources provided through the BASIN Web site are designed and developed by the providers of those data resources so the format and structure of those resources are beyond the influence of the BASIN team. Local data resources, including both data sets supplied by non partnering agencies and those data sets developed in cooperation with the BASIN project are presented in formats designed and implemented by the BASIN team. The datasets provided by non-partner agencies are presented as relatively simple graphs based on conversation with the data suppliers. The remainder of this chapter focuses on the design and development of output pages for the datasets integral to the BASIN project.

5.3.1 Putting Data And Information In Context

BASIN provides coverage of in-stream water quality for 17 parameters at 19 monitoring stations throughout the watershed. Water quality parameters represent a complex set of measurements including interacting constituents. It is essential that the presentation of the data provide a comprehensive explanation of each parameter and the influences of the spatial distribution and seasonal effects of the variation of these parameters.

Each dataset is supported by a comprehensive set of meta-data which identify the collecting agency and describe the specific procedures used to collect the sample and/

or analyze each parameter, including analysis detection limits. Each monitoring site is further described using photographs of the collection site and a small TIGER map of the specific collection site. Each dataset is linked to extensive general information describing the parameter and how it relates to the overall system behavior. A set of data set specific interpretive narratives are also provided for each parameter describing how the parameter varies across the watershed and over the course of the seasons. This information is maintained by the BASIN IMS as described in Chapter 4.

The procedures which generate the data presentation pages must integrate all the stored meta-data and supporting information into the display outputs.

5.3.2 Data Visualization Design

User selection interface

The BASIN water quality data user interface (http://basin.org/data/COBWQ) allows users to select one or more parameters to be displayed as longitudinal profiles for a selected month, a time series for a selected station or an entire years data displayed as miniature time series on a watershed map. Users can select stations from a menu or directly from a watershed map.

Page design

The initial page delivered in response to a user selection provides a summary page of the selected parameters including small versions of the selected plots, a block of meta-data describing the data set, data set-specific contextual information, and an optional data table.

When longitudinal profiles are selected a watershed image map is included which locates each of the stations included in the profile. Users may jump to time series display of a specific station by selecting a station from the map or by selecting the listed station in the data table.

When time series data are selected the contextual information includes a small map of the region around the monitoring station, specific data about the station, and a link to a photograph of the collection point. Users can jump to monthly longitudinal profiles by selecting the month label in the data table.

In both cases users can traverse to adjacent plots (upstream and downstream in the case of time series and preceding and following months in the case of profiles) through navigation links provided on each page. When users request a subset of the available parameters all navigation links retain this selection so users may traverse the data set in time and space viewing a specific subset of parameters.

Further information about each parameter can be obtained by selecting either the parameter plot or the parameter label in the data table. The resulting page includes a larger plot and more extensive general information and data set-specific analysis which seeks to provide users with a definitive explanation of the significance of the parameter, analysis of how it varies across the watershed and throughout the seasons and specific details on how the samples are collected and analyzed. Specific contact information is provided as well as an opportunity to download the data in a portable ASCII text format suitable for importation into typical spreadsheet and database applications. The user may also select a full screen plot of the parameter suitable for printing.

Plot elements

When selecting the formats for displaying the watershed data several considerations arise. The BASIN water quality data set consists of monthly values of 17 parameters collected from 19 sites throughout the watershed. Since the resulting 3 dimensional dataset cannot be easily displayed on two dimensional graphs, BASIN provides 3 views of the dataset.

Longitudinal profiles provide plots of the variation of each parameter over selected stream channels for each month of the year. Since samples are not collected simultaneously at all the stations the profiles are represented as bar charts rather than line plots. Three sizes of plots are generated; one small plot which is used on multiple parameter pages; a medium size plot used on a single parameter data page, and a full screen plot design for printer output. An example of a longitudinal profile plot for nitrate and nitrite is shown in Figure 5.2.

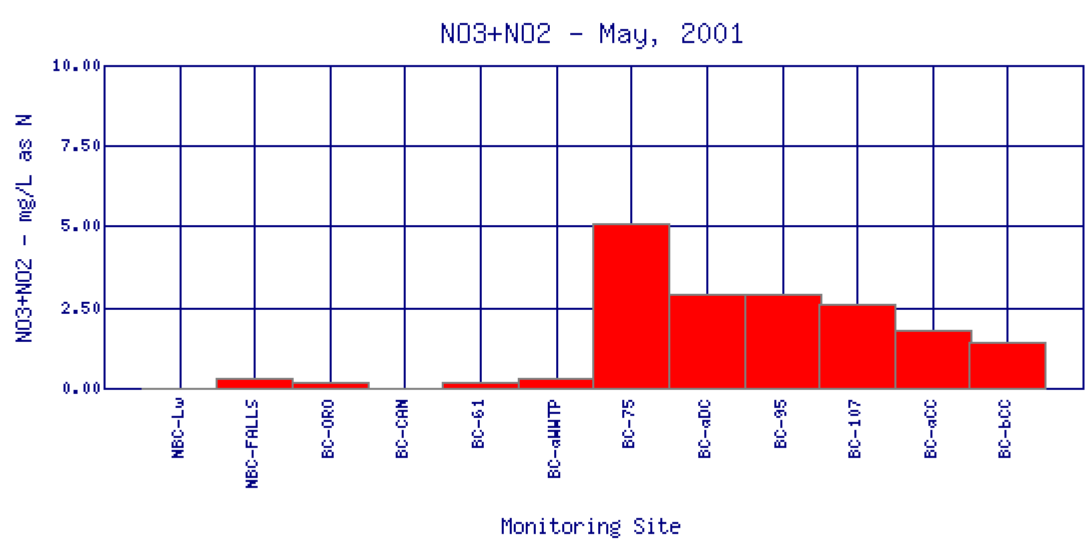


Figure 5.2. Example BASIN Longitudinal Profiles Plot (medium)

Annual time series are provided for each month of the year at each station. Time series plots are presented as bar charts to reflect the discontinuous nature of monthly data. Four sizes of plots are generated; one small plot used on multiple parameter pages; a medium size plot used on a single parameter data page, a full screen plot design for a printer and a miniature plot for full map displays. An example of a longitudinal profile plot for nitrate and nitrite is shown in Figure 5.3.

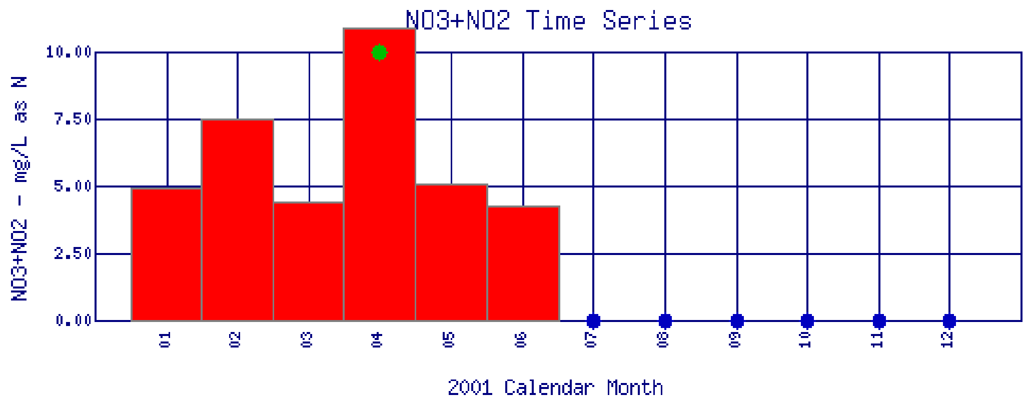


Figure 5.3 Example of BASIN Time Series Plot (medium)

Map plots summarize the entire annual data set in a single geographic display by overlaying reduced time series plots on the watershed map. Each miniature time series plot is generated when the larger time series plot is generated. The plots are overlaid on the map using the GD plot procedures discussed above and annotated with lines connecting the miniature time series to an icon at the specific location of the stations. The map is supported by a client side image map and java script code such that mousing over the plot or station icon identifies the station and selecting either image will jump to the station time series page. An example of a map plot is shown in Figure 5.4.

Some thought should be given to handling missing data, special cases, and the details of data presentations. For instance, in the BASIN data sets often specific parameter measurements fall below the practical detection limits of the analysis procedures. By maintaining these detection limits as part of the parameter meta-data the BASIN displays can flag these nondetectable levels as separate from missing data. Since parameters are plotted on a global set of axes, small values may appear missing on data plots; however, by specifically noting missing data on the plots BASIN insures small measured values are not overlooked. Alternatively, occasionally values are encountered that greatly exceed the normal range of a particular parameter. Plot scales must be ascertained which will provide meaningful display of the bulk of the data while providing a procedure to handle occasional outliers. The actual value of these outlying measurements can be obtained from the data tables.

