United States
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The EMPACT Collection

United States
Environmental Protection
Agency

Office of Research and Development
Office of Environmental Information
Washington, DC 20460

EPA/625/R-01/010
September 2001
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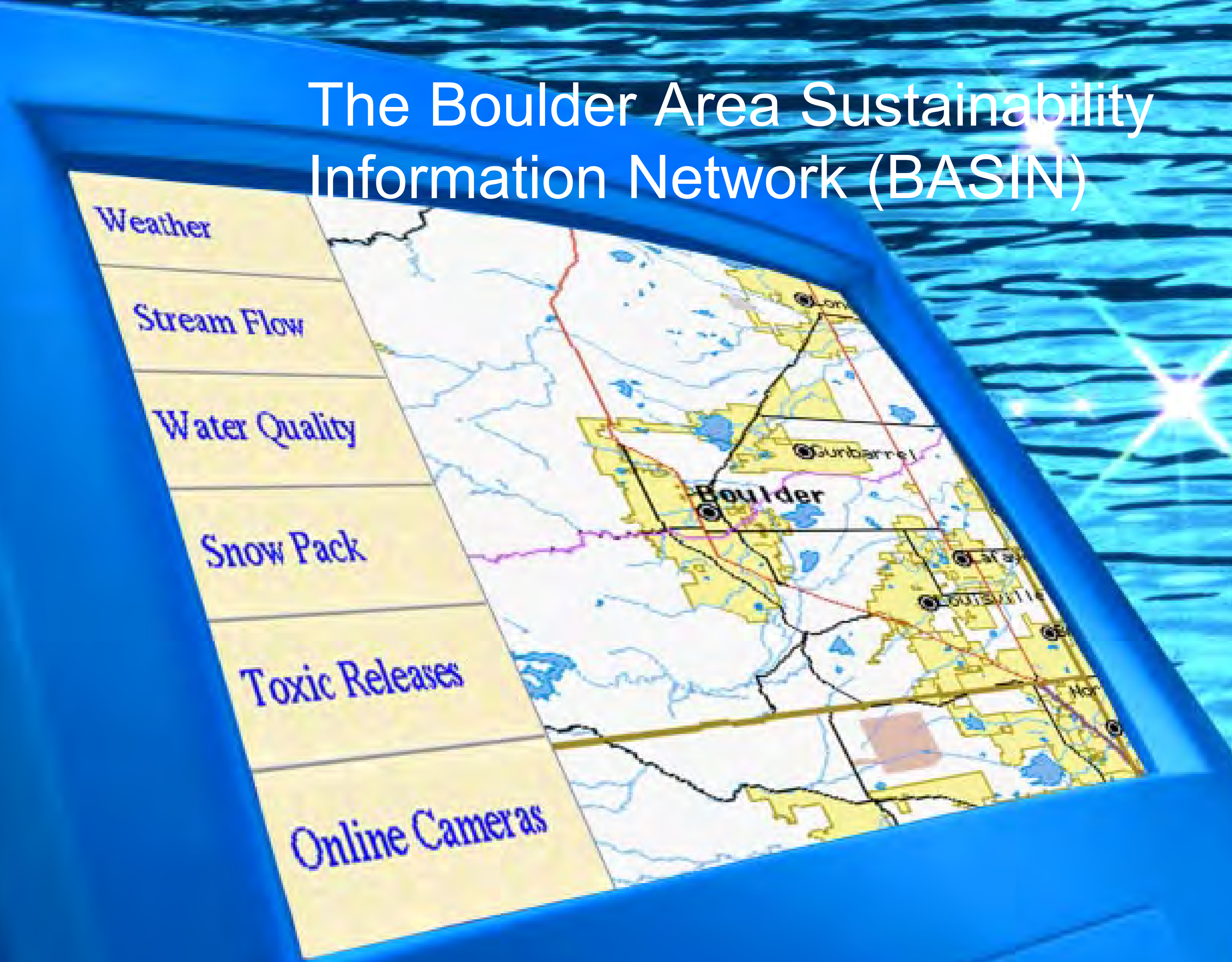
Delivering Timely Environmental Information to Your Community

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].

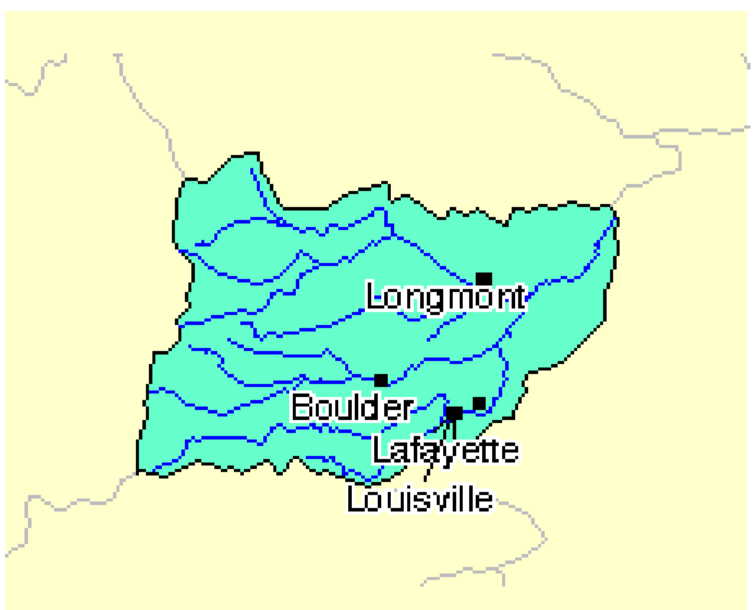


Figure 1.1 St. Vrain Watershed.
Source: http://bcn.boulder.co.us/basin/watershed/address.html

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]

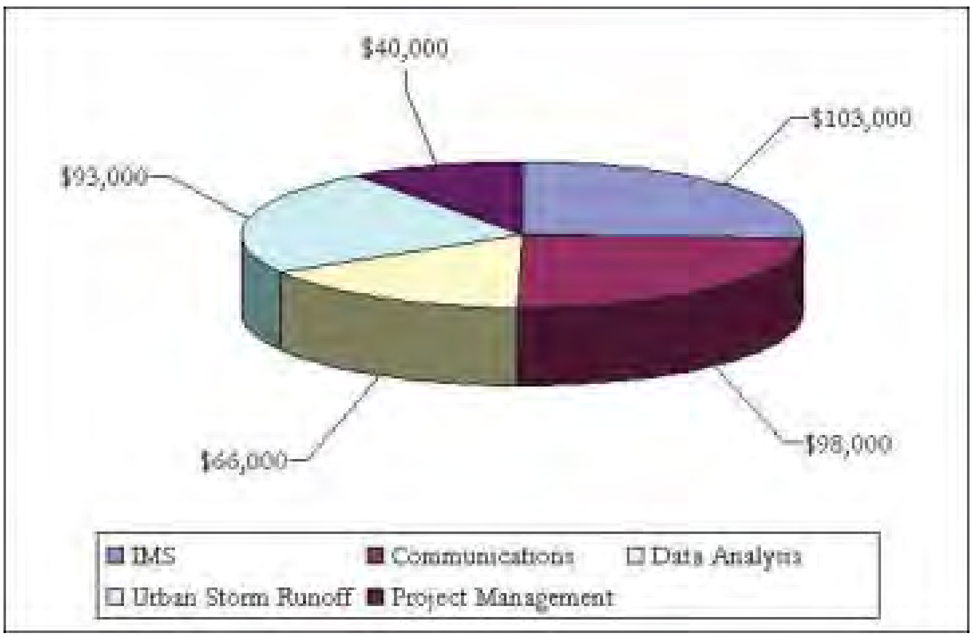


Figure 1.2 Budget Expenditures for the BASIN Project.

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:

Establish partnerships with community stakeholders and data collection organizations and collect supporting information sources.	→	Prototype data management procedures and data presentation standards while formalizing data sharing partnerships.	→	Present prototype systems to partner organizations and community stakeholders and gather feedback.	→	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).

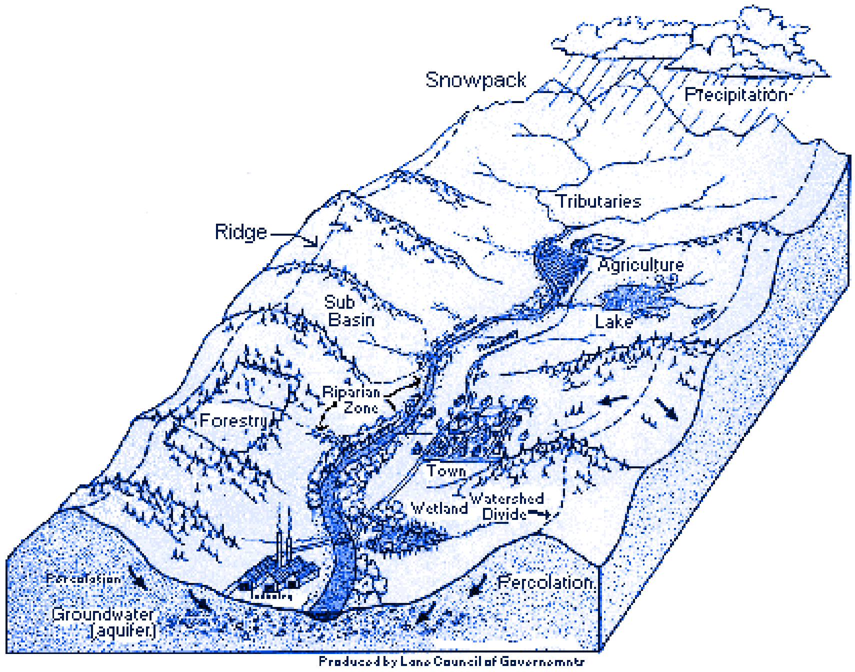


Figure 3.1. Schematic of a Watershed.
[Source: http://www.epa.gov/OWOW/win/what.html]

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.

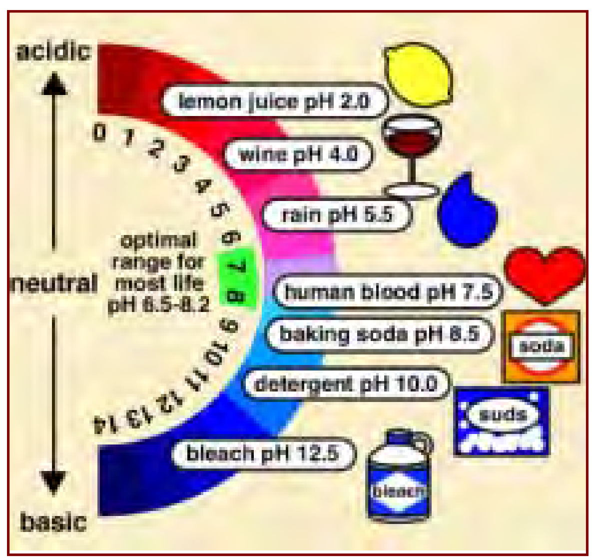
Excessive concentrations of ammonia, nitrate, or nitrite can be harmful to humans and wildlife. Toxic concentrations of ammonia in humans may cause loss of equilibrium, convulsions, coma, and death. Ammonia concentrations can affect hatching and growth rates of fish and changes may occur during the structural 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.

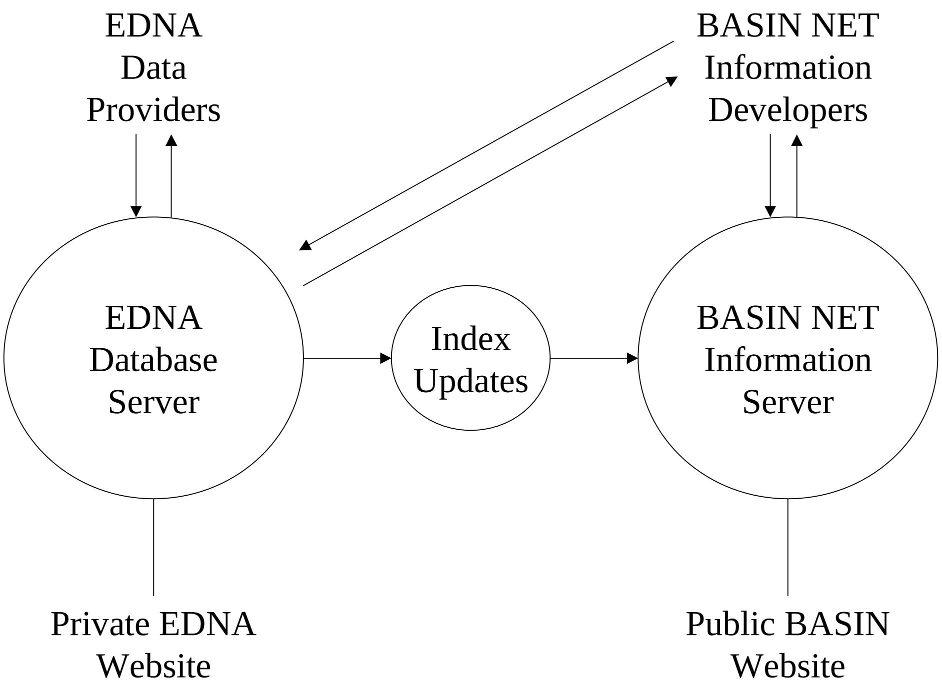


Figure 4.1 Database Servers

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.

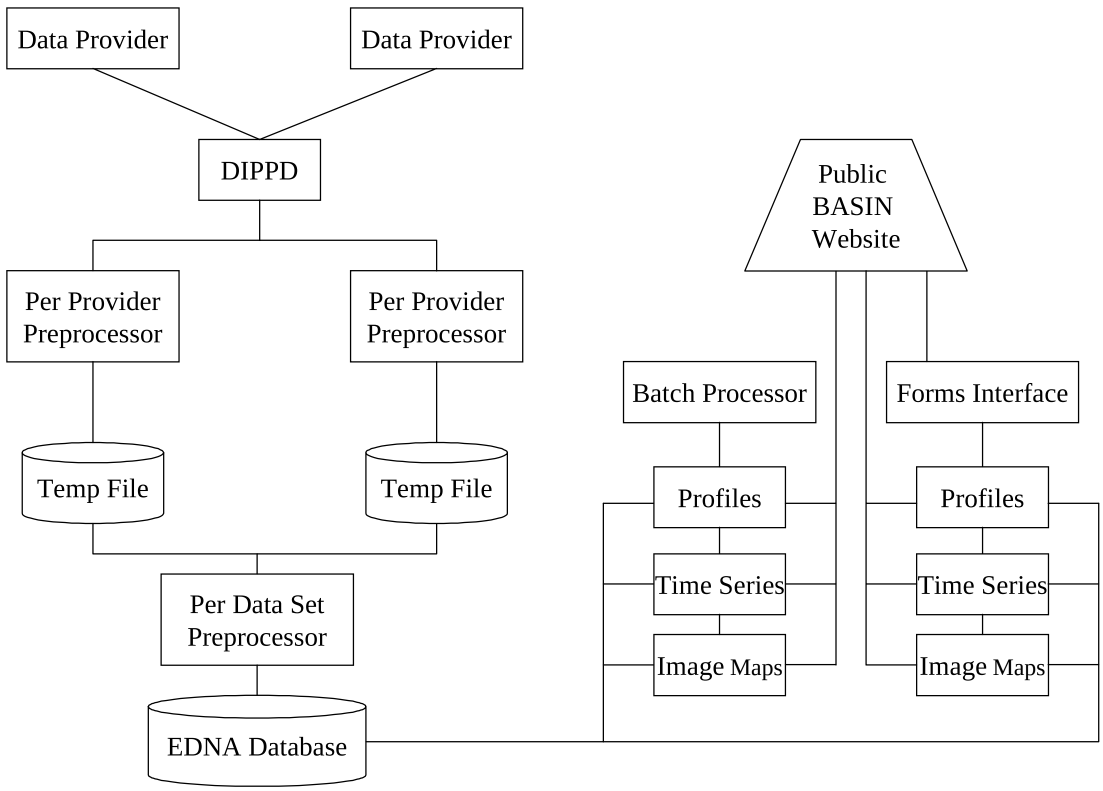


Figure 4.2 Data Flow for Water Quality Data.

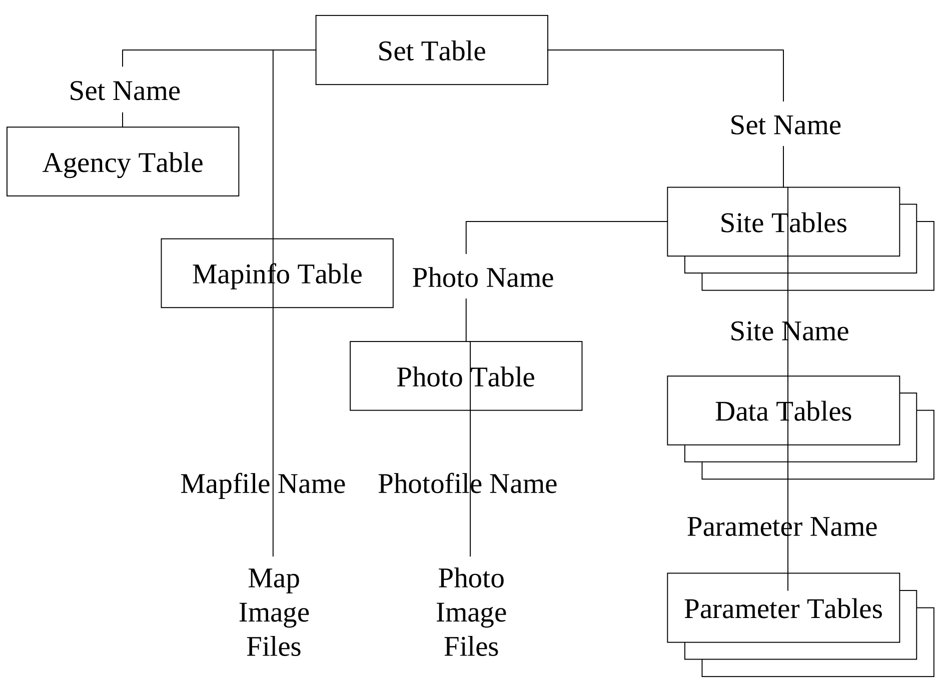


Figure 4.3 EDNA Database Structure.