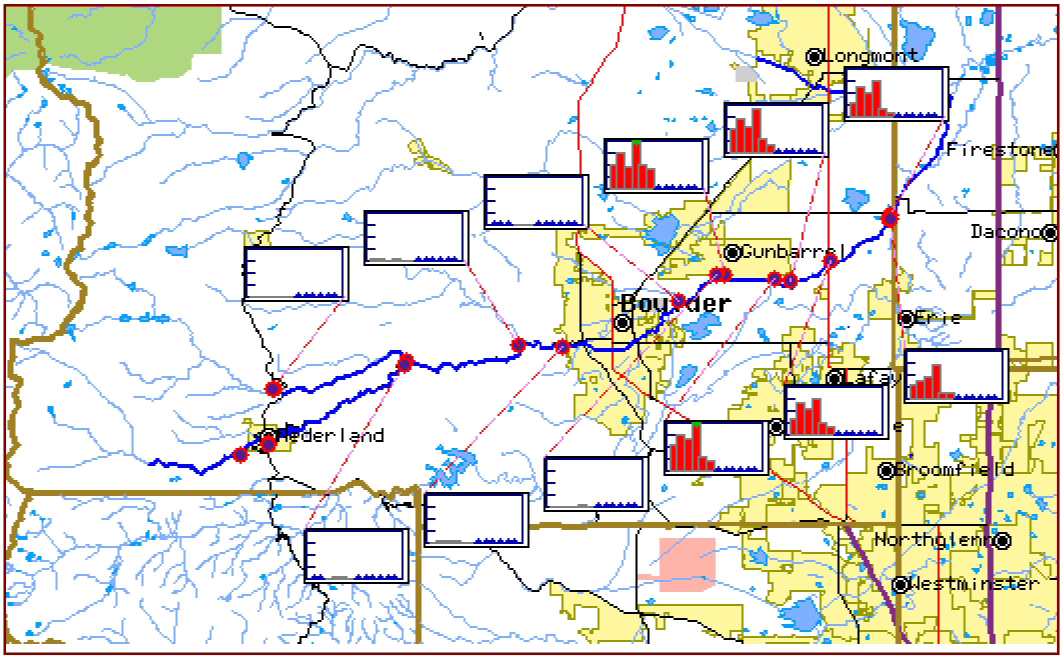


Figure 5.4 Example of BASIN Map Plot (Nitrate and Nitrite).

5.3.3 Implementation

The data display pages described above are developed through a combination of batch processing and interactive page generation. Since data sets are updated monthly but may be requested more frequently it was determined that better performance would result from preparing data plots when data sets are updated rather than on request. When new data is submitted to the system a PERL-based batch processor is executed and the entire set of annual data plots regenerated. Since each update involves 17 parameters, measured at 19 stations and up to 12 months in multiple sizes, each batch process generates approximately 1600 plots. Manual construction of this many plots would be infeasible using interactive spreadsheet or plotting applications. An additional advantage of this batch approach is the rapid regeneration of all plotting output in the face of data re-submissions or output design modifications.Batch processor routines are implemented using PERL object oriented programming techniques as described in Chapter 4. Upon execution, static database tables are assembled into a complex data tree which is then used to construct data vectors for each plotting routine. Plots are generated by GIFgraph library procedures through the PERL object interface and written into a static Web site directory hierarchy. Batch processors are programmatically connected with data update and preprocessing procedures such that Web site display elements are automatically updated upon receipt of data set updates.

Actual page construction occurs when users submit display requests. Summary pages are constructed by referencing the stored data plots and dynamically generating the requested data table. Similarly, data files are dynamically prepared for downloading upon user requests.

5.4 Water Quality Index (WQI) Computation and Display

In addition to the variety of data display options described above BASIN has implemented a water quality index which provides a rapid overview of conditions in the watershed. BASIN researched several types of water quality indices and selected an index developed by the National Sanitation Foundation (NSF) which is used by many communities for characterizing overall water quality. The BASIN water quality index is a modified version of the NSF index, based on seven parameters (i.e., DO, fecal coliform, pH, total phosphate, nitrate, total solids, and turbidity) measured at the sampling sites. On its Web site, BASIN provides a map of the watershed which presents the water quality index as calculated at several sites on Boulder Creek (http://basin.org/data/WQI/index.html). The index (or grade) scale is A through F, with "A" representing "Excellent" water quality and "F" representing "Very Bad" water quality.

Users who want more information on what parameter affects water quality at a specific sampling site may select the site grade signpost to view the WQI computation for that site. Note while the index provides a quick overview of the water quality throughout the watershed, the BASIN Web site provides more detailed analysis of specific Boulder Creek water quality data and general discussion of the specific factors that affect water quality in Boulder Creek as described in the preceding sections.

BASIN computes the NSF Water Quality Index using computational methods described in the book Field Manual for Water Quality Monitoring (Mitchell and Stapp, Kendall Hunt Publishing, c 2000). This procedure derives a single metric of stream water quality at a monitoring site using 7 water quality measurements (DO % saturation, pH, fecal coliform, total phosphates, nitrate, solids and turbidity). The computation maps the value of each parameter to a theoretically determined "Q value" using graphs provided by NSF researchers. These Q values are combined with factors to determine a single "Grade" at each site.

Calculation of the WQI is automated and occurs when data for the 7 required parameters are available at a site. When direct measurement of DO as a percent of theoretical saturation is not available at a site, the theoretical saturation is computed for the measured temperature and the result is corrected to the site elevation (maintained in the database site table). This derived DO% value is then used to determine the appropriate Q-value as discussed below.

The BASIN IMS implements the WQI computational algorithm using a graphical lookup procedure. Q-Value plots have been optically scanned and are maintained on the EDNA server as monochromatic image files. These files are loaded into memory as image arrays and Q-values are "read" off the plots for each parameter value using a pixel color index test. Once Q values are determined weighting factors are applied and the numerical grade is computed. This grade is then converted to a letter grade to assign a graphical signpost to the site.

BASIN's graphical image annotation procedures are then executed to generate an image-map with the NSF WQI Grade signpost at each station in the watershed. Each site and signpost is linked to an automatically generated HTML spreadsheet detailing the underlying WQI computations at that station. An example of this output procedure is shown in Figure 5.5. Other examples of the output of this procedure are available at http://basin.org/data/WQI/.

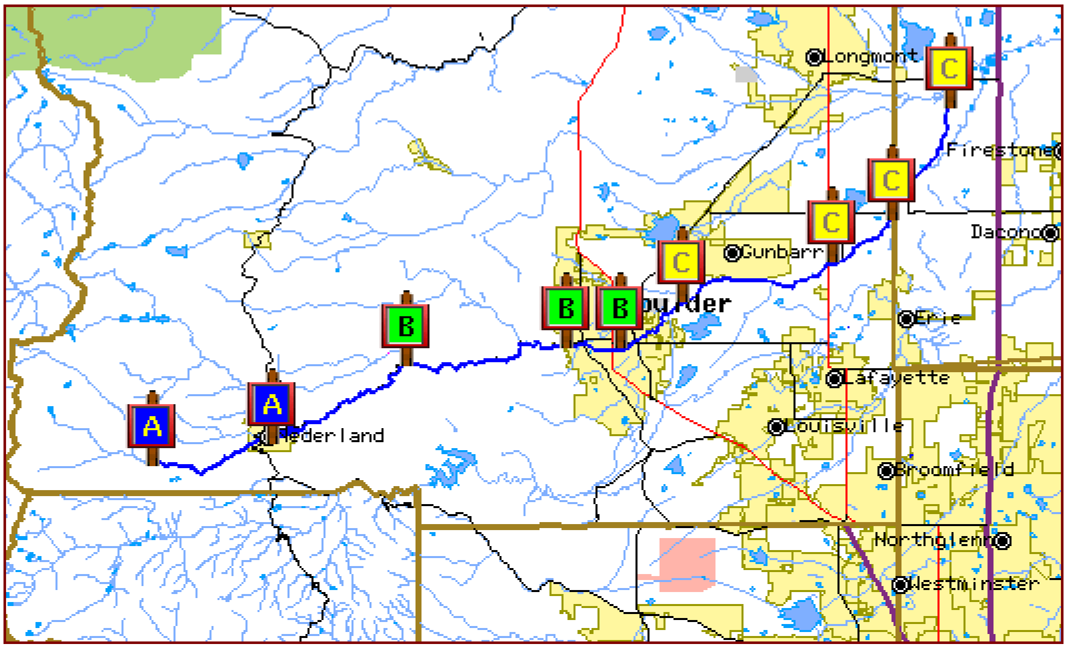


Figure 5.5 Water Quality Index

5.5 Conclusions

This chapter has described several of the approaches the BASIN EMPACT project has taken to present environmental data in a meaningful context to encourage community understanding of the Boulder Creek Watershed. While exhaustive detail on these techniques is beyond the scope of this manual, it is hoped this chapter has provided some ideas on a variety of data presentation alternatives and the importance of placing EMPACT data in an overall interpretative context.

6. COMMUNICATING TIMELY ENVIRONMENTAL INFORMATION

Providing timely environmental information to the community is not simply a matter of placing data files on a Web site. Working directly with members of the community-at-large, determining user needs and concerns, and going through an iterative process with key stakeholders will help make your environmental information more meaningful and accessible to the community you are trying to serve. This chapter is designed to help you develop an approach for communicating pertinent environmental information to people in your community, or more specifically, your target audience. This chapter provides the following:

- the steps involved in developing an outreach plan,
- guidelines for effectively communicating information,
- resources to assist in promoting community awareness, and
- the outreach initiatives implemented by the BASIN team.

6.1 Developing an Outreach Plan for Disseminating Timely Environmental Monitoring Data

Your outreach program will be most effective if you ask yourself the following questions:

- Who do we want to reach? (i.e., Who is your target audience or audiences?)
- What information do we want to distribute or communicate?
- What are the most effective mechanisms to reach our target audience?
- How do we involve users or target audiences in usability testing and, if possible, program development?

Developing an outreach plan ensures that you have considered all important elements of an outreach project before you begin. The plan itself provides a blueprint for action. An outreach plan does not have to be lengthy or complicated. You can develop a plan simply by documenting your answers to each of the questions discussed below. This will provide you with a solid foundation for launching an outreach effort.

Your outreach plan will be most effective if you involve a variety of people in its development. Where possible, consider involving

- a communications specialist or someone who has experience developing and implementing an outreach plan,
- technical experts in the subject matter (both scientific and policy),
- someone who represents the target audience (i.e., the people or groups you want to reach), and
- key individuals who will be involved in implementing the outreach plan.

As you develop your outreach plan, consider whether you would like to invite any organizations to partner with you in planning or implementing the outreach effort. Potential partners might include local businesses, environmental organizations, schools, boating associations, local health departments, local planning and zoning authorities, and other local or state agencies. Partners can participate in planning, product development and review, and distribution. Partnerships can be valuable mechanisms for leveraging resources while enhancing the quality, credibility, and success of outreach efforts. Developing an outreach plan is a creative and iterative process involving a number of interrelated steps, as described below. As you move through each of these steps, you might want to revisit and refine the decisions you made in earlier steps until you have an integrated, comprehensive, and achievable plan.

6.1.1 What Are Your Outreach Goals?

Defining your outreach goals is the initial step in developing an outreach plan. Outreach goals should be clear, simple, action-oriented statements about what you hope to accomplish through outreach. Once you have established your goals, every other element of the plan should relate to those goals. Here were some project goals for the BASIN EMPACT project:

- Improve existing environmental monitoring to provide credible, timely and usable information about the watershed to the public.
- Create a state-of-the-art information management and public access infrastructure using advanced, Web-based computer technologies.
- Build strong partnerships and an ongoing alliance of governmental, educational, non-profit and private entities involved in watershed monitoring, management, and education.

- Develop education and communication programs to effectively utilize watershed information in the public media and schools and facilitate greater public involvement in public policy formation.

- Increase public awareness of how the hydrologic cycle effects everyday life, where drinking and irrigation water come from, how it is used, and what happens downstream.

BASIN's general goals listed above also had specific objectives. For example, BASIN's specific objective for improving existing environmental monitoring included providing brochures and posters to all fifth grade teachers and middle school science teachers in the Boulder Valley School District.

6.1.2 Whom Are You Trying To Reach?

Identifying Your Audience(s)

The next step in developing an outreach plan is to clearly identify the target audience or audiences for your outreach effort. As illustrated in the BASIN project goals above, outreach goals often define their target audiences (e.g., the public and fisheries). You might want to refine and add to your goals after you have defined your target audience(s).

Target audiences for a water quality outreach program might include, for example, the general public, local decision makers and land management agencies, educators and students (high school and college), special interest groups (e.g., homeowner associations, fishing and boating organizations, gardening clubs, and lawn maintenance/landscape professionals). Some audiences, such as educators and special interest groups, might serve as conduits to help disseminate information to other audiences you have identified, such as the general public.

Consider whether you should divide the public into two or more audience categories. For example: Will you be providing different information to different groups, such as the citizens vs. businesses? Does a significant portion of the public you are trying to reach have a different cultural or linguistic background? If so, it may be more effective to consider these groups as separate audience categories.

Profiling Your Audience(s)

Once you have identified your audiences, the next step is to develop a profile of their situations, interests, and concerns. Outreach will be most effective if the type, content, and distribution of outreach products are specifically tailored to the characteristics of your target audiences. Developing a profile will help you identify the most effective ways of reaching the audience. For each target audience, consider the following:

- What is their current level of knowledge about water quality and general watershed awareness?
- What do you want them to know about water quality? What actions would you like them to take regarding water quality?
- What information is likely to be of greatest interest to the audience? What information will they likely want to know once they develop some awareness of water quality issues?
- How much time are they likely to give to receiving and assimilating the information?
- How does this group generally receive information?
- What professional, recreational, and domestic activities does this group typically engage in that might provide avenues for distributing outreach products? Are there any organizations or centers that represent or serve the audience and might be avenues for disseminating your outreach products?

Profiling an audience essentially involves putting yourself "in your audience's shoes." Ways to do this include consulting with individuals or organizations who represent or are members of the audience, consulting with colleagues who have successfully developed other outreach products for the audience, and using your imagination.

6.1.3 What Do You Want To Communicate?

The next step in planning an outreach program is to think about what you want to communicate. In particular, think about the key points, or "messages," you want to communicate. Messages are the "bottom line" information you want your audience to walk away with, even if they forget the details.

A message is usually phrased as a brief (often one-sentence) statement. The following are some examples of messages that are posted on the BASIN Web site:

- Real-time Boulder Creek flowrates.
- BASIN now provides a Water Quality Index for the main stem of Boulder Creek along with other water quality information for the Boulder Creek Watershed.
- Online cameras including Niwot Ridge Tundra Cam.

Outreach products will often have multiple related messages. Consider what messages you want to send to each target audience group. You may have different messages for different audiences.

6.1.4 What Outreach Products Will You Develop?

The next step in developing an outreach plan is to consider what types of outreach products will be most effective for reaching each target audience. There are many different types of outreach: print, audiovisual, electronic, events, and novelty items.

TIP!

> Include representatives of specific user groups when developing outreach products. They have valuable input regarding what the various needs and interests of your larger audience.

The audience profile information you assembled earlier will be helpful in selecting appropriate products. A communications professional can provide valuable guidance in choosing the most appropriate products to meet your goals within your resources and time constraints. Questions to consider when selecting products include:

- How much information does your audience really need? How much does your audience need to know now? The simplest, most straightforward product generally is most effective.
- Is the product likely to appeal to the target audience? How much time will it take to interact with the product? Is the audience likely to make that time?
- How easy and cost-effective will the product be to distribute or, in the case of an event, organize?
- How many people is this product likely to reach? For an event, how many people are likely to attend?
- What time frame is needed to develop and distribute the product?
- How much will it cost to develop the product? Do you have access to the talent and resources needed for product development?
- What other related products are already available? Can you build on existing products?

- When will the material be out of date? (You probably will want to spend fewer resources on products with shorter lifetimes.)

- Would it be effective to have distinct phases of products over time? For example, an initial phase of products designed to raise awareness, followed by later phases of products to increase understanding.

- How newsworthy is the information? Information with inherent news value is more likely to be rapidly and widely disseminated by the media.

6.1.5 How Will Your Products Reach Your Audience?

Effective distribution is essential to the success of an outreach strategy. You need to consider how each product will be distributed and determine who will be responsible for distribution. For some products, your organization might manage distribution. For others, you might rely on intermediaries (such as the media or educators) or organizational partners who are willing to participate in the outreach effort. Consult with an experienced communications professional to obtain information about the resources and time required for the various distribution options. Some points to consider in selecting distribution channels include:

- How does the audience typically receive information?

- What distribution mechanisms has your organization used in the past for this audience? Were these mechanisms effective?

- Can you identify any partner organizations that might be willing to assist in the distribution?

- Can the media play a role in distribution?

- Will the mechanism you are considering really reach the intended audience? For example, the Internet can be an effective distribution mechanism, but certain groups might have limited access to it.

- How many people is the product likely to reach through the distribution mechanism you are considering?

- Are sufficient resources available to fund and implement distribution via the mechanisms of interest?

Table 6.1 provides various distribution avenues and outreach products for communicating your environmental data to the public.

TABLE 6.1. METHODS OF COMMUNICATION

Mailing lists	• Brochures • Newsletters • Fact sheets • Utility bill inserts or stuffers
Phone/fax	• Promotional hotline
E-mail/Internet	• Newsletters • E-mail messages • Web pages • Subscriber list servers
Radio/TV	• Cable TV programs • Public service announcements • Videos • Media interviews • Press conferences/releases
Journals or newsletters	• Newsletters • Editorials • Newspaper and magazine articles
Meetings, community events, or locations (e.g., libraries, schools, marinas, public beaches, tackle shops, etc.) where products are made available.	• Exhibits • Kiosks • Posters • Question-and-answer sheets • Novelty items (e.g., mouse pads, golf tees, buttons, key chains, magnets, bumper stickers, coloring books, frisbees, etc.) • Banners • Briefings • Fairs and festivals • Meetings (i.e., one-on-one and public) • Community days • Speeches • Educational curricula

6.1.6 What Follow-up Mechanisms Will You Establish?

Successful outreach may cause people to contact you with requests for more information or expressing concern about issues you have addressed. Consider whether and how you will handle this interest. The following questions can help you develop this part of your strategy:

- What types of reactions or concerns are audience members likely to have in response to the outreach information?
- Who will handle requests for additional information?
- Do you want to indicate on the outreach product where people can go for further information (e. g., provide a contact name, number, address, or establish a hotline)?

The BASIN Web site (http://bcn.boulder.co.us/basin/main/about.html) provides information so that people can contact the BASIN Project Coordinator by phone, e-mail, or postal mail. The public can also contact the BASIN Project Coordinator via a Web site comment form.

6.1.7 What Is the Schedule for Implementation?

Once you have decided on your goals, audiences, messages, products, and distribution channels, you will need to develop an implementation schedule. For each product, consider how much time will be needed for development and distribution. Be sure to factor in sufficient time for product review. Wherever possible, build in time for testing and evaluation by members or representatives of the target audience in focus groups or individual sessions so that you can get feedback on whether you have effectively targeted your material for your audience. Section 6.3 contains suggestions for presenting technical information to the public. It also provides information about online resources that can provide easy to understand background information that you can use in developing your own outreach projects.