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).

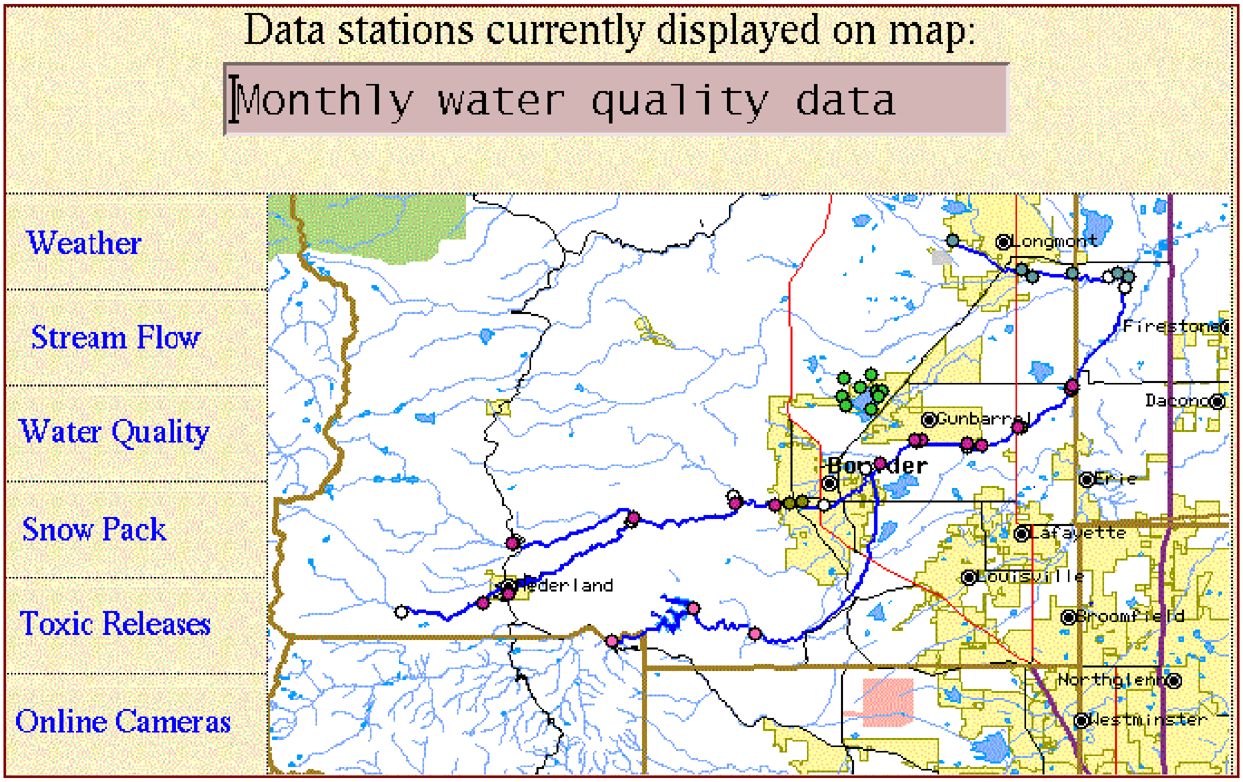


Figure 5.1 Example of BASIN's Spatial Data Catalog

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.

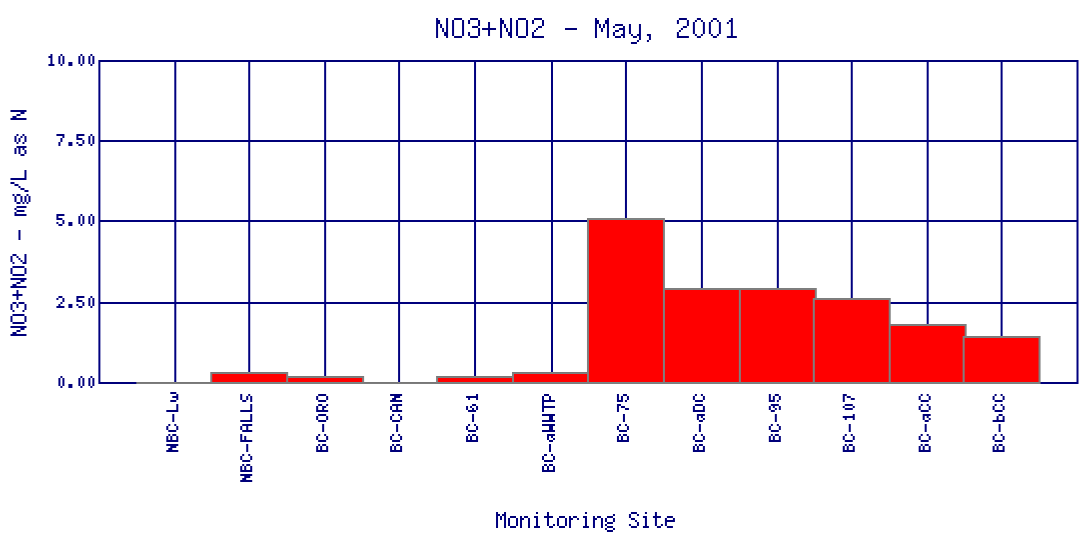


Figure 5.2. Example BASIN Longitudinal Profiles Plot (medium)

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.

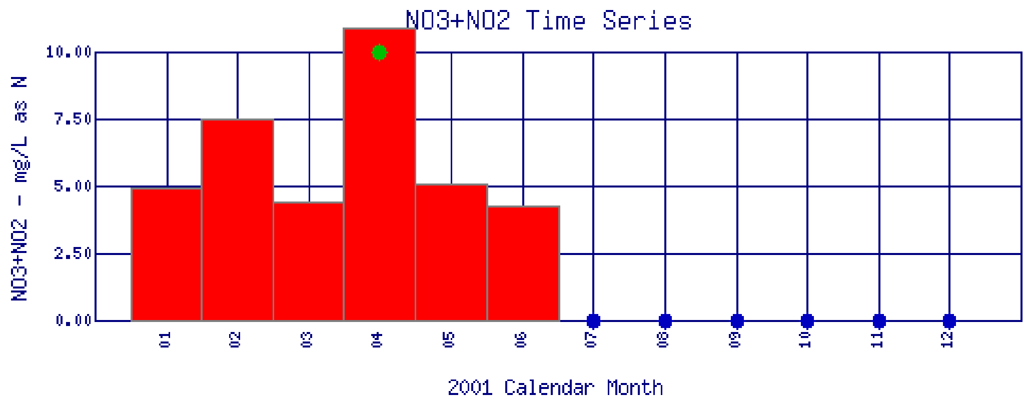


Figure 5.3 Example of BASIN Time Series Plot (medium)

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.

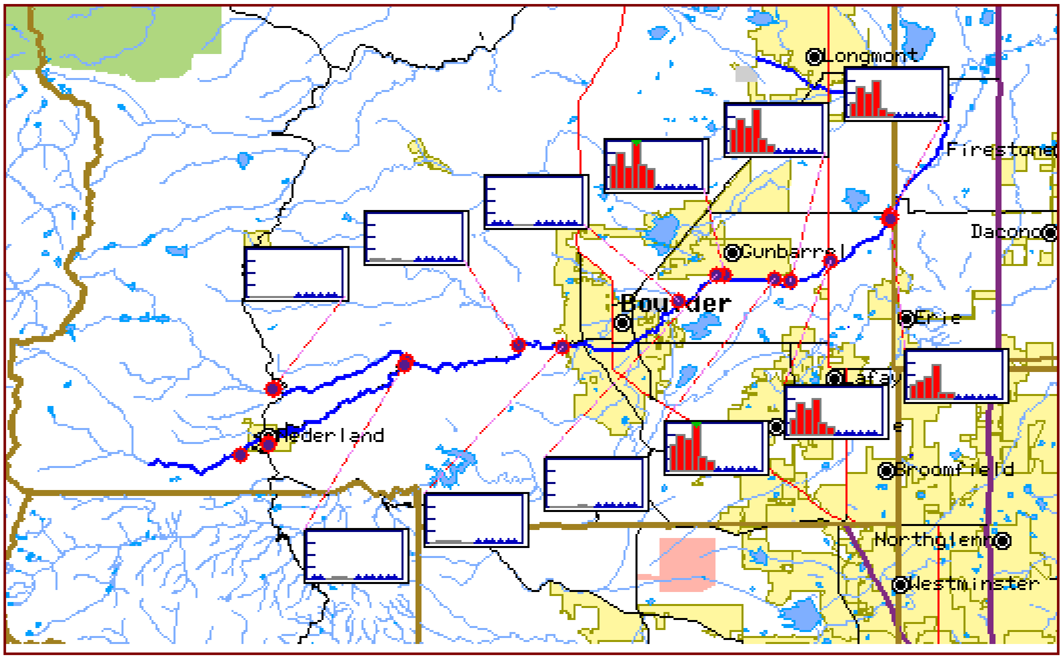


Figure 5.4 Example of BASIN Map Plot (Nitrate and Nitrite).

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/.

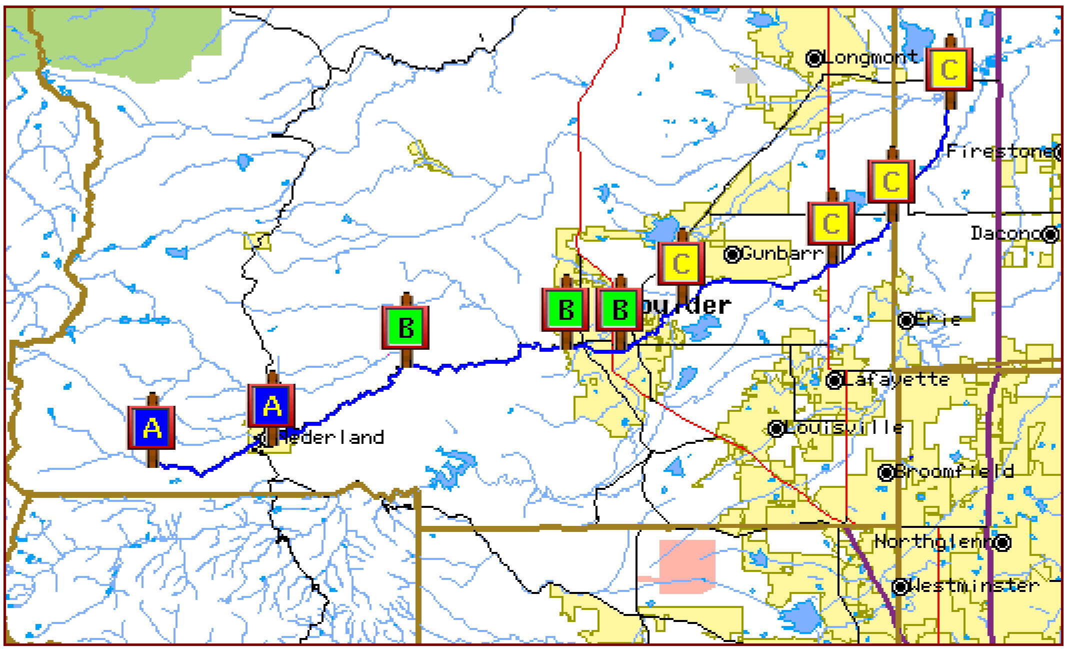


Figure 5.5 Water Quality Index

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.

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.

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

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 muroskij@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

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, enfo.com, U.S. Geological Survey, University of Colorado

BASIN

Boulder Area Sustainability Information Network

www.basin.org

All you want to know
about your water
... and more

Public Access to
Environmental Information

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.

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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

Official Business
Penalty for Private Use $300

EPA/625/R-01-010

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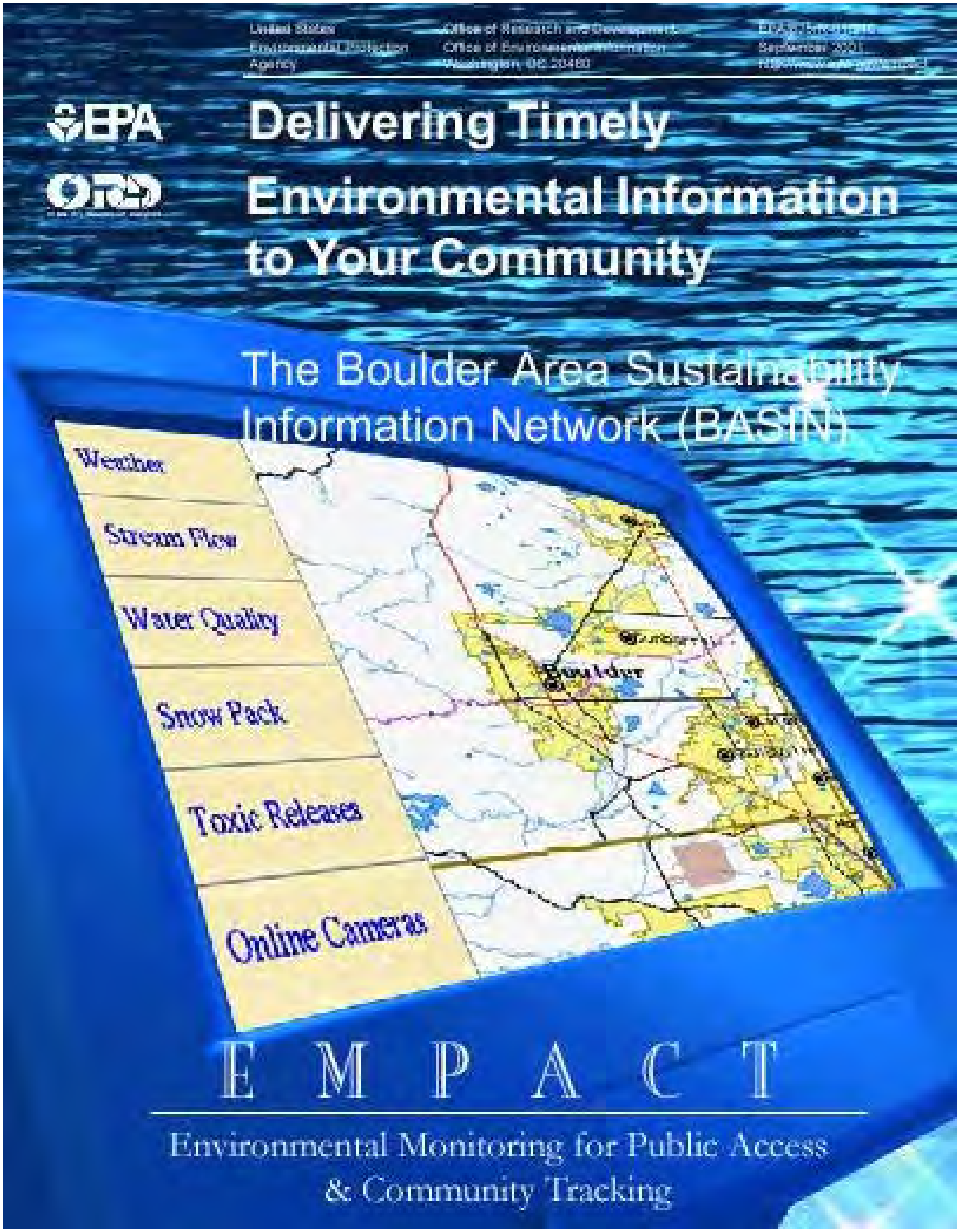

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EPA/625/R-01/010
September 2001

Delivering Timely Environmental Information to Your Community

The Boulder Area Sustainability Information Network (BASIN) Project

United States Environmental Protection Agency

Office of Research and Development

National Risk Management Research Laboratory

Cincinnati, OH 45268

CONTRIBUTORS

Dr. Dan Petersen of the U.S. Environmental Protection Agency (EPA), National Risk Management Laboratory, served as principal author of this handbook and managed its development with support of Pacific Environmental Services, Inc., an EPA contractor. The following contributing authors represent the BASIN team and provided valuable assistance for the development of the handbook:

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The BASIN Team would like to extend a special thanks to the following Boulder Community Network (BCN) Staff and Volunteers for their efforts in making the BASIN project a success:

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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 website, 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].