6.2 Elements of the BASIN Project's Outreach Program

The BASIN Project team uses a variety of mechanisms to communicate timely environmental information, as well as information about the project itself, to the Boulder area community. The team uses the BASIN Web site as the primary vehicle for communicating timely information to the public. Their outreach strategy includes a variety of mechanisms (e.g., Internet, brochures, presentations at events, and community television) to provide the public with information about the BASIN project.

6.2.1 Outreach Elements

Each element of the project's communication and participation program are discussed below.

Public Participation. The BASIN project vigorously encouraged public participation. BASIN continuously invited the public to join the project primarily through their Web site (which is discussed later). The interested public could join as a BASIN Boulder Community Network (BCN) Volunteer, join the BASIN Forum, complete the BASIN Survey, or join local school or neighborhood projects.

BASIN BCN. BASIN invited the public to help with graphic design, Web page development, scripting or video/audio streaming. BASIN provided an online "classified ads" (http://bcn.boulder.co.us/basin/news/classifieds.html) to help the community see the needs of the BASIN project. Potential BCN Volunteers could contact the BASIN Volunteer Coordinator either by phone or e-mail or sign up as a BCN Volunteer by completing the online BCN Volunteer Questionnaire (http://bcn.boulder.co.us/volunteer/register.html). BCN Volunteers provided over 1000 hours of assistance by offering ideas and feedback and designing the BASIN Web site.

BASIN FORUM. BASIN provided an online forum for the interested public to share ideas or information about local environmental and social concerns that relate to community livability and sustainability. The public could either post their ideas and comments online or subscribe to the Boulder Creek Watershed e-mail list serve to obtain information about BASIN forum.

BASIN Survey. For individuals who did not have time to become a BCN Volunteer, BASIN provided an opportunity for Web site visitors to provide comments regarding the usefulness and presentation of the information provided on the BASIN Web site (http://bcn.boulder.co.us/basin/surveys/index.html). The public could either type their comments in a text field or take an online 10-question survey.

School or Neighborhood Projects. Schools and neighborhoods could contact BASIN to find out how they could develop and implement their own school water monitoring projects.

Bringing together experts. The EMPACT project stakeholders included representatives from organizations that originally signed the BASIN Memorandum of Understanding (MOU), as well as other interested individuals in the community who use or provide environmental information to the public and were supportive of the BASIN's efforts. The MOU was a non-binding agreement among the BASIN partners to cooperate fully in the project, including active participation in the project design, development, and implementation of the project. The originals signers of the MOU are listed below.

- City of Boulder
- enfo.com
- Local environmental educators and organizers
- University of Colorado Department of Civil Engineering and Architectural Engineering
- The U.S. Geological Survey
- Boulder Community Network
- Boulder County Healthy Communities Initiative
- Boulder County Health Department
- Boulder Creek Watershed Initiative
- Boulder Valley School District
- Colorado Division of Wildlife - River Watch Network
- Community Access Television

Web site. The BASIN Web site can be accessed at http://bcn.boulder.co.us/basin. The EMPACT project is discussed at http://bcn.boulder.co.us/basin/main/about.html. The Web site was the main avenue used by the team for disseminating the various environmental monitoring data. It was estimated that 80 percent of all residents in the Boulder area have Internet access [Source: 1998 EMPACT Grant Application, Draft (5/11)]. Although the BASIN project ended in December 2000, the Web site still provides a variety of real-time data, maps and live on-line cameras. Data includes weather, stream flow, water quality, and snow pack. In addition to providing water-related data, the site provides air quality advisories, which are linked to the Colorado Air Pollution Control Division's Web site (http://apcd.state.co.us/psi/main.html). The site also announces the availability of new reports and studies for the Boulder area.

The left side of the BASIN Web page displays a list of "Themes" discussing a variety of topics such as watersheds, waterworks technology and infrastructure, personal actions for protecting water quality, recreation, and current events. Via the Web site, the public can read news about the project or participate in online forums. These are discussed below:

Newsletter. The project newsletter, *BASIN News*, featured local, timely environmental information which focused on water issues and links to other resources. The newsletter was published bi-monthly in electronic form. The public could read *BASIN News* online at http://bcn.boulder.co.us/basin/news/current.html or could subscribe to receive *BASIN News* in HTML or text only format for free through their email account. Hard copies were distributed in various city offices. Appendix C contains a copy of the December 2000 issue.

Online Forums. BASIN hosted an online forum to discuss topics of local interest and concern on October 23-31. Entitled *Drought, Fire & Flood in the Boulder Area: Are We Prepared?* this electronic seminar explored the background, current situation, and future concerns relating to climate change, wildfires and flash flooding in the Boulder area. The public participated by subscribing to the discussion list serve or could download a daily summary of the discussion from the BASIN Web site.

Stakeholder Update. Periodically, the BASIN team provided a Stakeholder Update letter which discussed the recent activities on the project. The Stakeholder Update announced the availability of new data, outreach and marketing efforts, new studies, staffing changes, etc. The Stakeholder Update letter was available on the BASIN Web site.

Television. Students from Sojourner Middle School in Boulder wrote and produced a television news program about various aspects of Boulder Creek which they had been studying throughout the school year. The students were assisted by members of BASIN in researching, developing, and producing the television program. The students interviewed various experts to gather information on drinking water, kayaking, flash flood hazards, the importance of snow runoff, the greenback cutthroat trout, ammonia, and macro invertebrates. The 50 minute program, including a 15 minute documentary on the making of the program, aired two days a week during July 2000 and won a local community media award for best student documentary. The program was featured in the American Water Works Association's (AWWA) Mainstream Magazine in May, 2001. In addition, a 13 minute television program entitled "BASIN Kid" showing basic water quality testing techniques and a 15 minute program providing an overview on the Millennium Baseline Study were shown on community television.

Presentations. BASIN representatives gave presentations to a variety of groups including the state Flood and Drought Task Force, Denver Regional Council of Governments, city advisory boards, EPA Region 8, PLAN Boulder, several EPA conferences and on the local radio station KGNU. In August 2000, Mark McCaffrey gave a presentation in Sweden at the Stockholm International Water Symposium. In September 2000, Mr. McCaffrey and Sheila Murphy gave a presentation at the American Water Resources Association (AWRA) Colorado State Convention in Vail.

Piggybacking on existing events. BASIN representatives attended many local events providing brochures and displaying project posters for the attending public. Such local events included the Boulder Earth Day Festival, the Boulder Creek Festival, Boulder Farmer's Market, and the Children's Water Festival. Maps of the watershed proved to be an excellent icebreaker at public events and a natural segue to providing the public with brochures about BASIN.

6.2.2 Developing the BASIN Web Site

Experience Gained and Lessons Learned

The BASIN team encountered several challenges as it tried to establish continuity and maintain momentum for the project. One collaborative challenge involved reaching a group consensus on the goals for the project. Many individuals had differing opinions regarding the goal of the project and how resources should be allocated to various endeavors. One member of the BASIN staff who had experience as a professional facilitator was able to aid in the dialogue process for reaching consensus and working through issues of contention and disagreement. By identifying potential areas of conflict and working to clarify their shared vision, the facilitator assisted the team as they attempted to pioneer new ways of networking and collaborating together. The experience also suggests that future teams desiring to implement a similar program allow time and resources for establishing the team relationships.

The team experienced several obstacles when soliciting partnerships with potential data providers. The team realized that providing public access to environmental information is a major paradigm shift. In most of the world, the idea of a public's "right-to-know" simply does not exist. While in the U.S. there is increasingly the technology and the will to inform the public about their environmental system's health, there are numerous political, technological, cultural, and personal challenges involved in pioneering systems and approaches to involving the public more directly in monitoring their local environment and taking responsibility for the impact of their actions.

Some institutions that were solicited for data were simply uncomfortable with making their data publicly available. They were concerned that there would be public inquiries arising from data without staff resources to address these inquiries. They were also concerned about the uncompensated in-house costs for preparing and delivering internal data to the public.

Other potential data providers supported the objectives of the BASIN project and expressed willingness to provide data; however, ongoing discussions with the potential data providers resulted in mixed success and a greater clarification of the challenges and difficulties associated with data partnering. BASIN had established rigorous standards for supporting meta-data and providing interpretive information along with the data, as well as standards for quality control and quality assurance. While most of the potential data providers readily provided access to raw data sets, obtaining or developing appropriate supportive interpretative information and agreeing to appropriate QA/QC procedures proved more problematic. [Source: 2000 Annual Report, BASIN Project EMPACT Grant, January 30, 2001]

While several environmental monitoring programs were identified within the watershed, the team quickly realized that few of the potential data providers were immediately prepared to make their data available to the general public. The following concerns were identified:

- The need for comprehensive information context to relay the significance of the data to the public.

- The need for additional internal quality control before releasing in-house data.

These early interviews also served to clarify technical challenges of developing the project's IMS. The team quickly realized that independent data collection programs involved highly specific collection and analysis procedures, software standards varied dramatically between monitoring programs, and data was retained in a variety of units.

These factors lead to a restructuring of the project plan. As a result, the project focus was shifted from a more standard software development cycle of needs assessment, initial design, user evaluation, implementation and testing to a more responsive and rapid approach. To ensure both public participation and data provider cooperation, the initial software development schedule was revised to advance the implementation of prototype data delivery and Web site information products. Prototype applications were then applied to additional data sets as providers agreed to participate.
[Source: BASIN Final Report, BASIN EMPACT Project, February 2001]

Key to the development of BASIN's Web site and associated outreach products were the volunteers of the BCN who brought a wide variety of skills and perspectives to the effort. In the early months of the project a series of monthly meetings were held with some 40 BCN volunteers. After an overview of the goals of the project was given, the volunteers broke into four primary teams: Web Design, Architecture, Resource Discovery Group and Outreach. One volunteer-- a geography teacher at a local high school was particularly interested in GIS on the Web, and while it was determined that GIS was beyond the scope of BASIN's pilot project, he continued to be involved and has now developed a GIS unit for his class using aerial photos from the BASIN Web site. A general BCN volunteer list was established to keep all the participants informed on new developments and to ask for assistance and feedback on particular aspects of the project. Many of the volunteers were involved with the high-tech field in the region and were able to bring their expertise and tools to the project.

In addition to the monthly meetings, the teams worked together with BASIN staff on specific tasks, and a password protected development site was developed to begin experimenting with approaches and artwork, and much of the actual development of the Web site including usability testing was conducted on the Web with the active involvement of key BCN volunteers. The volunteers gained experience and provided a valuable community service through their involvement with the project. BASIN's BCN volunteers proved to be more than just an in-house focus group for on-going feedback as the Web site and related outreach projects went through their iterative development. They also served as powerful advocates in their own communities, promoting BASIN with their families, schools, and work colleagues.

Within six months after first meeting with volunteers of the Boulder Community Network, the first release of the BASIN Web site was made available to the general public, and during that six month period much of the "place-based" information relating to the watershed community's unique history, geography and culture were developed. Historical photos from the Denver Public Library and the Library of Congress were added to the Web site, existing watershed education materials and quizzes were configured for the Web, historical essays and other materials helped to contextualize the environmental data that was added to the site in the following months. In addition to enriching the Web site with multi-disciplinary depth, it also served as an inspiration for other local contributors to ask that their own materials be added to the network. These include Dr. Pete Palmer's peer reviewed articles on sustainability at http://bcn.boulder.co.us/basin/local/sustainintro.html and excerpts from Joanna Sampson's digital book HIGH, WILD AND HANDSOME: The Story of Colorado's Beautiful South Boulder Creek and Eldorado Canyon at http://bcn.boulder.co.us/basin/history/Moffat.html.

Among the volunteer efforts that BCN volunteers provided were the BASIN logo (developed by Linda Mark) which played a key role in establishing "brand recognition" of BASIN and was used on all BASIN brochures and posters, and the online quizzes (by Paul von Behren).

6.3 Resources for Presenting Environmental Information to the Public

As you develop your various forms of communication materials and begin to implement your outreach plan, you will want to make sure that these materials present your information as clearly and accurately as possible. There are resources on the Internet to help you develop your outreach materials. Some of these are discussed below.

6.3.1 How Do You Present Technical Information to the Public?

Environmental topics are often technical in nature and full of jargon, and environmental monitoring information is no exception. Nonetheless, technical information can be conveyed in simple, clear terms to those in the general public not familiar with environmental data. The following principles should be used when conveying technical information to the public:

- avoid using jargon,

- translate technical terms (e.g., reflectance) into everyday language the public can easily understand,

- use active voice,

- write short sentences,

- use headings and other formatting techniques to provide a clear and organized structure.

The following Web sites provide guidance regarding how to write clearly and effectively for a general audience:

- The National Partnership for Reinventing Government has a guidance document, *Writing User-Friendly Documents*, that can be found on the Web at http://www.plainlanguage.gov.

- The American Bar Association has a Web site that provides links to on-line writing labs (http://www.abanet.org/lpm/bparticle11463_front.shtml). The Web site discusses topics such as handouts and grammar.

As you develop communication materials for your audience, remember to tailor your information to consider what they are already likely to know, what you want them to know, and what they are likely to understand. The most effective approach is to provide information that is valuable and interesting to the target audience. For example, the kayakers may want to know about the creek flow rates in Boulder Creek. Also, when developing outreach products, be sure to consider special needs of the target audience. For example, ask yourself if your target audience has a large number of people who speak little or no English. If so, you should prepare communication materials in their native language.

The rest of this section contains information about resources available on the Internet that can assist you as you develop your own outreach projects. Some of the Web sites discussed below contain products, such as downloadable documents or fact sheets, which you can use to develop and tailor your education and outreach efforts.

6.3.2 Federal Resources

EPA's Surf Your Watershed
http://www.epa.gov/surf3

This Web site can be used to locate, use, and share environmental information on watersheds. One section of this site, "Locate Your Watershed," allows the user to enter the names of rivers, schools, or zip codes to learn more about watersheds in their local area or in other parts of the country. The EPA's Index of Watershed Indicators (IWI) can also be accessed from this site. The IWI is a numerical grade (1 to 6), which is compiled and calculated based on a variety of indicators that assess the condition of rivers, lakes, streams, wetlands, and coastal areas.

EPA's Office of Water Volunteer Lake Monitoring: A Methods Manual
http://www.epa.gov/owow/monitoring/volunteer/lake

EPA developed this manual to present specific information on volunteer lake water quality monitoring methods. It is intended both for the organizers of the volunteer lake monitoring program and for the volunteer(s) who will actually be sampling lake conditions. It emphasizes identifying appropriate parameters to monitor and listing specific steps for each selected monitoring method. The manual also includes quality assurance/quality control procedures to ensure that the data collected by volunteers are useful to State and other agencies.

EPA's Nonpoint Source Pointers (Fact sheets)
http://www.epa.gov/owow/nps/facts

This Web site features a series of fact sheets (referred to as pointers) on nonpoint source pollution (e.g., pollution occurring from storm water runoff). The pointers covers topics including: programs and opportunities for public involvement in nonpoint source control, managing wetlands to control nonpoint source pollution, and managing urban runoff.

EPA's Great Lakes National Program Office
http://www.epa.gov/glnpo/about.html

EPA's Great Lakes National Program Office Web site includes information about topics such as human health, visualizing the lakes, monitoring, and pollution prevention. One section of this site (http://www.epa.gov/glnpo/gl2000/lamps/index.html) has links to Lakewide Management Plan (LaMP) documents for each of the Great Lakes. A LaMP is a plan of action developed by the United States and Canada to assess, restore, protect and monitor the ecosystem health of a Great Lake. The LaMP has a section dedicated to public involvement or outreach and education. The program utilizes a public review process to ensure that the LaMP is addressing their concerns.

You could use the LaMP as a model in developing similar plans for your water monitoring program.

U. S. Department of Agriculture Natural Resource Conservation Service
http://www.wcc.nrcs.usda.gov/water/quality/frame/wqam

Under "Guidance Documents," there are several documents pertaining to water quality that can be downloaded or ordered. These documents are listed below.

- A Procedure to Estimate the Response of Aquatic Systems to Changes in Phosphorus and Nitrogen Inputs
- Stream Visual Assessment Protocol
- National Handbook of Water Quality Monitoring
- Water Quality Indicators Guide
- Water Quality Field Guide

6.3.3 Education Resources

Project WET (Water Education for Teachers)
http://www.montana.edu/wwwwet

One goal of Project WET is to promote awareness, appreciation, knowledge, and good stewardship of water resources by developing and making available classroom-ready teaching aids. Another goal of WET is to establish state- and internationally-sponsored Project WET programs. The WET site has a list of all the State Project WET Program Coordinators.

Water Science for Schools
http://wwwga.usgs.gov/edu/index.html

The USGS's Water Science for Schools Web site offers information on many aspects of water and water quality. The Web site has pictures, data, maps, and an interactive forum where you can provide opinions and test your water knowledge. Water quality is discussed under "Special Topics."

Global Rivers Environmental Education Network (GREEN)
http://www.earthforce.org/green

The GREEN provides opportunities for middle and high school-aged youth to understand, improve and sustain watersheds in their community. This site also includes a list of water quality projects being conducted across the country and around the world (http://www.igc.apc.org/green/resources.html).

Adopt-A-Watershed
http://www.adopt-a-watershed.org/about.htm

Adopt-A-Watershed is a school-community learning experience for students from kindergarten through high school. Their goal is to make science applicable and relevant to the students. Adopt-A-Watershed has many products and services available to teachers wishing to start an Adopt-A-Watershed project. Although not active in every state, the Web site has a list of contacts in 25 States if you are interested in beginning a project in your area.

National Institutes for Water Resources
http://wrri.nmsu.edu/niwr/niwr.html

The National Institutes for Water Resources (NIWR) is a network of 54 research institutes throughout each of the 50 States, District of Columbia, the Virgin Islands, Puerto Rico, and Guam/Federated States of Micronesia. Each institute conducts research to solve water problems unique to their area and establish cooperative programs with local governments, state agencies, and industry.

Southeast Michigan Watershed Project Participants
http://imc.lisd.k12.mi.us/SE.html

This Web site discusses water testing projects conducted by various middle schools and high schools in southeast Michigan. Each school provided QuickTime videos of their sampling sites.

Water on the Web
http://ga.water.usgs.gov/edu/index.html

This Web site is maintained by USGS and provides water science information for schools. The site has information on many aspects of water, along with pictures, data, maps, and a site where you can test your knowledge.

Learning Web
http://www.usgs.gov/education/

Learning Web is a USGS Web site dedicated to K-12 education, exploration, and life-long learning. The site covers topics such as biology, geology, and hydrology.

Webmonkey for Kids
http://hotwired.lycos.com/webmonkey/kids/?tw=eg19990608

This site shows children how to build Web pages.

Northern Colorado Water Conservancy District -- Education
http://www.ncwcd.org/ncwcd?go_about/education.htm

This site offers an array of water-related educational services for preschoolers to retirees. It includes facts about water, teacher information, publications, and information about water festivals.