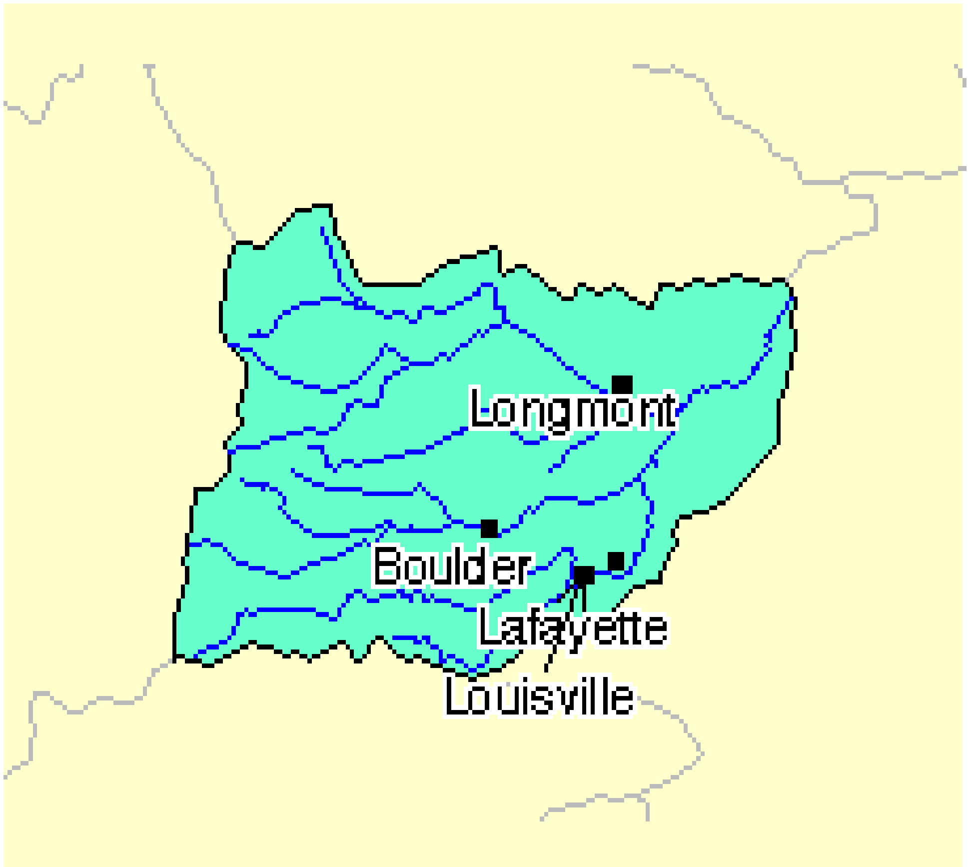

Figure 1.1 St. Vrain Watershed
[Source: http://bcn.boulder.co.us/basin/watershed/address.html]

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 website 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 connection 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 website 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 website.

- Data links to other websites (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 asscociated 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 Information Management System and provided technical coordination of website design and 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

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

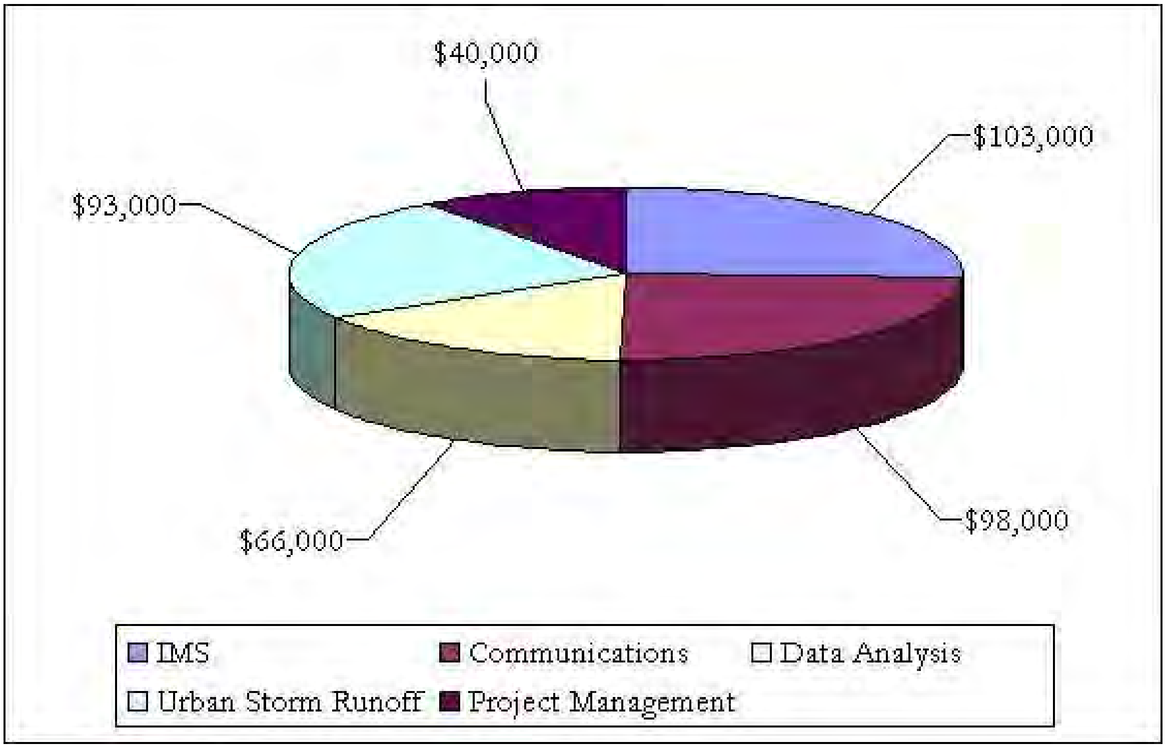

Figure 1.2 Budget Expenditures for the BASIN Project

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 website. This effort comprised 26 percent of the $400,000 project budget.

Communications - effort included website 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 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 website. Monthly data for 17 parameters measured along Boulder creeks were made available on the BASIN website. This effort also included the compilation of a 450-item Boulder Creek Watershed Bibliography which can be queried via the BASIN website (see IMS) and the development of an extensive list of household hazards and environmentally benign alternatives. This effort comprised 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 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 Environmental Index development process, and producing the *BASIN News* newsletter. This effort comprised 10 percent of the $400,000 project budget.

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.

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 website 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

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

Phoenix-Mesa, AZ
Pittsburgh, PA
Portland, ME
Portland-Salem, OR-WA
Providence-Fall River-Warwick, RI-MA
Provo-Orem, UT
Raleigh-Durham-Chapel Hill,

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
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
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San Diego, CA
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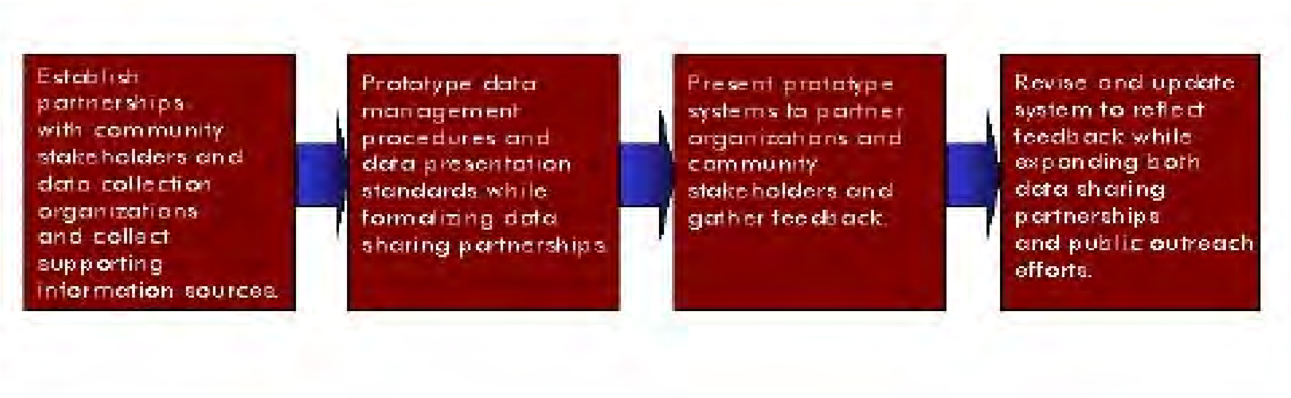
Seattle-Tacoma-Bremerton, WA
Shreveport-Bossier City, LA
Sioux Falls, SD
South Bend, IN
Spokane, WA
Springfield, MA
Springfield, MO
Stockton-Lodi, CA
Syracuse, NY
Tallahassee, FL
Tampa-St. Petersburg-Clearwater, FL
Toledo, OH
Tucson, AZ
Tulsa, OK Visalia-Tulare-Porterville, CA
Utica-Rome, NY
Washington-Baltimore, 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

T he 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:



- 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.

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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).

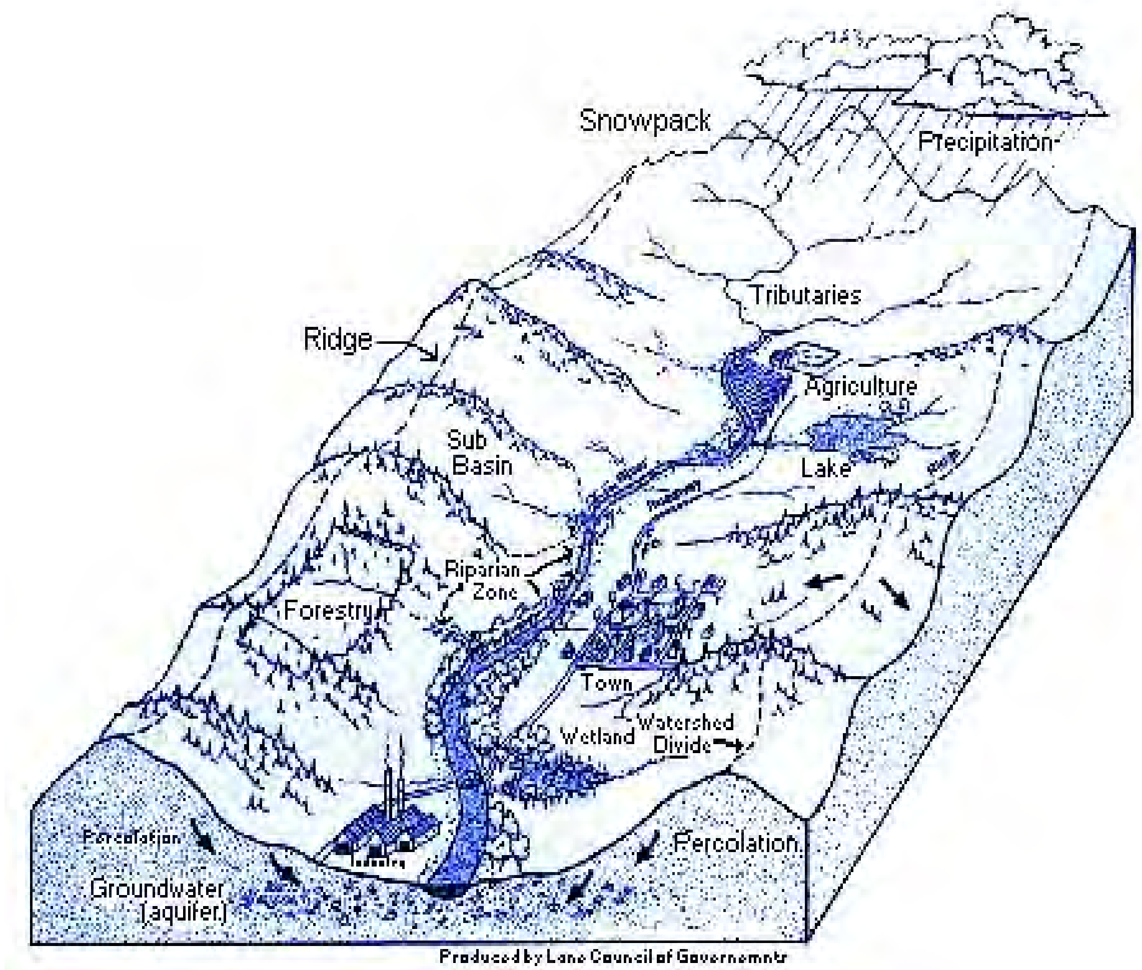


Figure 3.1 Schematic of a Watershed.
[Source:http://www.epa.gov/OWOW/win/what.html]

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.

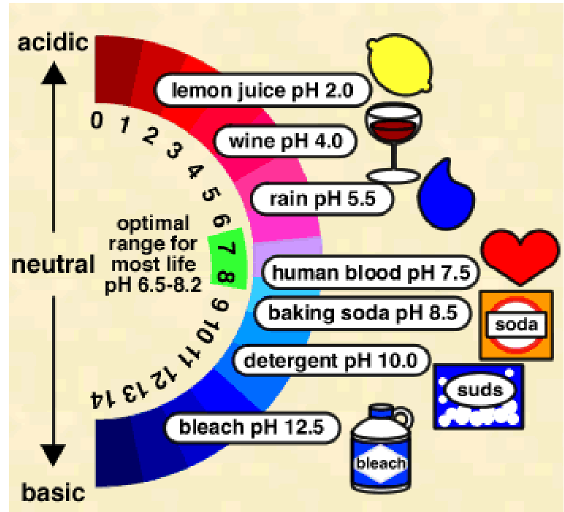
[Source: http://bcn.boulder.co.us/basin/data/COBWQ/info/NH3.html]

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 Millenium Baseline Study measured additional parameters including the following:

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

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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.

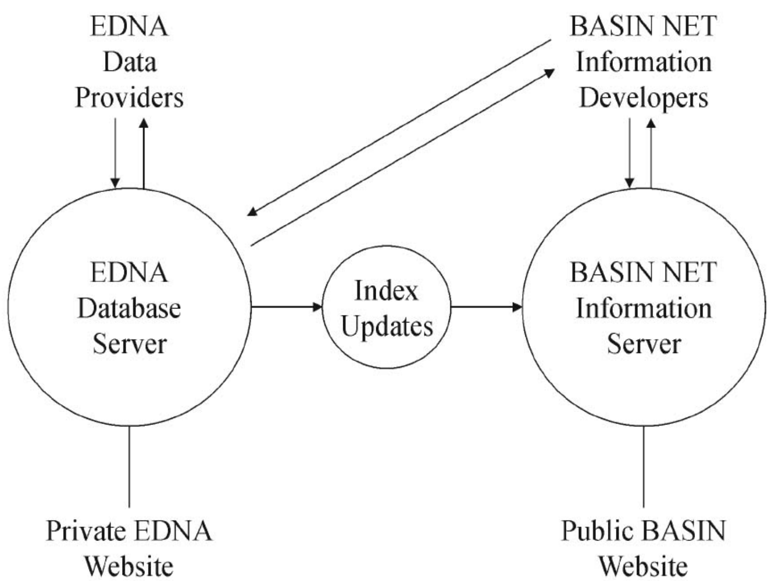

Figure 4.1 Database Servers

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.

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]

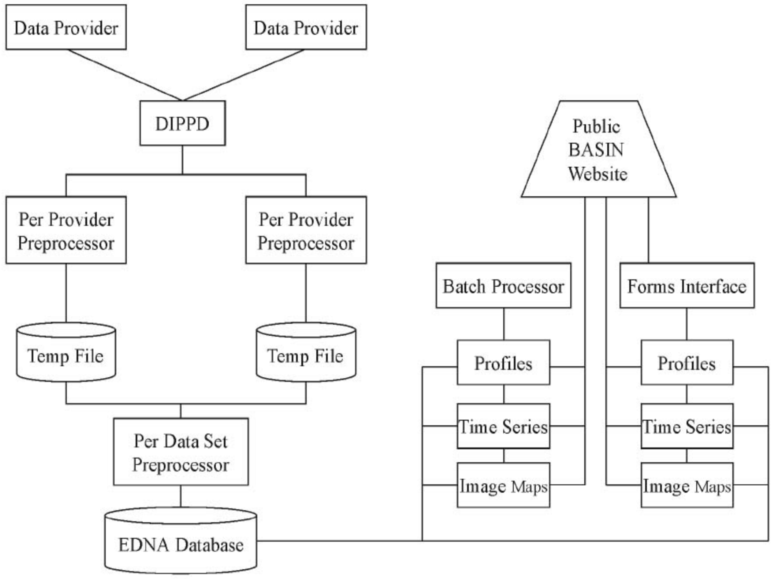

Figure 4.2 Data Flow for Water Quality Data.

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.

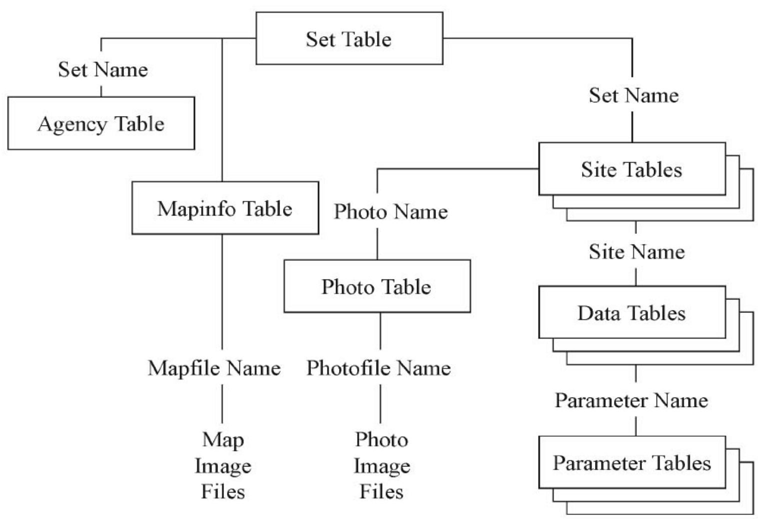

Figure 4.3 EDNA Database Structure.

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.

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.

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.

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

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]

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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).

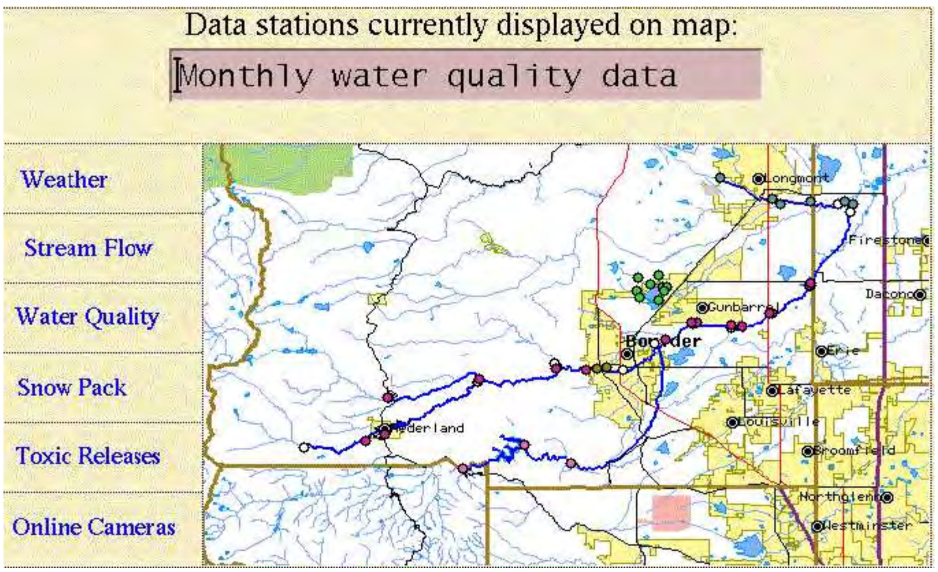

Figure 5.1 Example of BASIN's Spatial Data Catalog

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.

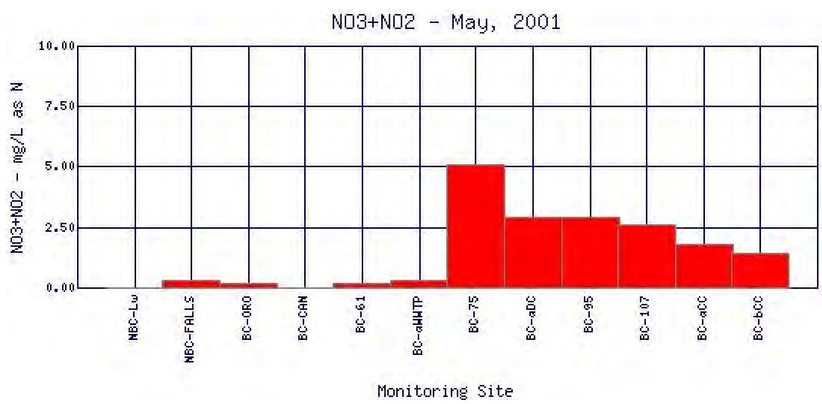

Figure 5.2. Example BASIN Longitudinal Profiles Plot (medium)

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.

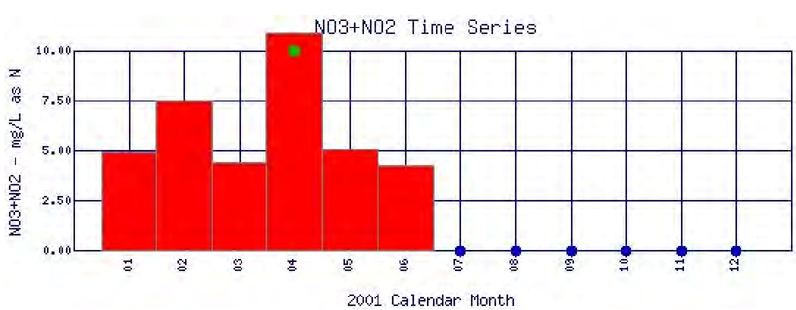

Figure 5.3 Example of BASIN Time Series Plot (medium)

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.

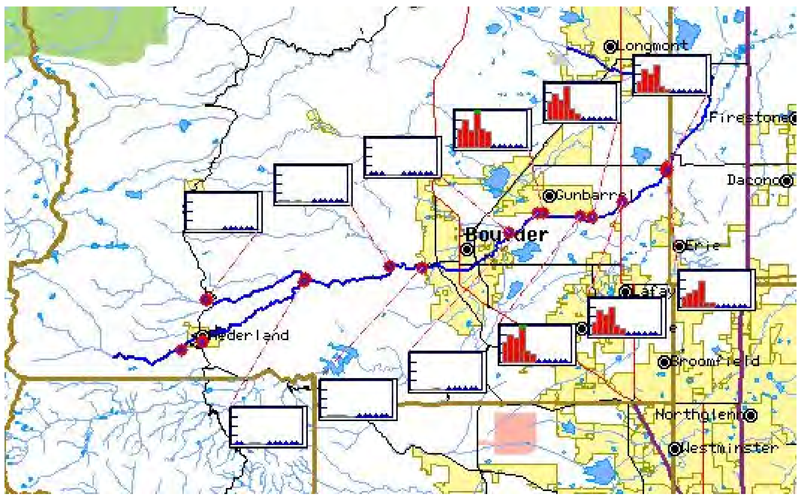

Figure 5.4 Example of BASIN Map Plot (Nitrate and Nitrite).

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/ .

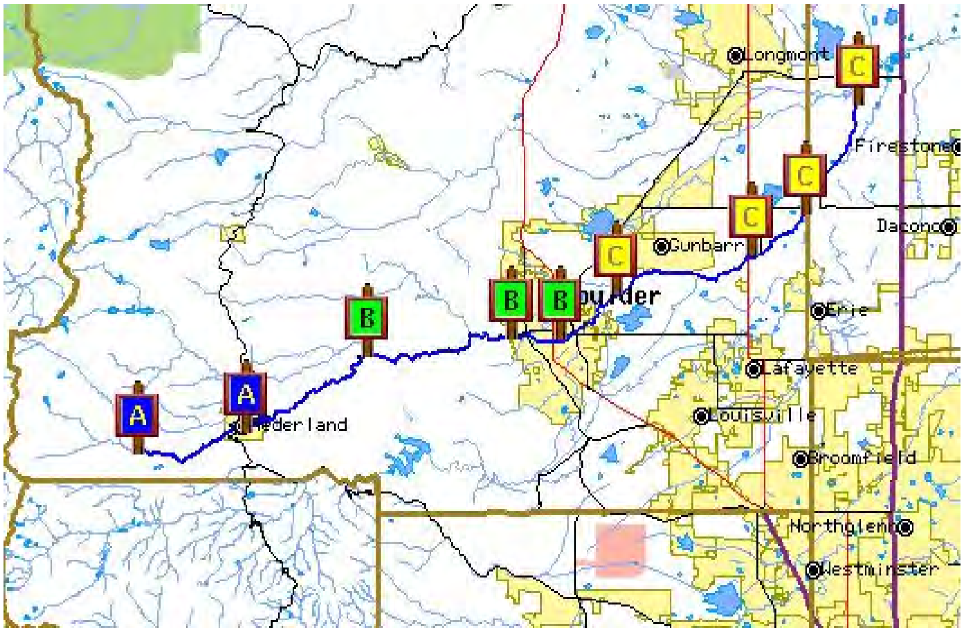

Figure 5.5 Water Quality Index

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.

NEXT CHAPTER

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6. COMMUNICATING TIMELY ENVIRONMENTAL INFORMATION

Providing timely environmental information to the community is not simply a matter of placing data files on a website. 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 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

Distribution Avenues	Outreach Products
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 project's website (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 website 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 website 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 website (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, webpage 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 website.

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 website visitors to provide comments regarding the usefulness and presentation of the information provided on the BASIN website (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

Website. The BASIN website 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 website 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 website 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 website (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 website, 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 website.

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 website.

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 website 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 website 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 website. 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 website 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 website 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 website 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 website, 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 website 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 websites 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 website that provides links to on-line writing labs (http://www.abanet.org/lpm/bparticle11463_front. shtml). The website 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 websites 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 website 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 website 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 website 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 website offers information on many aspects of water and water quality. The website 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 website 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 website 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 website 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 website 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 webpages.

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 website 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

BASIN's website 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 website 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 website 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 website was launched in 1999. The ongoing use of the website is a strong indication that citizens, students, researchers, and others both in the Boulder area and outside the watershed have found the BASIN website 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.

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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.

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."

***u*g/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

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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.

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.

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

BASIN Partners include USGS, Boulder Creek Watershed Initiative, Boulder Community Network, Enfocus(?), 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 muroskj@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

NEXT APPENDIX

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APPENDIX C

OTHER PRINTED PROMOTIONAL MATERIAL

FOR BASIN

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.

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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

Community-Based UV Risk Education

The SunWise Program Handbook

EMPACT

Environmental Monitoring for Public Access & Community Tracking

Disclaimer

Research and Development
Environmental Information
EPA/625/R-02/008
www.epa.gov/empact
July 2002

Community-Based Ultraviolet Radiation (UV) Risk Education

The SunWise Program Handbook

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

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Mr. Craig Sinclair, Anti-Cancer Council of Victoria, Australia

CONTENTS

1.0 INTRODUCTION

The sun is necessary for life, and while some exposure to sunlight is enjoyable, too much can be dangerous. There is increased concern that, due to the depletion of the ozone layer, more of the sun's rays are reaching Earth than ever before. Overexposure to ultraviolet (UV) radiation can lead to adverse health effects, such as blistering sunburns, skin cancer, eye problems, and premature aging of the skin. More than 1 million people in the United States are diagnosed with skin cancer each year, making it the most common form of cancer in the country. In fact, 90 percent of skin cancers are linked to sun exposure.[1]

Skin cancer and other health risks are largely preventable, however. Communities have access to a host of tools to help understand the risks from overexposure to the sun and how to protect themselves from harmful UV radiation. One of the most useful tools is the UV Index, which is a daily forecast of the level of UV exposure for a particular area of the country.

This handbook is designed to provide you with instruction and guidance on how to inform your community about the risks posed by overexposure to UV radiation and the steps that residents can take to reduce these risks. You will also learn more about the UV Index and how it can be incorporated into a successful sun protection education program. This handbook was developed by the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring for Public Access and Community Tracking (EMPACT) program. EPA created EMPACT in 1996 to take advantage of new technologies that make it possible to provide environmental information to the public in near-real time. EPA partnered with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) to help achieve nationwide consistency in measuring environmental data, managing the information, and delivering it to the public.

EMPACT projects have been initiated in 156 metropolitan areas. (See table at the end of this chapter.) These projects cover a wide range of environmental issues,

[1]American Cancer Society, "Cancer Facts and Figures 1999."

such as groundwater contamination, ocean pollution, smog, and overall ecosystem quality.

EMPACT projects aim to help communities:

- Collect, manage, and distribute time-relevant environmental information.
- Provide their residents with easy-to-understand, practical information they can use to make informed, day-to-day decisions.

Some projects have been initiated directly by EPA; others have been launched by communities with the help of EPA-funded Metro Grants. EMPACT projects have helped local governments build monitoring infrastructures and disseminate environmental information to millions of people.

1.1 What Is EPA's SunWise Program?

The SunWise School Program is an EMPACT project that raises awareness of the health risks of overexposure to the sun and aims to change behaviors to reduce these risks. This national program reaches out to children in grades K through 8, their teachers, and their caregivers. Through the use of classroom-, school-, and community-based lessons and activities, SunWise helps children:

- Follow action steps to reduce their exposure to UV radiation (see Chapter 4).
- Develop skills for sustained SunWise behavior and appreciate the environment around them.

SunWise activities and publications discuss the causes and effects of UV radiation, as well as how to monitor local and national UV levels using the UV Index.

The SunWise Web site (www.epa.gov/sunwise) provides detailed information on the program and is a comprehensive online resource for sun safety information. In addition, NOAA's Climate Prediction Center (www.cpc.ncep.noaa.gov) provides daily updates of the UV forecast for U.S. and international cities.

SunWise
a school program that **radiates** good ideas

1.2 What Is the Purpose of This Handbook?

This handbook provides information your community will need to develop a UV risk education program. The handbook is organized as follows:

- **Chapter 2** describes the health and environmental concerns of UV radiation, including detailed information on skin cancer, skin aging, cataracts, and immune system suppression. It describes the different types of UV radiation and discusses the relationship between ozone depletion and increased UV radiation, including the science of ozone depletion.
- **Chapter 3** includes detailed information on the UV Index, including when and why it was established, what it measures, what UV monitoring systems exist, and how the UV Index is influenced by factors such as elevation, cloud cover, time of day, and latitude.
- **Chapter 4** discusses how to communicate sun protection and public health information to residents. A UV/sun protection outreach project can take many forms, from a sustained, multi-year, community-wide effort to a seasonal campaign at parks and recreation centers. This chapter of the handbook explains the steps involved in developing a sun protection outreach program for a community and provides profiles of successful initiatives in the United States and internationally. It also describes a variety of successful tools and strategies that can be used in schools and communities, and it provides guidance for communicating information about sun protection and health risks to the community.

This handbook is designed for decision-makers and public health officials who may be considering whether to implement a UV risk communication or outreach program in their community, and for outreach coordinators or other individuals who are in charge of implementing community-based programs.

This handbook references supplementary sources of information, such as Web sites, publications, organizations, and contacts, that can help the user find more-detailed guidance. Interspersed throughout the handbook are success stories and lessons learned from communities and organizations that have already implemented UV outreach programs.

1.3 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, 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, SC
Columbus, GA-AL
Columbus, OH
Corpus Christi, 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-Morgantown-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
Lexington, KY
Lincoln, NE

Little Rock-North Little Rock, AR
Los Angeles-Riverside-Orange County, CA
Louisville, KY
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
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
Sound 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

Utica-Rome, NY

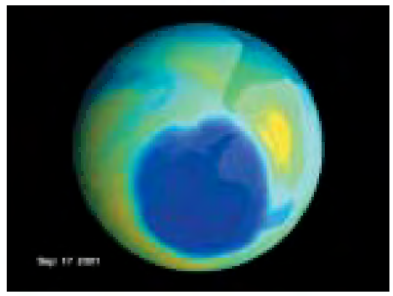
Visalia-Tulare-Porterville, CA

Washington-Baltimore, DC-MD-VA-WV
West Palm Beach-Boca Raton, FL
Wichita, KS

York, PA
Youngstown-Warren, OH

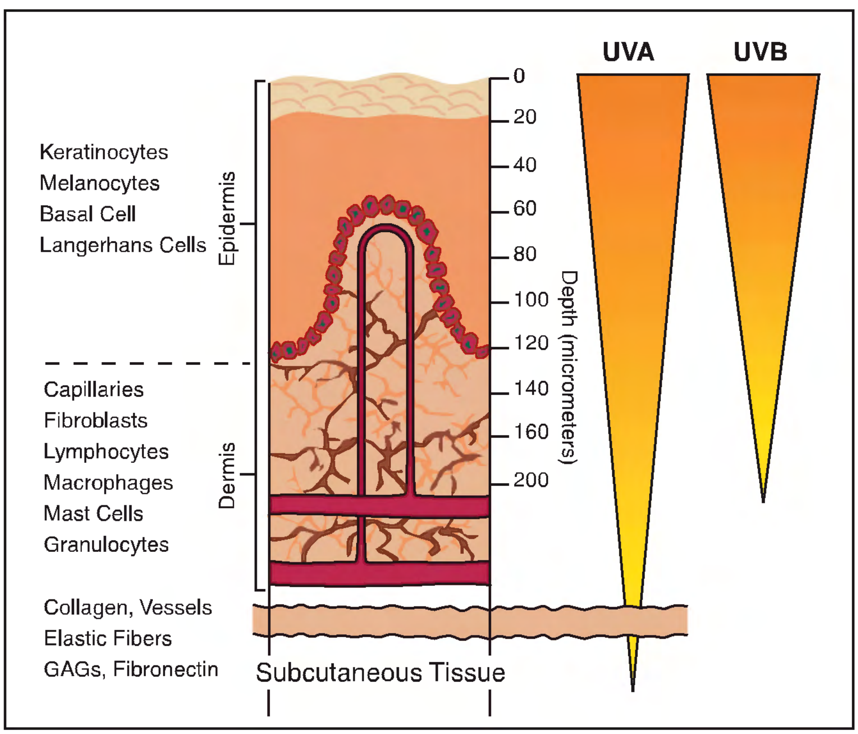
2.0 HEALTH AND ENVIRONMENTAL CONCERNS OF UV RADIATION

Ultraviolet (UV) radiation is a natural but dangerous part of the sun's energy. The ozone layer, located between 6 and 30 miles above the Earth in the stratosphere, blocks most of this radiation from reaching the Earth's surface and makes our planet livable. A dramatic loss of stratospheric ozone was first noticed in the mid-1980s above Antarctica. Since then, scientists have confirmed significant seasonal losses of stratospheric ozone over Antarctica and the Arctic region, and less dramatic losses in mid-latitude regions such as North America. The depletion of the ozone layer has created heightened concern about the health and environmental effects of increased UV radiation. UV radiation is known to cause a number of different health effects, including skin cancer and cataracts, and increased UV radiation is suspected to be contributing to a number of environmental problems, including the worldwide decline in frog populations and the bleaching of coral reefs.



2.1 What Is UV Radiation?

UV radiation is an invisible form of energy that has a shorter wavelength than either blue or violet light. UV radiation is made up of three components: UV-A, UV-B, and UV-C rays. Although the ozone layer does not absorb UV-A rays, it does absorb most UV-B rays and virtually all UV-C rays. UV-A rays penetrate deep into the skin and heavily contribute to premature aging, while UV-B rays mostly impact the surface of the skin and are the primary cause of sunburn. Both UV-A and UV-B have been linked to a number of other health effects, including skin cancer, and UV-B rays have been implicated in environmental effects from UV radiation. The main threat resulting from the depletion of the ozone layer is increased UV-B effects, even though UV radiation is only about 2 percent UV-B.



2.2 How Does the Ozone Layer Block UV Radiation?

The ozone layer is very important because it absorbs most UV-B rays and virtually all UV-C rays. The ozone molecules that make up the stratospheric ozone layer are each made up of three oxygen atoms. When ozone absorbs UV radiation, it creates heat as it splits into a pair of oxygen atoms and a lone oxygen atom, which eventually recombine to form ozone again. The molecular structure of ozone can be altered by human-made chemicals that are emitted into the air. When this happens, the stratospheric ozone layer can be depleted.