Bureau of Reclamation Environmental Education
http://www.usbr.gov/env_ed/

The site provides a list of various environmental educational programs and activities in which the Bureau of Reclamation participates, some of which are offered for general public participation. The site also provides a list and description of various educational classes relating to the study and care of water resources that the Bureau of Reclamation will provide to classes as "hands-on" science presentations.

6.3.4 Other Organizations

North American Lake Management Society (NALMS) Guide to Local Resources
http://www.nalms.org/

This Web site provides resources for those dealing with local lake-related issues. NALMS's mission is to forge partnerships among citizens, scientists, and professionals to promote the management and protection of lakes and reservoirs. NALMS's Guide to Local Resources (http://www.nalms.org/resource/lnkagenc/links.htm) contains various links to regulatory agencies, extension programs, research centers, NALMS chapters, regional directors, and a membership directory.

The Watershed Management Council
http://watershed.org/wmc/aboutwmc.html

The Watershed Management Council (WMC) is a non-profit organization whose members represent a variety of watershed management interests and disciplines. WMC membership includes professionals, students, teachers, and individuals whose interest is in promoting proper watershed management.

6.3.5 Examples of BASIN Resources

Note!

> The Colorado BASIN project should not be confused with the Environmental Protection Agency's BASINS (Better Assessment Science Integration Point and Nonpoint Sources) Modeling Course. The BASINS Modeling Course is a watershed training course offered by the EPA's Office of Wetlands, Oceans, & Watershed. Please see http://www.epa.gov/waterscience/BASINS/ for more information about BASINS.

BASIN's Web site has numerous resources which serves as examples of what other project's can do to bring a strong community focus on the health of the local environment. Some of these resources are listed below.

BASIN's Watershed Theme
http://bcn.boulder.co.us/basin/watershed/index.html

BASIN's Watershed link provides information about water quality, geology, stream flow, weather and climate, flash floods, and tributaries.

BASIN's Water and Community Theme
http://bcn.boulder.co.us/basin/waterworks/index.html

BASIN's Water and Community link provides information about drinking water systems, wastewater, underground storage tanks, and storm water runoff. The link also provides links to drinking water treatment and regulations.

BASIN's Personal Action Theme
http://bcn.boulder.co.us/basin/local/index.html

BASIN's Personal Action link provides the public practical guidance on how to protect the environment. Such topics include household hazards and alternatives and water-wise landscaping.

BASIN's History Theme
http://bcn.boulder.co.us/basin/history/index.html

BASIN's History link provides various historical environmental information about the Boulder Creek watershed. The site provides historical information about flash floods, early ditch decrees, pictures, etc.

BASIN's Recreation Theme
http://bcn.boulder.co.us/basin/recreation/index.html

BASIN's Recreation link provides information about rivers in Colorado and other general recreation links. The site also has links which are of interest to canoers and kayakers, fishermen, hikers and backpackers, and boaters.

BASIN's Learning Theme
http://bcn.boulder.co.us/basin/learning/index.html

BASIN's Learning link provides information about available watershed learning and service activities. The link which provides an online resource and teacher's guide, a fifth grade learning activity, as well as virtual field trips is a valuable resource to teachers.

BASIN's Library Theme
http://bcn.boulder.co.us/basin/gallery/index.html

BASIN's Library link provides a gallery of photographs taken around the watershed, a 450 document Environmental Research Bibliography, and additional learning activities.

6.4 Success Stories

The BASIN Project enjoyed several successes. BASIN provided a framework for successful collaboration between municipal and regional governments, educators, and concerned citizens to address a community need for access to environmental monitoring data and contextual information to explain the significance of that data. The BASIN project also generated a leveraging of existing resources. By creating a collaborative process and data repository, the project provided a focal point for researchers interested in the quality of Boulder Creek. The Boulder Creek Millennium Baseline Study (http://bcn.boulder.co.us/basin/BCMB)is one example of a leveraged resource effort that occurred as a result of the BASIN project. In this way, the BASIN Web site was able to respond to needs and opportunities not included in the initial EMPACT project scope.

The BASIN project enabled the City of Boulder's drinking water and storm water quality programs to develop similar protocols for QA/QC. Prior to the project, the data from each of the programs were kept in separate databases. Also, each program used different units for similar parameters. As a result those parameters could not be easily compared to each other. The BASIN team and City of Boulder collaborated so that the parameters measured by the two sampling programs could be easily compared to each other. The data collected from the two programs were eventually combined into a single database. Also both programs began measuring additional parameters so that the BASIN team could generate a water quality index which grades the streams. The index provides a quick and easy-to-understand assessment of the water quality in that particular stream. See Section 5 for a more complete discussion of the water quality index.

The BASIN Web site had become established as a community resource with robust usership. Daily page requests, distinct hosts served, pages requested, and total data transferred have continued to increase since the Web site was launched in 1999. The ongoing use of the Web site is a strong indication that citizens, students, researchers, and others both in the Boulder area and outside the watershed have found the BASIN Web site to be a useful source of environmental information.

BASIN was nominated for the 2001 Stockholm Water Prize that honors outstanding achievements that help protect the world's water resources. Although BASIN did not win, they considered their nomination for the award an honor. The $150,000 prize is the leading international award for outstanding achievements on behalf of the world's water. It is awarded to an individual, institution, organization, or company that has made the most contribution to preserve and enhance the world's water resources. The prize recognizes either outstanding research, action, or education that protects the usability of water for all life and increases knowledge of water as a resource.
[Source: http://www.worldwaterday.org/events/ev09.html]

User Feedback

Various partners and peers provided positive and complimentary comments to BASIN regarding their Web site. Some of the comments are listed below.

"I looked at the site - what a lot of info! The links go on for days - it's GREAT!!!"
- Trish McKenzie, U.S. EPA.

"What a fabulous program you have to offer! May we borrow your ideas/ format and implement them into our own plan?" - Denise Leidy, Union Soil & Water Conservation District, La Grande, Oregon.

"I am impressed with your Web site and have passed it along to our employees" - Doug Gore, Regional Director, FEMA.

"This is a GREAT Web site" - Ken Margolis, River Network.

6.5 Most Frequently Asked Questions and Answers

The majority of questions that the BASIN team receives are related to water quality. For example, the team receives questions about pesticides used in the watershed, questions about water quality issues related to the Boulder Waste Water Treatment Plant, and questions regarding E. coli bacteria count in the water. The water quality site located on the BASIN Web page now provides public access to monitoring data to help answer these questions.

APPENDIX A
GLOSSARY OF TERMS & ACRONYM LIST

A

Acre foot: The amount of water that would cover one acre at the depth of one foot (325,900 gallons).

Anoxia: Absence of oxygen in water.

APCD: Air Pollution Control Division.

AWRA: American Water Resources Association.

AWWA: American Water Works Association.

B

BASIN: Boulder Area Sustainability Information Network.

BCN: Boulder Community Network.

C

cfs: cubic feet per second.

Chlorophyll: Green pigment in plants that transforms light energy into chemical energy by photosynthesis.

CO_2: Carbon dioxide.

COB: City of Boulder.

CPAN: Comprehensive Perl Archive Network.

D

Dissolved oxygen (DO): The concentration of oxygen (O_2) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation (at the field temperature). Adequate concentrations of dissolved oxygen are necessary to sustain the life of fish and other aquatic organisms and prevent offensive odors. DO levels are considered a very important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. Levels above 5 milligrams per liter (mg O_2/L) are considered optimal and fish cannot survive for prolonged periods at levels below 3 mg O_2/L. Levels below 2 mg O_2/L are often referred to as hypoxic and when O_2 is less than 0.1 mg/, conditions are considered to be anoxic.

DMSO: Dimethyl sulfoxide.

DO: Dissolved oxygen.

DRCOG: Denver Region Council of Governments.

DVT(s): Data visualization tools.

E

Ecosystem: The interacting plants, animals, and physical components (sunlight, soil, air, water) of an area.

EDF: Environmental Defense Fund.

EDNA: Environmental Data Network Association.

EDTA: ethylenediaminetetraacetic acid.

EMPACT: Environmental Monitoring for Public Access and Community Tracking.

EPA: Environmental Protection Agency.

F

ft: feet.

FTP: File transfer protocol.

G

Geographic Information System (GIS): A computer software and hardware system that helps scientists and other technicians capture, store, model, display, and analyze spatial or geographic information.

GPL: General Public License.

GREEN: Global Rivers Environmental Education Network.

Groundwater: Water that sinks into the ground and collects over impermeable rock. It then flows laterally toward a stream, lake, or ocean. Wells tap it for our use. Its surface is called the "water table."

ug/l: micrograms (10^{-6} grams)/liter.

uS/cm: microsiemens per centimeter.

H

HCl: Hydrochloric acid.

HNO_3: Nitric acid.

H_2SO_4: Sulfuric acid.

I

IC: Inorganic carbon.

IMS: Information Management System.

IWI: Index of Watershed Indicators.

J

K

KCl: Potassium chloride.

$K_2S_2O_8$: Potassium persulfate.

L

L: liter.

LaMP: Lakewide Management Plans.

M

m: meters.

mg: milligrams.

mg/L: milligrams/liter.

mph: miles per hour.

Monitor: To track a characteristic, such as dissolved oxygen, nitrate level, or fish population, over a period of time using uniform methods to evaluate change.

N

NALMS: North American Lake Management Society.

NaOH: Sodium Hydroxide.

NH_3: Ammonia.

NH_4: Ammonium ion.

NIWR: National Institutes for Water Resources.

NOAA: National Oceanic and Atmospheric Administration.

nm: Nanometer, 10^{-9} meter.

Non-point Source: Diffuse, overland runoff containing pollutants. Includes runoff collected in storm drains.

NRCS: Natural Resources Conservation Service.

NSF: National Sanitation Foundation.

NTU: Nephelometric turbidity unit.

Nutrient loading: The discharge of nutrients from the watershed into a receiving water body (e.g., wetland). Expressed usually as mass per unit area per unit time (kg/ hectare/ yr or lbs/acre/year).

O

ORD: Office of Research and Development.

Organic: Refers to substances that contain carbon atoms and carbon-carbon bonds.

P

pH scale: A scale used to determine the alkaline or acidic nature of a substance. The scale ranges from 0 to 14 with 0 being the most acidic and 14 the most basic. Pure water is neutral with a ph of 7.

Parameter: Whatever it is you measure - a particular physical, chemical, or biological property that is being measured.

PERL: Practical Extraction Report Language.

ppt: parts per thousand.

Point Source: A pipe that discharges effluent into a stream or other body of water.

Q

Quality Assurance/Quality Control (QA/QC): QA/QC procedures are used to ensure that data are accurate, precise, and consistent. QA/QC involves established rules in the field and in the laboratory to ensure that samples are representative of the water you are monitoring, free from contamination, and analyzed following standard procedures.

R

Remote Monitoring: Monitoring is called *remote* when the operator can collect and analyze data from a site other than the monitoring location itself.

S

Salinity: Measurement of the mass of dissolved salts in water. Salinity is usually expressed in ppt.

SC: Specific Conductance.

Sediment: Fine soil or mineral particles.

SMSA: Standard metropolitan statistical area.

SNOTEL: SNOwpack TELemetry. Automated system that measures snowpack.

Specific Conductance (SC): The measure of how well water can conduct an electrical current. Specific conductance indirectly measures the presence of compounds such as sulfates, nitrates, and phosphates. As a result, specific conductance can be used as an indicator of water pollution. Specific conductivity is usually expressed in *u*S/cm.

STP: sewage treatment plant.

Suspended solids: (SS or Total SS [TSS]). Very small particles that remain distributed throughout the water column due to turbulent mixing exceeding gravitational sinking.

T

TDS: Total dissolved solids.

TIGER: Topically Integrated Geographic Encoding and Referencing.

Timely environmental data: Data that are collected and communicated to the public in a time frame that is useful to their day-to-day decision-making about their health and the environment, and relevant to the temporal variability of the parameter measured.

TOC: Total organic carbon.

TSS: Total suspended solids.

Turbidity: The degree to which light is scattered in water because of suspended organic and inorganic particles. Turbidity is commonly measured in NTU's.

U

UV: Ultraviolet.

USGS: United States Geological Survey.

V

W

Watershed: The entire drainage area or basin feeding a stream or river. Includes surface water, groundwater, vegetation, and human structures.

WET: Water Education for Teachers.

WMC: Watershed Management Council.

WQI: Water Quality Index.

X

Y

Z

APPENDIX B
BASIN NEWS Newsletter

www.basin.org November-December 2000

BASIN News is an outreach effort of the Boulder Area Sustainability Information Network, a partnership of various public and private organizations in the Boulder area. BASIN News offers updates on water and related environmental topics that are of interest to the local community and does not necessarily reflect the views of any of its partners. To subscribe to an online version of BASIN News, visit www.basin.org/news/subscribe.html

Wildfires Impact Aquatic Habitat and Water Quality

Aftermath of Walker Ranch fire, September 2000 by Jim Stout, city of Boulder

Wildfires not only impact vegetation and land animals - including human beings and their property - they can also trigger flooding and harm aquatic habitat and water quality. During the fire itself, rapid and extreme increases in water temperatures, lower water levels, and soil and ash polluting the water make it impossible for fish to breathe. The use of slurry to fight fires may also cause death in fish and amphibians and is a concern for drinking water sources. (See sidebar)

Researchers studying the aftermath of the Walker Ranch fire, which burned 1,100 acres on Boulder County open space in the mountains west of Boulder in mid-September, are finding minimal damage to fish and amphibians in South Boulder Creek. Fresh water entering the streams helped clean and dilute pollution.

The Effects of UVB Radiation on the Toxicity of Fire-Fighting Chemicals

A new report published by the U.S. Geological Survey examines the effect of sunlight on slurry used in fire fighting entering waterways. Fire suppressant compounds like the red slurry that is dropped onto wildfires are essential in stopping some otherwise uncontrollable fires. However, such compounds do contain chemicals that are toxic to fish and amphibians. Sunlight intensifies the toxicity of at least one chemical, sodium ferrocyanide, in slurry. Even in slurry compounds without this chemical there are still toxic levels of ammonia. Natural processes during a wildfire also play a role in killing fish and amphibians. In the case of the Walker Ranch fire, cloudy skies reduced the amount of sunlight striking dropped slurry and low precipitation after the fire kept erosion minimal. The USGS is working with the industry to find safer compositions that still suppress fires.

To read the USGS slurry report, visit http://www.fs.fed.us/fire/aviation/retardant/USGS_report.htm

A variety of interested groups have joined together in mitigation efforts for the Walker Ranch fire. Representatives from almost 20 agencies met to discuss erosion control and water quality monitoring of the damaged area.

For more information about mitigation efforts, call Therese Glowacki, Boulder County Open Space, at (303) 441-3952.

Also visit the BASIN website for more information.

BASIN Partners include USGS, Boulder Creek Watershed Initiative, Boulder Community Network, Enfo.com, University of Colorado at Boulder, city of Boulder, Boulder Valley School District, Boulder County Health Department, Community Access Television, Rivers of Colorado Water Watch Network and Boulder County Healthy Communities Initiative.

Spills Contaminate Local Waterways

In July, 54 fish were found dead at the Coal Creek Golf Course after chemicals were dumped into the creek which turned the water white. The fish included various minnows such as white suckers, creek chubs, stone rollers, and long nosed dace, ranging in length from 1 1/2 inches to 6 inches. The Colorado Division of Wildlife sought sanctions against Lowe's Hardware for dumping water - containing remnants of vinyl tile flooring and mastic down the drain, which fed into the creek along the golf course.

At the end of the summer, Clear Creek in Golden, Colo. was damaged twice in a matter of weeks as Coors Brewing Company accidentally discharged 2,500 barrels of Coors beer and wastewater into the creek killing over 10,000 fish. About a week later, a Mesa Oil truck rolled over and dumped 3,200 gallons of used oil into the creek harming more aquatic life.

A fourth spill incident occurred on Boulder Creek in September. A chlorine spill was discovered between 28th Street and Foothills Parkway, which killed 365 Brown Trout and 80 suckers. Walsh Environmental Scientists and Engineers, an environmental firm hired by the city of Boulder, discovered that the source of the fish kill originated from a pipe leaking chlorine-rich water connected to the Scott Carpenter Swimming Pool, located at 30th and Arapahoe. The leaked contents seeped through cracks in the nearby pool maintenance building foundation and into the floor drain. The Boulder County Health Department and the city's Public Works Water Quality staff worked together to evaluate the impacts to the creek. Ned Williams, Assistant Director of Public Works for Utilities stated, "It's unfortunate that a large number of fish were killed in this incident. However, there is not any threat to public health or safety from this spill." A copy of the Walsh report is available on the city Web site at www.ci.boulder.co.us/comm/pressrelease.

These spills were costly for the aquatic life as well as for the responsible parties. Phil Aragon of the Colorado Division of Wildlife estimated that a fine would total $15,575, since according to state law each fish can be worth up to $35. Citizens should be aware that storm drains funnel directly into local waterways, therefore, hazardous materials should be disposed of properly. A spill can violate water quality regulations, health regulations, and wildlife regulations. Tina Youngwood from the Colorado Division of Wildlife advises citizens to report spills as soon as possible before contaminants travel downstream. Persons wanting to report spills into Boulder's creeks should contact the Boulder Regional Communications Center at 303-441-4444. For additional information about water quality, call the city's water quality hotline at 303-441-4H2O or go online at www.ci.boulder.co.us/publicworks.

Success at Stockholm

This August, BASIN communications coordinator Mark McCaffrey was among the 800 water quality experts gathered in Stockholm, Sweden, for the 10th Annual Stockholm International Water Symposium.
At the conference, McCaffrey delivered a presentation entitled: "BASIN.org: a case study on the use of information technology in developing local water networks." The Symposium was organized by the Stockholm International Water Institute (at www.siwi.org) and Professor Malin Falkenmark a renown Swedish water scientist who for decades has helped steer Sweden to take a lead in addressing the spectrum of water-related issues around the globe.

During the various workshops and breakout sessions participants had an opportunity to listen to presentations and participate in discussions on a wide range of general topics– water efficiency and effectiveness, balancing technical and social concerns, education and public outreach, water security, and human rights issues.

Awards were given out to students working on water projects. Ashley Mulroy of the United States was announced as the winner of the Stockholm Junior Water Prize. Ashley, a student at the Linsly School in Wheeling, W. Va., examined water quality of a local creek and discovered that small amounts of chemicals, in this case antibiotics from the runoff from livestock feedlots, can cause *e coli* bacteria to become resistant to the drugs.

BASIN has recently been nominated for the 2001 Stockholm Water Prize that honors outstanding achievements that help protect the world's water resources. The winner will be announced on March 22, 2001, the United Nations World Water Day.