Chlorofluorocarbons (CFCs) are the principal cause of ozone depletion, although a number of synthetic halocarbon chemicals also are known to reduce stratospheric ozone. CFCs were once widely used as propellants in spray cans, as refrigerants and electronics cleaning agents, and in foam and insulating products. Other ozone-depleting substances include pesticides such as methyl bromide, halons used in fire extinguishers, and methyl chloroform used in industrial processes. CFCs now are banned from production in the United States and many other countries, but they still are found in certain products. CFCs can escape into the air during CFC manufacturing, from leaks in air conditioners and refrigerators, and when used appliances are disposed before recovering the remaining CFCs within them.

When CFCs are released into the air, they do not break down. Instead, they are mixed and dispersed by atmospheric currents. This process can continue for 2 to 5 years, until the CFCs eventually reach the stratosphere. In the stratosphere, CFCs break down and release chlorine atoms when exposed to UV radiation. The chlorine atoms destroy ozone, but are not destroyed themselves. As a result, each chlorine atom can destroy a large amount of ozone (up to 100,000 ozone molecules) before it is eventually removed from the stratosphere by other atmospheric processes.

Ozone depletion is heightened above the North Pole and especially the South Pole. The very cold, dark winters of the polar regions cause stratospheric ice clouds to form, and this promotes the breakdown of CFCs. Each spring above Antarctica, up to 60 percent of the ozone layer disappears and does not return to normal until the summer. The Arctic loses up to 25 percent of its ozone layer each spring, while mid-latitude regions, such as North America, lose up to 5 percent. Global warming, which occurs when greenhouse gases prevent heat from escaping from the lower atmosphere into the stratosphere, can set the stage for increased ozone depletion by creating a colder environment in the stratosphere.

In 1987, countries from around the world recognized the threat to the ozone layer and signed a treaty—the Montreal Protocol on Substances that Deplete the Ozone Layer—to reduce the global production of ozone-depleting substances. Amendments in 1990, 1992, 1995, and 1997 strengthened the treaty to promote the earliest possible restoration of the ozone layer. Scientists predict that ozone depletion will peak between 2000 and 2010. With full compliance from participating countries, the ozone layer is expected to be restored by the middle of this century. Until that time, however, increased levels of UV radiation will reach the Earth's surface.

2.3 How Does UV Radiation Affect Your Skin, Eyes, and Immune System?

Overexposure to UV radiation can cause a number of health effects, including skin cancer, accelerated skin aging, cataracts, and a suppressed immune system.

Skin Cancer

Everyone knows the short-term discomfort of too much sun—redness, tenderness, swelling, and even blistering. However, overexposure to the sun and repeated sunburns can lead to a much worse condition—skin cancer. More than 1 million Americans are diagnosed with skin cancer every year, representing nearly half of all cancers diagnosed annually. One in every five Americans will get some type of skin cancer in his or her lifetime. There are three main types of skin cancer: melanoma, basal cell carcinomas, and squamous cell carcinomas. (See Section 2.5 for descriptions of the different types of skin cancer and how to recognize them.)

Skin Aging

Repeated overexposure to the sun causes changes in the skin called actinic (solar) degeneration. Over time, the skin becomes thick, wrinkled, and leathery. This condition occurs gradually, often appearing many years after the majority of a person's exposure to the sun. Up to 90 percent of the visible skin changes commonly attributed to aging are caused by sun exposure.[2] Many people believe that photoaging is a normal, but unavoidable, part of growing older. However, with proper protection from UV radiation, photoaging can be substantially avoided.

Cataracts

Research has shown that UV radiation increases the chances of developing cataracts, a form of eye damage that involves a loss of transparency in the lens of the eye. Although curable with modern eye surgery, cataracts affect millions of Americans each year. If left untreated, cataracts can cause cloudy vision and lead to total blindness.

Exposure to UV radiation may also increase the chances of other types of eye damage, including pterygium, a tissue growth on the white of the eye that can block vision, and macular degeneration. The macula is the part of the retina near the center, where your vision is most sensitive. Macular degeneration may include development of spots that can result in blindness.

[2]Taylor, C.R. et al, Photoaging/Photodamage and Photoprotection, J Am Acad Dermotol, 1990: 22: 1-15.

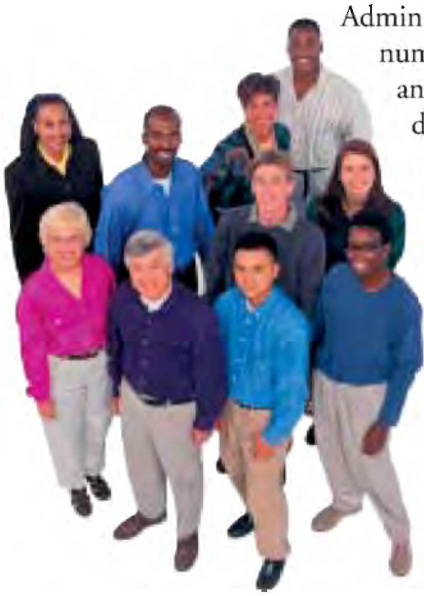
Immune System Suppression

Scientists have found that sunburn can affect disease-fighting white blood cells for up to 24 hours after exposure to the sun, making your body more prone to infections and cancers. Sun exposure can aggravate diseases such as herpes simplex (cold sores), chicken pox, and lupus. Repeated exposure to UV radiation might cause more long-lasting damage to the body's immune system. Mild sunburns can directly suppress the immune functions of human skin where the sunburn occurred, even in people with dark skin.

2.4 Are Some People More Prone to the Effects of UV Radiation?

Skin Type

Everyone, regardless of race or ethnicity, is subject to the potential adverse effects of overexposure to the sun. However, skin type affects the degree to which some people burn and the time it takes them to burn. The Food and Drug Administration classifies skin type on a scale from 1 to 6. The lower the number, the lighter the skin color. Individuals with fair skin, skin types 1 and 2, tend to burn more rapidly and more severely. Individuals with darker skin, skin types 5 and 6, do not burn as easily.



The same individuals who are most likely to burn are also most vulnerable to skin cancer. Studies have shown that individuals with large numbers of freckles and moles also have a higher risk of developing skin cancer. Although individuals with higher-number skin types are less likely to develop skin cancer, they should still take action to protect their skin and eyes from overexposure to the sun. Dark-skinned individuals can and do get skin cancer.

Other factors

Factors other than skin type may affect a person's vulnerability to the sun's rays. Some medications, such as antibiotics and antihistamines and even certain herbal remedies, can cause extra sensitivity to the sun's rays. People taking medications should contact their physician to learn about potential risks resulting from sun exposure.

2.5 Recognizing the Signs of Skin Cancer

Skin cancer is one of the most treatable forms of cancer. Early detection of skin cancer can decrease chances of the cancer spreading to other parts of the body and increase chances of survival. The survival rate for patients with early stages of melanoma has increased from about 50 percent in the 1950s to about 90 percent today. Nonmelanoma skin cancers have an even higher cure rate—95 percent or higher if detected early.

Skin cancer occurs most commonly on areas of the body most exposed to the sun, such as the face, neck, ears, forearms, and hands.

Different Types of Skin Cancer

Melanoma is the most deadly form of skin cancer and one of the fastest-growing types of cancer in the United States, according to the American Cancer Society. New cases of melanoma in this country have more than doubled in the past 2 decades, with more than 53,000 cases expected in 2002. An estimated 7,400 people will die from melanoma in 2002, almost 4 times as many deaths as nonmelanoma skin cancers. Melanoma can spread to other parts of the body quickly, but when detected in its earliest stages, it is usually curable.

Melanomas often start as small, mole-like growths. The growth, an uncontrolled development of pigment-producing cells in the skin, leads to the formation of dark-pigmented malignant moles or tumors, called melanomas. Melanomas can appear suddenly without warning but also can develop from or near a mole. For this reason, people should know the location and appearance of moles on their bodies so they will notice any changes. Melanomas are most frequently found on the upper backs of men and women, and the legs of women, but they can occur anywhere on the body. To recognize potential problems, conduct periodic self examinations and watch for changes that meet the ABCDs of melanoma:

Asymmetry: One half of the growth does not match the other half.

Border irregularity: The edges of the growth are ragged, notched, or blurred.

Color: The pigmentation of the growth is not uniform. Shades of tan, brown, and black are present. Dashes of red, white, and blue also may appear.

Diameter: Any growth greater than the size of a pencil eraser should be examined by a doctor immediately.

The two types of **nonmelanoma skin cancers**—basal cell carcinomas and squamous cell carcinomas—are not as fatal as melanoma. An estimated 1 million Americans will develop nonmelanoma skin cancers in 2002, while approximately 2,200 will die from the disease.[3] Nonmelanoma skin cancers are the most common skin cancer found in fair-skinned people.

Basal cell carcinomas are tumors that usually appear as small, fleshy bumps or nodules on sun-exposed areas such as the face, lips, neck, ears, and hands, but may appear anywhere. This cancer does not grow quickly and rarely spreads to other parts of the body. It can, however, penetrate below the skin to the bone and cause considerable local damage.

Squamous cell carcinomas are tumors that might appear as nodules or as red, scaly patches. This cancer can develop into large masses, and unlike basal cell carcinoma, it can spread to other parts of the body. It is the most destructive type of skin cancer.

[3]American Cancer Society, "Cancer Facts and Figures 2002."

Going to the Doctor

A person should see a doctor or dermatologist if he or she sees any of the signs of skin cancer. To identify the warning signs, individuals can periodically examine their skin, especially after prolonged periods in the sun. Skin self-examinations consist of regularly looking over the entire body, including the back, scalp, soles of feet, between the toes, and on the palms of the hands. If there are any changes in the size, color, shape or texture of a mole, the development of a new mole, or any other unusual changes in the skin, a person should see his or her dermatologist immediately.

As part of its screening program, the American Academy of Dermatology (AAD) can inform individuals annually when it is time to schedule their yearly visit for a skin cancer screening. AAD's Web site allows an individual to locate a skin cancer screening location in his or her community and sign up for annual notification. Volunteer dermatologists provide free skin cancer screenings as part of the program. See <www.aad.org>.

2.6 Why Are Children and Teenagers Most Vulnerable to Overexposure?

School-aged children spend a lot of time outdoors. They usually have the summer off and often spend many days swimming at beaches and community pools, playing team sports such as baseball and soccer, and attending summer camp. These outdoor activities mean more sun exposure. In fact, an estimated 80 percent of a person's sun exposure occurs before age 18.[4] Many dermatologists believe there might be a link between childhood sunburns and malignant melanoma later in life. Therefore, it is especially important for parents and caregivers to ensure that children consistently use sunscreen and take other protective measures. In addition, parents must remember to be good role models for children; parents who get a sunburn are more likely to have kids who get a sunburn.

[4]Stern RS, Weinstein MC, Baker SG. Risk reduction for nonmelanoma skin cancer with childhood sunscreen use. Arch Dermatol. 1986: 122: 537-545

2.7 What Are the Environmental Threats from UV Radiation?

In the regions of the world where ozone depletion has occurred, increased UV radiation threatens plants and wildlife on land and in the sea. These areas include Antarctica, the Arctic, and mid-latitude regions such as North America.

On land, increased UV radiation is suspected of contributing to population declines and limb deformities in frogs and other amphibians. It also is known to be damaging to some plants, particularly agricultural crops. UV damage to crops can affect growth and food quality, as well as the ability of plants to withstand pests and diseases. Crops, plants, and trees also provide food and shelter for many animals, so if these resources are damaged, other species and even entire ecosystems also can be affected.

In the sea, increased UV radiation damages sea grasses, sea urchins, corals, krill, and microscopic plants and animals known as plankton. Many of these organisms are important food resources. Plankton and krill are at the bottom of the marine food chain and feed a multitude of creatures, from starfish to whales. UV radiation also is suspected to be one of the reasons why some colorful corals are turning white and dying.

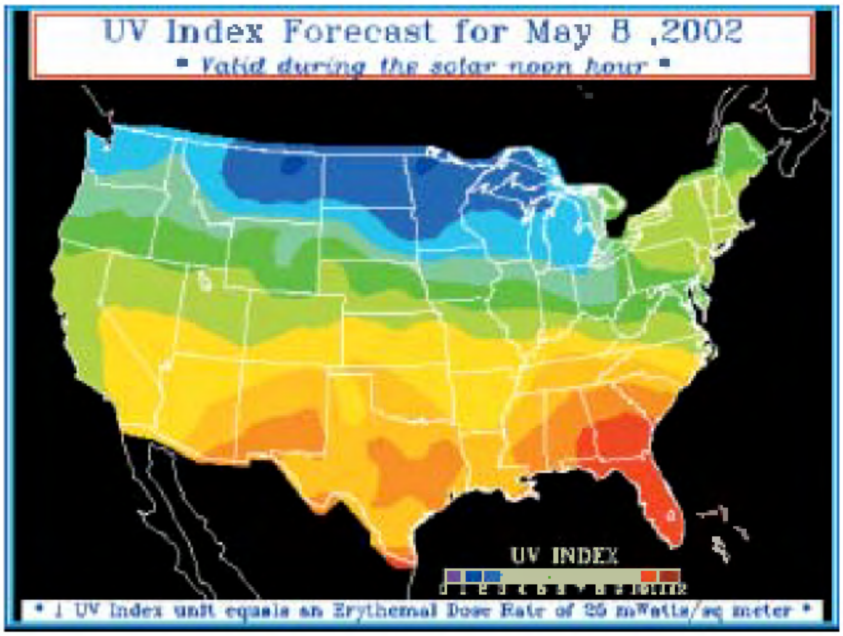
In addition, in areas with high levels of air pollution, an increase in UV radiation can worsen air quality. Increased UV-B radiation causes an increase in the reaction of nitrogen oxides with volatile organic compounds (byproducts of vehicle exhaust, industrial emissions, and chemical solvents), producing increased amounts of ground-level ozone. Exposure to ground-level ozone causes many health problems.

Although UV radiation has negative impacts on plants and wildlife, not all species are affected equally. Some agricultural crops are more tolerant of UV radiation than others, and some marine creatures are able to repair some UV damage at night. On the other hand, in areas affected by additional environmental impacts, such as pollution, UV affects might be more damaging.

3.0 WHAT IS THE UV INDEX?

Developed by the National Weather Service (NWS), the UV Index forecasts the next day's ultraviolet (UV) radiation intensity at different locations on the Earth's surface for "solar noon," which is when the sun is at its highest point in the sky.

NWS first began testing an "Experimental UV Index" for 58 U.S. cities on June 28, 1994, in cooperation with EPA and the Centers for Disease Control and Prevention (CDC). Scientists at the NWS Climate Prediction Center developed the forecasting tool and its supporting science. In April 1995, NWS deleted the "experimental" and made the UV Index an official product. NWS subsequently has encouraged meteorologists to make similar UV Indices widely available across the country. In addition, it has worked with EPA and CDC, meteorologists, health and medical professionals, and the World Meteorological Organization to ensure there is consistency among different UV Indices. As a result, these groups, as well as the general public, use the UV Index and accept its widespread dissemination.



3.1 How Is the UV Index Calculated?

To derive the UV Index, scientists collect ozone data from satellite observations and atmospheric pressure and temperature forecasts and scale the information to produce an index with a range of 0 to 15. The UV Index is adjusted to account for the potential presence of clouds and the elevation of the location. The lower the number, the less UV radiation is reaching the surface. Low numbers occur when the sun is low in the sky (i.e., during winter) and during overcast conditions. A higher number is forecasted when the sun is higher in the sky (i.e., during summer) and during clear or only partly cloudy conditions.

NWS uses a computer model to calculate the UV Index. The model takes into account a number of factors, including the amount of stratospheric ozone and clouds overhead, latitude, elevation, and time of year. The model first calculates a UV "dose" rate, or the amount of UV radiation to which a person will be exposed at the next day's solar noon under "clear sky" (no clouds) conditions. Higher elevations will increase the UV dose rate because there is less atmosphere to absorb and scatter UV rays. Greater cloud cover will tend to reduce the UV dose rate because clouds screen out some—but not all—UV rays. The UV dose rates are then adjusted for the effects of elevation and cloud cover at specific locations.

Quick changes in cloud conditions can alter the predicted UV Index forecast. The UV Index is applicable to a 30-mile radius around the city for which it is forecasted. Because the UV Index does not take into account differences in surface reflectivity, individuals must make adjustments based on these factors. You get much more UV on snow, sand, water, and concrete, since these surfaces reflect the sun's rays back onto your skin, just like a mirror. The brighter the surface, the more UV is reflected—fresh snow and dry sand reflect the most.

The resulting value is the next day's UV Index forecast. The UV forecasts for select locations are provided daily using a 0 to 10+ scale, where 0 indicates a minimal likely level of exposure to UV rays and 10+ means a very high level of exposure. EPA's SunWise Web site (www.epa.gov/sunwise) includes a feature that allows the user to enter his or her ZIP code and receive the UV Index forecast for that location for the current day. (See Chapter 4 to determine what steps you can take to protect yourself from the sun under different UV Index situations.)

For more information on how the UV index is calculated and validated, see Appendix D: How is the UV Index Calculated?

4.0 RAISING AWARENESS IN THE COMMUNITY

As a person begins to gather information about ultraviolet (UV) exposure and its risks, he or she will want to consider how to effectively communicate this information to others in the community. A UV risk education project can take many forms, from a sustained, multi-year community-wide effort to a short-duration or seasonal campaign at selected venues, such as schools, recreation centers, or parks. This chapter of the handbook is designed to help the user determine the kind of project that is right for his or her community by providing:

- Examples of UV risk education projects.
- Steps involved with outreach planning.
- Educational tools and resources that can be used in your schools and community.
- Messages that every UV risk education program should convey.
- Guidelines and sample language for successfully communicating information about sun protection and health risks to the community.

4.1 Developing an Effective Outreach Program

Community outreach programs can take many forms, depending on issues such as the groups most at risk, the scope of the effort, the available resources, and the commitment of key leaders. Across the United States, different UV risk education programs have been developed and conducted with varying levels of effectiveness. In general, community-wide programs with a strong mass media component have been most effective, and sustained activities have proven more effectual than shorter or one-time projects. Additionally, sun protection and health risk messages have more resonance when they are consistent and repeated. People also tend to trust the "messenger," so consider credible sources within the community (e.g, schoolteachers, pediatricians, dermatologists) to deliver your messages.

Many communities will want to build on existing UV risk education programs, such as SunWise, PoolCool, and the SunWise Stampede. Schools can join EPA's SunWise School program to receive free educational materials for classes and assistance with developing school policies that promote sun safety. In addition, the Centers for Disease Control and Prevention have recently issued guidelines urging schools to try to protect children from excess sunlight by implementing policies designed to minimize students' midday sun exposure. Be aware that sunscreen technically is considered an over-the-counter drug, similar to aspirin or cough drops, and in most state school districts, it is prohibited from student use without doctors' and parents' permission to allow nurses or aides to administer it. However, this is a barrier that can be overcome, as students in the Rockwood, Missouri, school district successfully demonstrated (see

Appendix B: Case Studies of UV Risk Education Programs). Swimming pool managers can contact the PoolCool program for free sun-safety signs and technical support to promote sun protection during pool activities. Local zoos can participate in SunWise Stampede, a program designed to promote sun safety to zoo visitors. (See Appendix A: List of Resources for more information on these and other UV/sun protection programs.)

Other communities will want to develop their own UV risk education programs or modify educational materials from existing programs. Throughout this chapter, a wide variety of ideas are presented for UV risk education projects. Regardless of the type of program you ultimately choose to implement, it is important to first think through issues such as your goals, audiences, messages, resources, available tools, and measurement options before committing to a plan of action.

Lastly, it can help to work with others who are also interested in promoting sun safety in your community. For example, you can contact your local chapter of the American Cancer Society (ACS) (see the "In My Community" section of the ACS Web site <www.cancer.org>) to ask about working with volunteers or ACS staff. Another option is to inspire others in your community to become sun safety advocates. For example, parents especially can be strong advocates for sun safety. They can inspire others by giving informal presentations on sun safety at the local library or at a parent-teacher association, by setting up a table and distributing sun safety brochures at a community festival or sporting event, or by working with the local media to broadcast messages on sun safety. By working with other like-minded individuals, you can have more of an impact on UV risk education efforts by expanding the reach of your effort, by having more resources available, and by having a stronger voice to advocate for policies and programs in your community that promote sun safety.

Step 1: What Are You Trying To Accomplish?

The first step in any outreach effort is to define what you want to accomplish. In general, UV risk education programs aim to:

- Increase awareness of sun exposure, UV radiation health risks, and sun safety measures.
- Change behaviors and attitudes to ensure sun safety.
- Change policies to reduce sun exposure and encourage sun safety.

Getting your community's residents to change the way they view sun exposure and tanning and to always practice sun-safe behaviors is ultimately the best way to prevent skin cancer and the other adverse health effects of UV overexposure. It can, however, be difficult to effect permanent attitude and behavior change. For this reason, many communities will begin or also seek to make changes at the policy level. Policy changes have proven effective because they don't rely on individuals to take voluntary actions. Additionally, policies can serve as reminders to people of the importance of a particular behavior. Examples of community policies to encourage sun safety and reduce sun exposure include:

- Providing shade infrastructure at community parks, recreational areas, or school grounds.
- Requiring the posting of signs at recreational sites, such as parks, beaches, and pools, that encourage sunscreen and hat use and limiting time spent in the sun.
- Requiring parents to provide their children with hats and sunscreen at community outdoor camps.
- Requiring teachers to apply sunscreen to children before recess or enforcing a no hat, no play rule at schools: children who do not wear a hat must sit or play in the shade during recess and other outdoor breaks.

- Requiring very brief sunscreen breaks for children at outdoor pools, camps, and recreation sites.
- Passing legislation that encourages sun safety and education. For example, California introduced a sun safety law that specifies skin cancer as a type of employment "injury" for lifeguards. Under the bill, affected lifeguards could potentially receive payment through the workers' compensation system.

Some communities also craft their programs to not only encourage sun safety, but also to specifically raise awareness of skin cancer. Goals for these programs can include:

- Increasing people's knowledge of what skin cancers look like.
- Increasing the number of people who seek medical advice and early screening.
- Encouraging medical practitioners to educate patients and adults about skin cancer and check all adult patients.

Keep in mind that, with the right tools, many outreach programs (both short- and long-term) can be effective in raising a community's knowledge of sun exposure, skin cancer and other health risks, and sun-safe practices, but more sustained and intense programs are generally more successful in effecting permanent behavior change and attitudes.

As you begin to define your goals, keep in mind how you will measure achievement of them. For example, if one of your aims is to change behaviors of elementary school-age children at recess, how will you make sure this goal is achieved? Or if you seek to have the UV Index broadcast on your local television channel daily, how will you track these broadcasts? Whenever possible, define your goals in concrete, measurable terms and consider how you will follow up. You might also consider seeking the help of someone experienced in measurement as you define your goals—consider hiring or recruiting a volunteer with a back-

Developing a Sun Protection Policy for Schools

To ensure the success of sun protection policies at schools, it is important to work with parents, students, and school staff to help them understand the purpose of the policy and to encourage them to implement it. Adjust the policy based on the recommendations of the school community. Consider the following suggestions:

- Form a committee that includes representatives from the school community affected by the policy.
- Conduct information sessions to explain the purpose of the policy.
- Consider sun protection measures that might already be in place at the school.
- Prepare a draft policy and ask for comments.
- Request endorsement of the final policy from the school council or other appropriate organization.
- After implementing the policy, publicize it to ensure everyone is aware of the policy and its purpose.
- Monitor and evaluate the success of the policy.

(This information was adapted from Australia's SunSmart program. For more information, go to <www.sunsmart.com.au>.)

ground in statistics or market research. (See "Step 6: How Will You Measure Success?")

Step 2: Who Are You Trying To Reach?

Successful outreach hinges on defining and understanding the target audiences you are trying to reach within the community. Outreach can be targeted at a variety of audiences, including:

- Children/young adults
- Parents and adult caregivers
- Outdoor occupational workers and recreational users
- Health care community
- Community leaders and activists
- Older adults and senior citizens

An outreach project can be directed at one or more primary audiences, such as children, or focus more specifically on a particular subset within an audience, such as elementary school-age children. A broad, community-based effort will most likely target multiple audiences, including children and their parents or adult caregivers, businesses and workers, the health community, community group leaders, the school district, and community and recreational directors.

When considering the audiences at which to direct your program, look at your community and determine the groups of people most at risk and the places where people are likely to be sun-exposed. In many communities, children are a primary target audience program, given that the majority of a person's lifetime exposure takes place before age 18. Other individuals most at risk from adverse health effects due to overexposure to the sun include people who:

- Spend a large amount of time outdoors (e.g., construction workers, people at the beach).
- Have lighter skin types.
- Have certain diseases such as lupus.
- Are taking certain medications such as antibiotics, antihistamines, or some herbal remedies.

However, anyone who spends time outdoors, regardless of their risk level, are subject to the potential adverse effects of overexposure to the sun.

Keep in mind that often a more in-depth educational message can be delivered to a smaller group of people, while a more simple message can be delivered to many people. Audiences that receive a more in-depth message are probably more likely to change their behavior than those receiving a more simple message.

Children and Young Adults

Many successful programs have been developed that reach out to children and young people directly, most frequently in schools, but also in childcare organizations, recreational centers and sites, service programs (e.g., 4-H, girl and boy scouts), and other community organizations that serve large numbers of children.

Within the school system, teachers, administrators, superintendents, nurses, and parent/teacher organizations can all be effective partners in changing behaviors, instituting policies, and generally spreading the sun protection word. An easy step for your community would be to find an elementary school teacher who is interested in joining EPA's SunWise Program. The teacher would then receive free teaching materials and classroom activities. Once this teacher's class has implemented the program, results and messages can be shared with other classrooms, schools, and even the community at large through activities and events such as sports matches, parents' nights, presentations in the auditorium, and exhibitions in school halls or community libraries. Teachers can also work with parent-teacher associations to encourage school sun protection policies or with school nurses who also can promote sun protection to students.

Older children can be effective messengers in delivering the sun protection message to their peers and younger classmates and siblings. Children look up to older peers, and the message may resonate more for teenagers if they hear it from someone their own age. Parental influence also can be beneficial, especially if used in

Effective Messages: Having a SunWise Field Day

As participants in a SunWise pilot, students in 6th and 7th grade health classes at Brownstown Middle School in Brownstown, Michigan, successfully reached out to the rest of the school in sending a SunWise message. Prior to one of the school's annual field days, when students compete in outdoor events, the students in the health classes launched a sun-safe campaign, encouraging their schoolmates to use sunscreen, hats, and sunglasses during the event. To help spread the safety message, the classes made posters to hang in the school's hallways and asked local businesses to donate sunscreen for the students to use on the field day. Teachers noted no incidences of sunburn as a result.

SunWise students at the same school also have planted oak saplings on the school grounds to eventually provide protective shade for students participating in outdoor activities.

For examples of other successful SunWise schools, see Appendix C.

concert with other factors, such as opportunities for children to self-select types of personal sun protection (e.g., hats, sunscreen, clothing).

Parents and Adult Caregivers

Parents, child-care workers, and other adult caregivers are important target audiences because they often are role models and can be instrumental in encouraging children to practice sun-safe behaviors. Additionally, parents often influence the organizational policies within schools and the community that can promote sun protection for children, and can be effective champions in changing practices or policies. Parents and caregivers can be reached though a variety of ways, such as through health events conducted at schools and community recreational sites; through educational materials distributed at schools, recreational centers, and community sites; through radio, print, and television announcements; and through the health care system.

Outdoor Occupational Workers and Recreational Users

Don't overlook other people who might be at particular risk of sun overexposure in your community, including those who work outside (e.g., lifeguards, farmers, fishers, landscapers, construction workers) and those who spend a lot of time engaged in outdoor recreational activities, including both children and adults. Occupational UV risk education programs should look at targeting the workers themselves, as well as the businesses that employ them. Trade organizations and unions are other potential audiences. Recreational UV risk education programs could reach out to individuals and groups such as zoo workers, park rangers, golf course and tennis court managers, fitness centers, marinas, sports and bicycle shops, and community garden clubs. You might consider a training program to help community workers, such as lifeguards, parks and recreational directors, or camp leaders, incorporate sun protection messages and practices into their programs. With these audiences, it is especially important to communicate the potential health effects of UV overexposure and the importance of medical consultations, screening, and early detection.

Health Care Community

Maternity nurses, school nurses, dermatologists, pediatricians, and other medical practitioners can all play key roles in communicating sun protection and health risk messages to their patients. Many of these individuals are already working with their patients to communicate this information; others, like school nurses, can receive training and encouragement to do so. Some communities have found that reaching out to new parents in maternity wards and through well child visits is particularly effective; not only does this encourage parents to protect babies and toddlers from sun exposure, it can also instill these behaviors in children as they grow older. The health care community can be important allies in not only encouraging sun safety, but also in raising awareness of skin cancer signs and stressing the importance of screening.

Community Leaders and Activists

Outreach efforts are most successful when there are champions behind the cause, volunteering to help with whatever needs to be done—from stuffing envelopes to rallying community support. Look to those individuals in your community who have the ear of your residents for help in spearheading your efforts and spreading the word. Community activists, such as those already working on health or children's issues, also can be effective partners.

Older Adults and Senior Citizens

Older adults and senior citizens are still at risk of overexposure to the sun, particularly those who spend large amounts of times outdoors. This audience, in particular, requires education and awareness-building concerning the health effects of sun overexposure, such as skin cancer, which could now be manifesting. The health community, senior citizen centers, assisted living centers, and organizations directed at retired individuals are all potential avenues for reaching these individuals and encouraging early screening and detection of sun-related health issues.

Step 3: What Do You Want To Communicate?

Think about the key points or messages you want to communicate through your effort. While the messages will vary depending on the audience you are targeting, they should be consistent, repeated, and delivered by credible sources or role models. It is also important to think through the potential barriers you might encounter, such as people's desire for a suntan or enjoyment of sports and other outdoor activities, in attempting to reach out to different target audiences.

Section 4.3, "Communicating UV Risk Information to the Community," presents some basic communication guidelines to consider when reaching out to the public about UV radiation and sun exposure. It also provides sample text and sun protection messages that can be incorporated into your actual outreach products.

If you are considering a large media component in your outreach, it is useful to pretest the chosen messages and slogans with your targeted audiences (through means such as surveys or focus groups) before executing the actual campaign. Testing will help you determine if your messages are appropriate and effective. Depending on the scope of your effort, you might hire a professional or find a volunteer who has market research experience. But don't forget that a number of community and national campaigns on sun protection and skin cancer have already been successfully launched, and you can also learn from the formative research and testing that these programs have already conducted when developing your own messages (see Appendix B: Case Studies of UV Risk Education Programs).

Step 4: Who Will Lead the Effort?

Within a community, various individuals and government offices share responsibility for communicating public health information to residents. Consider building a coalition with these and other individuals who will commit to and help execute your mission. For a short-duration or limited effort, you may need to simply identify a handful of committed people who can work with you to reach your targeted audience. These may be people within your organization, your school system, or the community at large.

For a school-based program, such as SunWise, an individual teacher might initially take the lead role, incorporating lessons focusing on sun protection in the classroom and encouraging sun-safe behaviors at recess and after school. This individual and the class can also become "champions" for spreading these messages to other classrooms and schools. Within the school system, a group of parents from a parent-teacher organization can also be effective leaders in encouraging policy changes, such as planting trees around the playground or requiring children to wear hats and sunscreen at recess.

Leadership for a program can also come from unexpected sources. In Dayton, Ohio, a group of dermatologists were the impetus behind the Raising Awareness About Your Skin (RAYS) program; however, the program's development and leadership were carried out by the Montgomery County Ohio Medical Alliance, a volunteer group made up of doctors' spouses. (See Appendix C: Successful SunWise Programs for more information on RAYS.)

For a broad-based community effort, such as the Safe Skin Project conducted in Falmouth, Massachusetts, (see Appendix B: Case Studies of UV Risk Education Programs) you might want to set up a town-wide advisory board made up of community leaders, organization representatives, and select community members. The advisory board would be instrumental in planning and implementing the program, as well as for gaining recognition and support in the community. Members of such a board could include:

- Elected officials
- Local health department officials
- Pediatricians and physicians
- Dermatologists
- Maternity nurses
- Child-care directors
- Recreational program directors
- School superintendents, teachers, and nurses
- Parents
- Teenagers

In some communities, advisory boards are made up of people with a history of working together. The advantages to this approach are that people know and feel comfortable working with each other. In other communities, there is an intentional effort to build a board of "unlikely partners"—people that might view sun protection from quite different experiences and perspectives. While establishing this kind of advisory board may require more up-front effort, it can also yield more positive results.

Finally, you might want to team up with other communities in your area to develop a regional campaign. The advantages of a regional campaign are many, including the ability to pool resources, share responsibilities, reach out to more people, and deliver consistent and repeated messages in a larger geographic area.

Step 5: How Will You Fund Your Outreach Program?

Resources are essential to any outreach effort. While the resources required for an outreach effort will vary depending on the scale and goals of your program, it's important to consider early on what type of resources (e.g., personnel, facilities, research, publicity) are required, if they are readily available, and how will they be managed, as these decisions can impact your effort. Consider local sources of funding, such as from the city or county government, as well as state and even national sources, such as grants from government agencies or organizations that fund health-based research or work on children's health issues (see Appendix A: List of Resources for more information).

Sponsors or partnering organizations also can be recruited to lend their resources and credibility to the program. Think of the various sectors of your community, and of the organizations and agencies that could help carry out your objective, particularly those that are already working with your targeted audiences. For example, Australia's SunSmart campaign partnered with several recreational organizations, including tennis and cricket associations. When considering sponsors, think in terms of your community's variety of racial and ethnic groups, income levels, occupations, and political views. Once you have recruited sponsors, solidify their commitment. Consider a pledge of participation to help sponsors understand their role and make explicit their commitment to the program.

Donations, bartering agreements, and volunteer support can also be useful in stretching your outreach dollar. The RAYS program, for example, received funding from the Children's Medical Center in Dayton, Ohio, in exchange for printing the center's name on the program's risk education CD-ROM. In addition, consider asking a local printer or copier to print your sun protection flyer at no cost; in return, provide a credit thanking the printer on the cover, which also serves to advertise the business.

Step 6: How Will You Measure Success?

Measuring the impacts of your program provides many benefits. It is always useful to know if your outreach is having an effect and if you are accomplishing what you set out to do. Additionally, having concrete measures of the results you have achieved might help you improve your program, consider ways to redirect your resources for future efforts, and even solicit additional funding.

You can measure success in a variety of ways, depending on the goals you establish. For this reason, it is important to think about measurement when you are establishing goals. (See Step 1: What are You Trying to Accomplish?) In many cases, it is useful to have baseline knowledge and information to evaluate trends in your community and predict what is in store in the near future. Many groups and communities that have instituted UV risk education programs make use of surveys, which are conducted before and after the launch of a program to measure attitude and behavior change. Some programs also have conducted follow-up surveys at different intervals (e.g., 3 months, 6 months, or 1 year) to gauge long-term behavior change regarding sun safety.