Colorado Watershed Assembly

Over the summer, nearly 60 people representing 22 different watershed groups attended a meeting from Aug. 4 -5 about watershed protection around the state. The River Network facilitated the meeting, organized by Larry MacDonnell of the Stewardship Initiative (www.stewardshipinitiatives.com), with support from the Environmental Protection Agency. The gathering discussed ideas for statewide watershed organizing. Participants broke into groups to brainstorm and discuss a series of questions. Many of the watershed groups agreed on their goals and mission statements: to enhance watershed health, to help create swimmable waters in Colorado, and to create a water literate culture through environmental education. They also shared the same obstacles such as lack of funding, lack of public support and political barriers.

In voicing these common thoughts and concerns, the groups identified certain advantages which a statewide entity could bring. The overriding idea was that a statewide entity could improve networking between the many watershed groups in Colorado, create a common voice, and help provide a variety of resources.

The watershed assembly ended with commitment from members from the different watershed groups to continue to work on a process to create an entity to support watershed g roups. A second assembly is scheduled for February 2001 to start implementing a state-level organization. Contact Larry MacDonnell at 303-545-6467 for more information.

News from BASIN: Drought, Fire and Flood

From Oct. 23-31, BASIN hosted an on-line discussion on the history of drought, fire and flood in the Boulder area. The forum was geared at answering the questions: How much do you really know about drought, fire and flood? How do each of these events impact one another? How should communities prepar e for these events? The forum included essays from several local experts: Lee Rozaklis of Hydrosphere Inc put together information about Extended Historical Stream Flows in the Boulder Creek Watershed; Connie Woodhouse from NOAA Paleoclimatology Dept. incl uded information on tree ring studies; Donna Scott provided Water Quality Concerns from the Walker Ranch Fire; and the state's office of emergency management posted Colorado's drought mitigation and response plan. Go to the Basin Web site at www.basin.org to check out the results from the on-line seminar.

The BASIN Web site has also recently undergone a major upgrade. Communications Coordinator, Mark McCaffrey, notes that "developing the BASIN Web site has been a work i n progress, and we're very grateful to the volunteers with the Boulder Community Network who have been instrumental in developing the design of the site and helping maintain and upgrade the content. We also appreciate the contributions of many local writer s who have shared their expertise with the community through BASIN –Pete Palmer and Al Bartlett's essays on sustainability, Joanna Sampson's piece on South Boulder Creek, and Elizabeth Black's accounts of flash floods." The Web site includes an online sea rch engine and bibliography to help users locate information within and beyond the BASIN Web site.

Water Shortages Around the World

Over the next 25 years, the number of people facing chronic or severe water shortages could increase from 505 million to more than 3 billion, according to a report released this week by Population Action International. The report stated that water shortages would be worst in the Middle East and much of Africa. "These figures are an improvement over what we thought would happen a decade ago," said PAI President Amy Coen. She attributed the improvement to more family planning and the reduced rate of population growth around the world. Still, the report's lead author, Robert Engelman, hastened to point out that hundreds of million s of people continue to lack access to family planning tools and basic health care.

"In many of the poor, developing countries, water shortages could become a severe problem, writes Lester Brown, author of "The world is running low on H20." Water tables are already falling on every continent, thanks in large part to powerful pumping technology developed in the last 50 years which allows humans to deplete aquifers faster than they can be replenished by precipitation. Water shortages could turn into food s hortages, since it takes roughly 1,000 tons of water to produce one ton of grain and far more water to produce meat. Brown argues that governments can work to avert catastrophe by limiting population growth and raising the price of water to encourage effic ient use. Brown, who was the keynote speaker at this year's Stockholm International Water Symposium, offers alerts on these and related issues via www.worldwatch.org/alerts.

Information included in this newsletter was drawn from BASIN, Boulder Daily Camera, city of Boulder's Open Space Department, Colorado Water Newsletter, EPA Homepage www.epa.gov, EPA's Waternews, Grit News, Natural Resources Conservation Service, and the Northern Colorado Water Conservancy District.. BASIN News is written by Jennelle Murosky and edited by Mark McCaffrey, with assistance from Jane Nelson and Tammy Fiebelkorn.

Basin Calendar of Events

November 15th, Wednesday. Boulder Creek Watershed Forum. Dr. Connie Woodhouse from NOAA Paleoclimatology Program National Geophysical Data Center will present: Clues on Climate Change: Reconstructing Middle Boulder Creek Streamflows from Tree Ring Data. Free and open to the public. Doors open at 6:00 with forum beginning at 7pm. Refreshments provided by Moe's Bagels. Contact Jennelle Murosky at muroskjo@hotmail.com for more information.

November 16th, Thursday. The Colorado Water Congress Presents: A Review of Federal Environmental Laws, Denver, CO. Contact 303-837-0812 or http://www.cowatercongress.org for more information.

November 17th, Friday. The Colorado Water Congress Presents: Workshop on Legal Ethics in Water & Environmental Law. Contact 303-837-0812 or http://www.cowatercongress.org for more information.

November 30th, Thursday. Healthy Watersheds: Community-based partnerships for environmental decision making. Contact Phyllis O'Meara at paomeara@opm.gov or 303-671-1034 for more information.

November 30th, Thursday. Hot Topics in Natural Resources: Fire in the Urban-Wildland Interface: A Special Program. 12:00pm-3:30pm. For further information, please contact the Natural Resources Law Center at (303) 492-1272 or email nrlc@colorado.edu; visit their Web site at www.colorado.edu/Law/NRLC/.

December 12, Tuesday. Boulder County Ecosystems at the Winter Solstice. Presented by: Steve Jones, Naturalist and Author. Presented by the Louisville Environmental Action Forum and the Louisville Open Space Advisory Board. Program begins at 7:00pm at the Louisville Arts Center, 801 Grant Ave. Call 303-665-7435 for more information.

BASIN
Office of Environmental Affairs
PO Box 791
Boulder, CO 80306

APPENDIX C

OTHER PRINTED PROMOTIONAL MATERIAL FOR BASIN


BASIN
Boulder Area Sustainability
Information Network
www.basin.org
All you want to know
about your water
... and more
Public Access to
Environmental Information
www.basin.org
3062 11th Street
Boulder, CO 80304
BASIN is a pilot project funded through a grant
from the U. S. EPA EMPACT program.
BASIN Partners include: Boulder Community
Network, Boulder County Health Department,
Boulder County Healthy Communities Initiative,
Boulder Creek Watershed Initiative, Boulder
Valley School District, City of Boulder,
Community Access Television, eInfo.com,
U.S. Geologic Survey, University of Colorado

KNOW YOUR H_2O

Panorama photograph of "Arapahoe Peaks and Glacier" taken by Ed Tangen in 1921 from the Library of Congress

A SENSE OF PLACE
— THE GREATER BOULDER AREA—

Educational Opportunities for the Entire Family

— Historical photos of & information about the area
— Interactive quizzes about water and the environment
— Numerous local and regional links to background information

Many Ways to Participate

— As website user
— As Boulder Community Network volunteer
— As data provider
— As content contributor
— As program partner and participant

A SENSE OF ENVIRONMENTAL CONDITIONS
— WATER RESOURCES—

Public Information

— Real-time and time-relevant information on weather, water quality, climate and stream flow
— Links and supporting materials

Science Education

— WatershED curriculum custom-designed for the Boulder Creek Watershed
— Local information from the **Rivers of Colorado Water Watch Network**

Government and Research Information

— Source for water quality and quantity information
— Medium for public outreach/feedback

Scientific Data | **Environmental Information** | **Personal Action**

The Boulder Area Sustainability Information Network

www.basin.org

A Sense Of Place
The Greater Boulder Area

- Educational opportunities for the entire family
- Maps, photos, quizzes, links and learning activities
- Many ways to participate

A Sense Of Environmental Conditions

- Public Information
- Science Education
- Government & Research Information

BASIN Partners include USGS, Boulder Creek Watershed Initiative, Boulder Community Network, University of Colorado at Boulder, city of Boulder, Boulder Valley School District, Naropa University, Boulder County Health Department, Community Access Television, Rivers of Colorado Water Watch Network and Boulder County Healthy Communities Initiative.

Scientific Data → Environmental Information → Personal Action

KNOW THE FLOW

TEST YOUR H_2O IQ

11. How much water does the average person in the Boulder area use in a day?

c) 8 gallons
b) 33 gallons
c) 80 gallons

12. In Colorado, what percentage of water use is by cities and agriculture?

a) 10% city, 90% agricultural
b) 90% city, 10% agricultural
c) 50% city, 50% agricultural

13. Name two instream uses of water.

a) car washing, showering
b) lawn watering, dishwashing
c) habitat protection, recreation

14. Does runoff increase or decrease in urban areas?

a) decrease
b) increase
c) stays the same

15. What agency is responsible for administering water rights in Colorado?

a) local governments
b) Department of Transportation
c) State Engineer's Office

FOR MORE WAYS TO TEST YOUR WATER WISDOM, GO TO **www.basin.org/quizes**

BASIN-- the Boulder Area Sustainability Information Network—is a partnership of various public and private organizations in the Boulder area funded through an EMPACT grant from the U.S. EPA.

Printed on recycled paper with vegetable-based inks. Please recycle this by giving to a friend or colleague.

Answers: 1-C, 2-A, 3-C, 4-B, 5-C


Introducing
The
Boulder Area Sustainability Information Network
www.basin.org
Public Access To Environmental Information

United States Environmental Protection Agency/ORD
National Risk Management Research Laboratory
Cincinnati, OH 45268

EPA/625/R-01-010