Communities interested in conducting attitudinal/behavior surveys might consider looking at those that have already been done (see the text box, "Sample Survey Questions," and Appendix A: List of Resources) for ideas on the types of questions to ask. Many surveys ask respondents to check the sun protection measures currently in place; after a program is implemented, the surveys are repeated and then cross-checked to see if improvements have been made. Some surveys also attempt to gauge respondents' awareness and attitudes regarding sun exposure before and after a program is implemented. Others also include questions designed to gather information to determine if policy, education, and training goals have been met. Any survey you develop should be closely linked to the goals you establish.

Sample Survey Questions

The following questions are from the community surveys given during the Falmouth Safe Skin Project (see section 4.2, Successful UV Risk Education Programs, for more information).

- Has your child ever had a painful sunburn? (Y/N)
- During a typical week this past summer, how often did your child go to the beach? (Never, 1-2, 3-5, every day)
- In the past 5 years, has your child intentionally worked on getting a suntan? (Y/N)
- Have your child's sunbathing habits changed compared to last year? (More, less, same, never)
- When going to the beach on a hot, sunny day, does your child wear a shirt or hat? (All, most, rarely, never)
- How often does your child use sunscreen at the beach? (Always, often, sometimes, rarely, never)
- How often does your child use sunscreen when outside in the summer but not at the beach? (Always, often, sometimes, rarely, never)
- During the past summer, if your child was outside for 6 hours on a hot day, how much of the time did he or she have on sunscreen? (6 hours, 3-5, 1-2, never)
- Compared with last year, how likely is your child this year to use sunscreen? (More, same, less)
- In the past 5 years, have you (as a parent) intentionally worked on getting a suntan? (Y/N)
- How often do you use sunscreen when you are sunbathing? (Always, often, sometimes, rarely, never)
- Do you find it difficult to protect your children from the sun? (Y/N)
- During the past summer, on hot days, how often did you insist that your child use sunscreen? (Every day, most days, half the time, less than half the time, rarely, never)
- Do you (as a parent) think that people look more healthy when they have a suntan? (Y/N)
- Does your child really enjoy getting a suntan? (Y/N)
- Compared with last year, has your child's interest in getting a tan __? (increased, stayed the same, decreased)
- This summer, my child told me that sunscreen prevents skin cancer. (Y/N)
- Have you (as a parent) ever heard of the disease malignant melanoma? (Y/N)

Given the technical nature of developing and administering scientific surveys, you might consider recruiting or hiring a statistician or market research expert (possibly as a member of your advisory board) to help you define goals and measure outcomes, particularly if the media is a major component of your program.

Step 7: What Outreach Tools and Community Events Will You Need To Communicate Your Messages?

Many organizations, including EPA, have already developed free tools that are available to the public. You may be able to use or modify these tools to meet your needs, especially those developed as part of EPA's SunWise School Program. (See Appendix A: List of Resources.) Be aware that most government-produced materials are typically in the public domain, which means they are available for public use and dissemination; programs developed by the private sector or other organizations may, however, be copyrighted. If you have doubts about the legality of using existing materials, contact the organization for more information.

There are many benefits to using existing materials, including saving money and resources, and accessing pretested messages. Some communities, however, might want to launch their own targeted campaigns, with their own slogans and artwork. Even if you develop your own materials, however, you might get useful ideas and save some time by looking at some existing tools.

The topics of sun safety and UV awareness can be explored through community events and a variety of outreach products spanning print, multimedia, electronic, and event formats. The table on the following page provides some examples.

The community events and products you choose should be based on the audience profile information you assembled in "Step 2: Who Are You Trying to Reach?" Think about which communication mediums are used most frequently and are most credible to your targeted audience. Then consider how you can use them as a vehicle for your message. A communications professional can provide valuable guidance in selecting the outreach products that will best meet your goals within your resource and time constraints. Questions to consider when choosing your products include:

- How much information does your audience need to have? How much does your audience know now?
- 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?

Print

Fact sheets, brochures

Checklists

Health screening reminders

Newspaper articles, editorials by health professionals or elected officials

Articles in health, school, recreation department newsletters

Articles in children- and parent-oriented magazines

Public service announcements in health or community publications

Bill stuffers, postcards

Press releases, media kits

Curricula and other educational materials for children

Electronic

Web pages

E-mail messages

Computer-based or animated presentations at events or libraries

Multimedia

Posters

Radio public service announcements

Cable TV programs

Exhibits

Kiosks

Videos

Signs

Events

Community days or fairs

National Skin Cancer Awareness Month

School events

School field days

Sports events

Health fairs

Small group meetings

One-on-one meetings

Public meetings

Press conferences

Media interviews

Novelty Items

Cups

Hats

Frisbees

UV-sensitive beads

T-shirts

Banners

Bumper stickers

Mouse pads

Buttons

Magnets

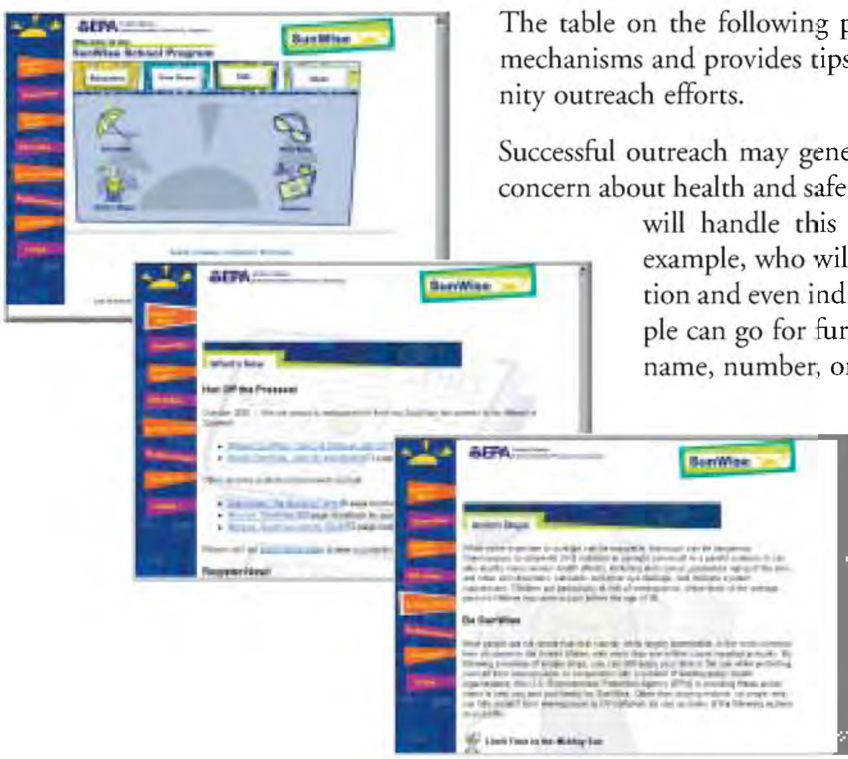
- How many people is the product likely to reach? For an event, how many people are likely to attend?
- What time frame is needed to develop and distribute the product?
- How much will it cost to develop the product? Do you have access to the talent and resources needed for development?
- When will the 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, a first phase of products designed to raise awareness, followed at a later date by a second phase of products to encourage changes in behavior.
- How newsworthy is the information? Information with inherent news value may be rapidly and widely disseminated by the media.

Step 8: How Will You Distribute Your Products?

Effective distribution is essential to the success of any outreach effort. There are many avenues for distribution. Before choosing your route, consider the following questions:

- 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 may have limited access to it.
- Are sufficient resources available to fund and implement distribution via the mechanisms of interest?



The table on the following page lists some examples of distribution mechanisms and provides tips and ideas for their use in your community outreach efforts.

Successful outreach may generate requests for further information or concern about health and safety issues. Consider whether and how you will handle this interest. You may want to define, for example, who will handle requests for additional information and even indicate on the outreach product where people can go for further information (e.g., provide a contact name, number, or address.) In planning a follow-up strategy, also consider directing people to EPA for further information about SunWise and the UV Index. EPA's SunWise Web site at <www.epa.gov/sunwise> is an excellent resource, linking to a wealth of sun safety materials and resources.

Medium	Characteristics	SunWise-Specific Ideas
Mailing lists	Highly focused on a target audience of your choice. You can tailor the message included in different mailings.	–Identify mailing lists from partner organizations or community organizations that include decision-makers, parents, educators, environmental groups, and health professionals. –Use existing SunWise informational materials in your mailings.
Phone/Fax	More time-intensive and personal communication.	–Conduct a phone survey on sun safety awareness in your community. Use the opportunity to speak to people one-on-one about SunWise.
E-mail	Effective, economical way of reaching community members in the workplace.	–Target the e-mail lists of partner organizations, corporations, schools, healthcare, and child-care facilities. –Use existing SunWise materials to create and send out an e-mail detailing the action steps for protection, and how people can find out more about the UV Index and sun-safe behavior.
Internet	Reaches diverse audience, but site might need promotion to attract initial attention. Also, make sure your target audience is Web-savvy and has ready access to the Internet.	–Create a community portal site about sun safety. Link to EPA's SunWise Web site.
Journals or newsletter	More in-depth treatment of your message, may use direct quotes from press releases; requires advance planning.	–See <www.epa.gov/sunwise/presskit.html> for example press releases that you can send to local journals and newsletters to promote sun safety and encourage schools to join SunWise. –Write your own press release on a SunWise news story of local interest in your community, such as a school project or community partnership, to attract media attention. –Develop and track media contacts, such as meteorologists, to get them involved in a UV Index story for your community.

Medium	Characteristics	SunWise-Specific Ideas
Television	Highly visible media designed to visually portray your message.	–Work with weather departments at your local station to work in segments on UV Index and sun safety. –Contact an assignment editor with an idea to profile a skin cancer survivor in your community. Include a sun safety message. –Prepare a SunWise media kit for your local station, include existing materials from the SunWise Program, such as brochures and fact sheets. Also, include a press release giving the information a local spin—such as a school's SunWise project or a company's UV awareness efforts.
Radio	Brief sound bites in which tone and delivery are important.	–Prepare a public service announcement on the importance of SunWise behavior. –Arrange for a respected health professional or community leader to participate in a talk show, delivering a sun safety message.
Hotline	Sustained effort, requires external promotion.	–Participate in a local health hotline by providing staff with sun safety information.
Meeting, events, or locations	One-time, high-profile opportunities to deliver your message to a target audience.	–Create a SunWise event of your own. Involve schools, companies, and organizations. Consider having a radio or TV station co-sponsor the event. –Look for ways to tie in with local events, such as fairs, parades, conferences, or sports events, to house a SunWise exhibit or distribute SunWise materials.

4.2 Successful UV Risk Education Programs

A number of UV/sun protection education programs have been successfully implemented in communities nationwide, as well as internationally. These programs educate youth and communities about sun protection through activities inside and outside of school. As a result, these concentrated efforts have had numerous positive effects on people's behaviors. For example, a community in Massachusetts reduced sunburn rates of children under 6 years old by more than 75 percent. In addition, a pilot project in Georgia improved the sun-safe behaviors of a youth soccer organization, while an in-school program in Australia focused on teaching teenagers proper sun-safe behavior by exploring myths about

Working With the Media

In a growing number of communities, media institutions are key players, even partners, in community-wide education programs. Some communities have relied primarily on media-based campaigns to deliver sun protection messages through newspapers, radio stations, television stations, and outdoor or transit advertising. The media has the advantage of reaching large numbers of people and can inspire people to become sun safety advocates. Long-term media coverage (periodically over at least 1 year) is most effective at raising people's awareness. Meteorologists who work for the media can play a particularly important role in broadcasting the UV Index daily and explaining what this measurement means in terms of sun protection. Newspapers also can print the UV Index daily. In general, media messages should be based upon an understanding of the prevailing culture and the level of community awareness of the issue.

If you are new to media work, it is important to realize that you don't need special training or experience to effectively promote your story. Take advantage of free media coverage by sending press releases or public service announcements (see the Centers for Disease Control and Prevention's Choose Your Cover campaign at <www.cdc.gov/ChooseYourCover/preview.htm>) to local media outlets or by asking newspapers and television stations to cover a local sun safety presentation, meeting, or start of a new SunWise Program at a nearby school. What you do need is the readily available information on basic methods for communicating with the media. You can find this information in books and "how-to" guides published by nonprofit organizations. Also, see Appendix A: List of Resources for more information to help you get started.

sun exposure and the pressures of tanning. For detailed information on many of these programs, see Appendix B: Case Studies of UV Risk Education Programs.

4.3 Communicating UV Risk Education Information to the Community

Communicating information on environmental and health risk topics can be challenging. Frequently, this information can be technical, full of unfamiliar terms and jargon. In addition, talking to people about health issues can be frightening, particularly when you are dealing with potentially life-threatening health effects, such as cancer. As you begin to implement your outreach and develop or tailor existing products, you will want to make sure that these products present your messages and information as clearly, accurately, and sensitively as possible.

Writing for the Public

Information should be conveyed in simple, clear terms. Principles of effective writing for the public include:

- Avoid using scientific jargon and acronyms. Where possible, translate technical terms into everyday language the public can easily understand. For example, use "skin" instead of "dermal." If you need to use technical terms or acronyms, make sure you define them.
- Use the active voice. Active voice means putting the subject of your sentence before the verb rather than after. For example, "Overexposure

to UV radiation can cause skin cancer" is written in active voice. "Skin cancer can be caused by overexposure to UV radiation" is not.

- Keep sentences short.
- In written materials, use headings and other format devices to provide a very clear, well-organized structure.

The Web site <www.plainlanguage.gov> provides many useful guidelines and examples for writing in clear, plain English.

Know Your Audience

As you develop communication materials for a specific audience, remember to consider what the audience members are likely to know, what you want them to know, and what they are likely to understand. Then tailor your information accordingly. Provide only information that will be valuable or interesting to the target audience. In addition, when developing outreach products, be sure to consider any special needs of the target audience. For example, if your community has a substantial number of people who speak little or no English, you will need to prepare communication materials in their native language.

Clinical Information and Photographs

Many programs have made use of testimonials and clinical pictures of actual skin cancer cases to communicate the importance of sun protection in reducing health risks. These tools can send a memorable message, and make an impression on children and adults alike. "Scary" messages and tools need to be used with sensitivity, however, when directed at younger children.

Essential UV Risk and Sun Protection Messages: Sample Text for Outreach Products

The rest of this section contains the messages that every UV risk education program should convey and sample text for outreach products. These examples, presented in a question-and-answer format, are written in a plain-English style designed to be easily understood by the public. You can use this text as a model to stimulate ideas for your own outreach materials or you can incorporate any of this text directly into your products. You also can use fact sheets, brochures, or other materials developed by the SunWise Program. These materials are available from <www.epa.gov/sunwise>.

What Are the Risks From Overexposure to Sunlight?

- We are all at risk from exposure to too much sun. This is because the sun contains harmful ultraviolet (UV) rays, called UV-A and UV-B, which can penetrate into the skin and eyes. Everybody, regardless of race or ethnicity, may be affected by overexposure to sunlight.
- Overexposure to UV radiation can cause a painful sunburn. Over time, it can also lead to skin cancer, early aging of the skin, and other skin

disorders; cataracts and other eye damage; and suppression of the immune system.

- More UV radiation is reaching the Earth's surface than ever before because pollution has thinned the ozone layer, which is high in the Earth's atmosphere and shields us from the sun's UV rays. There has been a continued increase in the reporting of skin cancer in the United States—1.3 million cases annually. In fact, one in five Americans will develop skin cancer in their lifetime.
- There is no such thing as a healthy suntan. Any change in your natural skin color is a sign of skin damage. Every time your skin color changes after sun exposure, your risk of developing sun-related ailments increases.

Who Is Most at Risk?

- You may be at greater risk of contracting skin cancer if your skin always burns or burns easily, and if you have fair skin, blond or red hair, or blue, green, or gray eyes.
- You may also be at increased risk of skin cancer if you have a history of blistering sunburns in early childhood, many moles, or a family history of skin cancer.
- People who spend a lot of time outdoors may be at higher risk for health effects from UV radiation.
- Children are particularly at risk of overexposure because they tend to spend a lot of time outdoors and can burn more easily. An estimated 80 percent of a person's sun exposure occurs before age 18. Blistering sunburns during childhood can significantly increase the risk of developing skin cancer later in life.
- Certain diseases, such as lupus, and certain medications, such as antibiotics, antihistamines, and even some herbal remedies, can make you more sensitive to the sun's harmful rays.
- Everyone is equally at risk for eye damage.

When and Where Is the Sun Strongest?

- The intensity of the sun's UV rays reaching the Earth's surface varies and should be considered when you plan outdoor activities. You can obtain a daily forecast of UV intensity for your area from the Internet (see "What Is the UV Index?" below).
- UV radiation is strongest at midday (from 10 a.m. to 4 p.m.) and during the summer. Also, exposure to UV radiation is greater at lower latitudes (i.e., the further south you are in the U.S.) and at higher altitudes.

- Up to 80 percent of the sun's UV rays pass through clouds. This means that you can burn on a cloudy day even if it doesn't feel warm.
- Snow, water, and sand reflect the sun's rays, so skiers, swimmers, boaters, and beachcombers are exposed from both direct and reflected sunlight.

How Can I Protect Myself and My Family?

Always Use Sunscreen

- Sunscreens protect your skin in two ways: by reflecting UV radiation away from your skin and by absorbing UV radiation before it can penetrate your skin.
- All sunscreens sold in the United States contain a Sun Protection Factor (SPF) label to indicate how much protection the sunscreen will provide when used properly. The higher the SPF, the greater the protection from UV-B rays. An SPF of 30 blocks out 96 percent of harmful UV-B rays (the primary cause of sunburn). An SPF of 15 offers 93 percent protection from UV-B. Many sunscreens—called "broad-spectrum" sunscreens—also protect the skin from UV-A rays (the primary cause of premature skin aging). **For these reasons, use of a broad-spectrum sunscreen with an SPF of at least 15 is recommended.**
- Apply about 1 ounce of sunscreen 20 minutes before going out into the sun (or as directed by the manufacturer) to give it time to absorb into your skin. Reapply sunscreen—about 1 ounce—every 2 hours or more if you are swimming or perspiring.
- Apply sunscreen to all areas of your body that are not covered by clothing or a hat and that might be exposed to the sun, including ears, feet, hands, back, bald spots, and the back of the neck, as well as areas under bathing suit straps, necklaces, bracelets, and sunglasses. To protect your lips, use a lip balm of at least SPF 15.
- Discard sunscreen after the expiration date or after 3 years, because the ingredients can become less effective over time.
- Sunscreens labeled "water resistant" should maintain their protection level for 40 minutes of water immersion. Sunscreens labeled "very water resistant" should maintain their protection level for 80 minutes of water immersion. Reapply these sunscreens regularly because heavy perspiration, water, and towel drying diminish their effectiveness.
- Occasionally, sunscreen ingredients cause skin irritation or reactions. If this happens, try using sensitive skin formulas or brands made for children.
- Using sunscreens does not mean that it is safe to spend more time in the sun, because they don't block all of the sun's damaging rays. In fact, there is no evidence that sunscreens protect you from malignant

melanoma—the deadliest form of skin cancer. So when you use sunscreen, be sure to use other protective measures as well, including limiting your time in the sun and wearing protective clothing, hats, and sunglasses.

Limit Your Time in the Sun

- The sun's UV rays are strongest between 10 a.m. and 4 p.m. Whenever possible, limit your exposure to the sun during these hours.
- When you are outside, stay in the shade as much as possible. Staying under cover is one the best ways to protect yourself from the sun.
- Remember that incidental time in the sun can add up to long-term sun damage. This includes, for example, time spent walking the dog, window shopping, performing outdoor chores, or jogging at lunch.
- Sun exposure is not required to get a sufficient amount of vitamin D. Most people get sufficient vitamin D in their diets. If you are concerned about getting enough vitamin D, you can drink vitamin D-fortified milk daily or take a multivitamin.

Wear Protective Sunglasses

- Sunglasses that provide 99 to 100 percent UV-A and UV-B protection will greatly reduce sun exposure that can lead to cataracts and other eye damage. Check the label when buying sunglasses. Be aware that dark, polarizing, or mirror lenses by themselves do not offer effective protection. Protective wrap-around frames provide the best protection
- If you wear corrective lenses, you should add UV-protective coating or obtain prescription sunglasses if you spend significant periods outside.

Wear a Wide Brimmed Hat

- Whenever possible, wear a hat with a wide brim. This offers good sun protection to your eyes, ears, face, and the back of your neck—areas particularly prone to overexposure from the sun. Be aware that baseball caps, visors, and narrow-brimmed hats provide less protection, particularly for the ears and nape of the neck.
- Choose a hat made from a close-weave fiber. If you can see through the hat, then sunlight will also get through.

Wear Protective Clothing

- Clothing that is tightly woven, loose-fitting, and full-length (in other words, with a collar, long sleeves, and long pants or skirts) provides good protection from the sun's harmful rays.
- UV rays can pass through the holes and spaces of loosely knit fabrics. Also, wet, faded, or older clothing provides less protection.

Avoid Sunlamps, Tanning Parlors, and Suntan Products

- Sunbeds and sunlamps emit UV light that can damage the skin and unprotected eyes.
- Suntan products do not contain a sunscreen and do not provide any protection against sun exposure.

Protect Children and Babies

- Children typically spend so much time outdoors that they are at high risk for overexposure to sunlight. Studies increasingly suggest a link between early sun exposure and skin cancer as an adult. Encourage your children to take all the safety steps listed above whenever they go outside. Started early and followed consistently, each of these steps will become an accepted habit, as easy as fastening seatbelts every time you drive the car.
- Keep babies out of direct sunlight. The American Academy of Pediatrics recommends using sunscreen on infants for small areas such as the face and back of the hands where protection from clothing is inadequate. For infants younger than 6 months, consult your physician.
- EPA has been working with schools and communities across the nation to launch the SunWise School Program. SunWise teaches children in elementary schools and their caregivers about how to protect themselves from overexposure to the sun. Educating children about sun safety is the key to reducing the risk of future UV-related health problems. For more information about SunWise, visit the program's Web site at <www.epa.gov/sunwise>.

Check the UV Index

- The UV Index forecasts the next day's likely intensity of UV rays. This is a useful tool for planning your outdoor activities to protect yourself from overexposure to sunlight. See below for more information on where to find the UV Index and how to use it.

What Is the UV Index and How Can I Use It?

- The UV Index is reported daily for localities across the United States. It forecasts the next day's likely intensity of UV rays.
- Calculated by the National Weather Service, the UV Index takes into account many factors, including the amount of ozone and clouds overhead, latitude, elevation, and time of year.

- UV Index forecasts are reported on a scale of 1 through 10+ as follows:

INDEX NUMBER	INTENSITY LEVEL
0 to 2	Minimal
3 to 4	Low
5 to 6	Moderate
7 to 9	High
10+	Very High

The higher the UV Index, the stronger the sun and the greater the need to follow all the sun protection measures. When a UV intensity of 5 or more is predicted for your area, it is especially important to protect yourself against sun exposure. The UV Index should not be used to determine the best time to go out and get a tan.

- You can obtain your local UV Index forecast daily from local weather stations or newspapers. EPA's Web site provides the UV Index forecast for your ZIP code. The address is <www.epa.gov/sunwise/uvindex.html>.
- Because the UV Index is a forecast, it won't always be exactly correct, but it is very reliable. The UV Index is 84 percent accurate to within ±2.
- Remember that snow, water, and sand reflect the sun's light, so you can get a double dose of UV exposure in these environments. The UV Index does not take these factors into account. If you are outdoors in these environments, your actual exposure will be higher than the UV Index value indicates.
- Some medications and diseases (e.g., lupus erythematosus) cause serious sun sensitivity. The UV Index is not intended for use by seriously sun-sensitive individuals. Consult your doctor about additional precautions you may need to take.

Appendix A: List of Resources

The following list of Web sites, contact information, and additional suggestions can help you get started with your UV risk education project. This list includes examples of existing UV risk outreach tools, information on successful UV risk education strategies, financial assistance resources, volunteer groups that might be able to provide assistance, measurement resources, and information on working with the media.

Examples of Existing UV Risk Outreach Tools

- **SunWise <www.epa.gov/sunwise>.** Teachers and schools can join EPA's SunWise Program and receive a number of educational and outreach products. These include the SunWise Tool Kit (which includes a UV-sensitive frisbee), the SunWise Internet Learning Site, and UV Database. Students and teachers can use the SunWise Internet Learning Site and UV Database to report and interpret daily measurements of UV radiation, explore interactive Web-based games and activities, and link to other educational activities and resources. Go to <www.epa.gov/sunwise/join.html> to join the SunWise Program.

- **SunSmart <www.sunsmart.com.au>.** Australia's SunSmart Internet site provides comprehensive educational material, technical assistance tools, and sample sun-safe policies for primary and secondary schools, child-care facilities, community health service organizations, local government, medical specialists, workplaces, community groups, sport and recreation clubs, and the tourism industry.

- **Choose Your Cover <www.cdc.gov/ChooseYourCover>.** The Choose Your Cover Web site includes facts and statistics about skin cancer, information about the program, and access to all campaign and educational materials, some of which can be ordered online.

- **PoolCool <http://splash.hawaii.edu/sbsp/projects/poolcool/home.html>.** PoolCool is a sun safety program especially designed for use at swimming pools. Swimming pools that join PoolCool receive an educational toolkit, sun safety signs, and technical support to promote sun safety during swimming lessons and other pool activities. For more information, contact Tom Elliot, Project Coordinator, at <poolcool@crch.hawaii.edu> or 808 586-3076, extension 69916.

- **Sunwise Stampede <www.foundation.sdsu.edu/sunwisestampede/index.html>.** Sunwise Stampede is a sun safety program that encourages zoo visitors to protect themselves from UV radiation. The program consists of a tip sheet for parents, coupons for sunscreen and hats, art activities for children, and sun protection signs and reminders. The Sunwise Stampede Web site includes fun educational games for children. For more information, contact Sunwise Stampede at <blewis@projects.sdsu.edu> or 619 594-8745.

- **Raising Awareness About Your Skin (RAYS).** The RAYS program is a skin cancer and sun awareness program for middle and high school students developed by the RAYS Task Force of the Montgomery County Ohio Medical Alliance. Contact RAYS at <RAYSTaskforce@aol.com> to receive a CD-ROM with slide presentations, study guides, and tests.

Successful UV Risk Education Strategies

- **Guide to Community Preventive Services <www.thecommunityguide.org/guide_basics/guide_basics_f.html>.** The Guide to Community Preventive Services is a federally-sponsored initiative that will help communities develop effective skin cancer (and other disease) prevention education programs. The cancer chapter, which will provide recommendations on successful skin cancer prevention strategies, should be complete by summer 2002.

- **Plain English Network <www.plainlanguage.gov>.** This Web site is dedicated to helping make all communication materials more user-friendly through the use of plain English, which means to organize and write information with the reader's needs in mind. For tips on writing user-friendly documents, go to <www.blm.gov/nhp/NPR/pe_toc.html>.

Financial Assistance

- **EPA Grants Administration Division <www.epa.gov/ogd/index.htm>.** EPA and other government agencies provide grants to organizations that address a variety of environmental issues. To access funding opportunities, go to <www.epa.gov/ogd/funding_opportunities.htm>. For information on how to apply for a government grant, go to <www.epa.gov/ogd/grants/how_to_apply.htm>.

- **The Foundation Center <www.foundationcenter.org>.** As the most authoritative source of up-to-date information on private philanthropy in the United States, the Foundation Center provides print, CD-ROM, and online resources to help individuals and organizations identify appropriate grant sources and develop targeted proposals. To get started, visit <www.fdncenter.org/about/fchelp.html> for easy access to Foundation Center services. Note that some grants are available only to nonprofit organizations.

Volunteer Groups that Could Provide Assistance

- **Environmental Alliance for Senior Involvement <www.easi.org/about.html>.** The Environmental Alliance for Senior Involvement (EASI) seeks to increase opportunities for older adults to play an active, visible role in protecting and improving the environment in their communities. Contact EASI to learn more about the availability of senior volunteers at <easi@easi.org> or 540 788-3274.

- **Experience Corps® <www.experiencecorps.org/index.html>.** Experience Corps® provides schools and youth-serving organizations with older adults who serve as volunteers to improve the academic performance and development of young people. Go to <www.experiencecorps.org/site/sites/map.html> to find an Experience Corps® in your area.

Measurement Resources

- **Surveys Developed by Other UV Risk Education Programs.** Many UV risk education programs use surveys to measure their effectiveness in changing sun protection attitudes and behavior. Contact any of the programs listed above or mentioned in this handbook's case studies. (See Appendix B: Case Studies of UV Risk Education Programs to request sample surveys.)

- **InnoNet Evaluation Resources <www.innonet.org/workstation/about.cfm>.** InnoNet helps organizations improve their effectiveness. Go to <www.innonet.org/resources/eval_resources.cfm> for answers to frequently asked questions on how to evaluate programs and for background information on a number of evaluation topics.

Working With the Media

- **It All Adds Up to Cleaner Air Campaign, Effective Media Relations <www.epa.gov/oms/transp/traqpedo/italladd/media.htm>.** This Web page provides good descriptions of different media types and instructions on successfully working with the media to get your message out to the public.

- **Buckle Up America Campaign, Working With the Media <www.nhtsa.dot.gov/people/injury/airbags/buckleplan/buckleup/media.html>.** Although focused on increasing seat belt use, this Web page provides helpful suggestions on generating media attention and creating newsworthy information.

Appendix B: Case Studies of UV Risk Education Programs

School-Based Program: SunWise

EPA developed the SunWise School Program to raise awareness of the health risks associated with UV overexposure and to encourage behavior change to reduce these risks. EPA focused on schools because children are at particular risk for sun exposure. Along with traditional education practices that promote sun protection, SunWise encourages schools to implement infrastructure enhancements, such as providing shade through canopies and trees, and to establish policies such as requiring hats, sunscreen, and sunglasses when outdoors. The program is designed to provide maximum flexibility—elements can be used as stand-alone teaching tools or to complement existing school curricula. Though based in schools, SunWise also supports community partnerships, such as inviting guest speakers to school assemblies.

SunWise Partner Schools receive materials and tools free of charge to help implement SunWise in their classrooms and communities. The SunWise Toolkit contains cross-curricular classroom lessons and background information for K through 8 learning levels. The toolkit also includes tools, including a UV-sensitive frisbee, a hand-held UV meter (if requested), and the *On the Trail of the Missing Ozone* comic book, that reinforce sun safety lessons. To reward your students for their participation in the SunWise Program, the kit also contains an easily photocopied "Certificate of SunWisdom."

Along with the toolkit, SunWise offers several brochures, fact sheets, and activity books with suggestions and recommendations for sun safety practices and activities. The program also maintains an Internet Learning site and a newsletter highlighting issues, trends, and success stories. The SunWise Web site (www.epa.gov/sunwise) gives details on the program and the importance of sun safety and is divided into sections for educators, students, health care providers, and the media.

The SunWise Web site offers a database for partner schools to enter their local daily UV forecast and intensity data. This collected data can then be accessed to create maps and graphs that can be used as educational tools. For more information, go to <www.epa.gov/sunwise> or contact Kevin Rosseel at <rosseel.kevin@epa.gov>.

Community-Wide Program: Working with New Hampshire Caregivers To Protect Children from the Sun (The SunSafe Project)

By training a variety of caregivers on how to promote sun protection to children and parents, health specialists at Dartmouth Medical School in New Hampshire demonstrated that community-wide UV risk education programs can lead to long-term positive changes in sun protection behavior. After initial SunSafe project interventions at New Hampshire schools, daycare centers, primary care physician offices, and beaches in 1996, and then a brief follow-up in 1997, the proportion of children 2 to 11 years of age practicing at least some sun protection behavior increased from 58 percent to 73 percent. SunSafe also resulted in an increase in the proportion of children fully protected by sunscreen, clothes, and shade (from 31 percent to 50 percent), a decrease in the proportion of children without any sun protection (from 42 percent to 27 percent), and an increase in the proportion of parents receiving sun protection information from physicians and schools (from 46 percent to 62 percent).

Ten New Hampshire communities participated in the SunSafe project, with five receiving interventions, and five acting as controls. Instead of targeting children and parents directly, project organizers instead focused on teachers, primary care physicians, and lifeguards.

- Teachers at schools and daycare centers received SunSafe curricula with lesson plans and educational activities modeled after Australia's SunSmart program (see page 48).
- Primary care physicians received a manual that teaches office staff and clinicians how to promote sun protection during medical checkups. In addition, to enhance sun protection counseling, project organizers provided physicians with educational posters, pamphlets, and self-adhesive reminder notes.
- Lifeguards received displays about the UV Index and sun protection to be posted at beaches. Project organizers also encouraged lifeguards to provide SunSafe pamphlets and free sunscreen samples to beachgoers.

In addition to providing outreach and educational materials, organizers visited principals, teachers, physicians, and lifeguards to encourage implementation of the SunSafe project and provide technical assistance with activities. All outreach and educational materials conveyed the same basic messages:

- Avoid or limit exposure during the sun's peak hours of 11am to 2pm. Teach your child to seek shade if he or she is outside during peak hours.
- Cover up with clothing and a hat with a brim. Wear a shirt and long shorts that go to the knee or below.
- Block the sun's rays through the use of a sunscreen with an SPF of 15 or higher. Be sure to put sunscreen on all areas not covered up.
- Say something to your friends and family about being SunSafe. Remind them that shirts, hats, and sunscreen are important for the whole family to use every time you are going to be out in the sun.

To track changes in children's sun protection behavior, project organizers trained a number of observers to visit beaches, interview parents, and detail children's sun protection behavior. Based on their observations and analyses, Dartmouth

Medical School health specialists demonstrated that the SunSafe UV risk education project provided long-term benefits to the community.

Since completing the study in 1998, project organizers have initiated a new SunSafe project that targets adolescents. This project, which will run through 2003, will provide educational materials to middle school teachers and outdoor sports and recreation staff, and will ask teenagers to participate in a survey and keep a diary to track their sun protection behavior during the summer. For more information, contact the SunSafe Project, Department of Community and Family Medicine, Dartmouth Medical School, at 603 650-1566, or visit the SunSafe Web site at <www.dartmouth.edu/dms/sunsafe/>.

Outdoor Recreation Program: Helping Georgia Soccer Coaches Promote Sun Protection

In Georgia, where sports are played almost year-round, more than 75,000 youth play soccer in recreational and competitive leagues. To address the need to protect soccer-playing youth from overexposure to the sun, university medical researchers and health communication professionals developed a UV risk education pilot project that trained soccer coaches to promote sun-safe behavior to young soccer players. The project focused on eight soccer teams of the St. Simons Island's youth soccer association in south Georgia.

To determine the content of the soccer coach training program, project organizers conducted a pretest survey to understand the sun protection practices and beliefs among soccer coaches and parents of soccer-playing youth. The pretest identified, for example, that coaches and parents believed it would be difficult for them to get youths to practice sun protection behaviors. The pretest also underscored knowledge gaps, such as in understanding the differences between waterproof, water-resistant, and sports sunscreens.

Project organizers randomly selected half of the soccer coaches who had participated in the pretest survey to receive the UV risk education training. Based on the results and insights gained from the pretest, the program trained coaches to serve as role models by practicing sun-safe behaviors themselves, encouraging youth to apply sunscreen before coming to games and soccer practices, and educating parents about the importance of sun protection. To complete the training, coaches attended a sun protection seminar and received an informational booklet on sunburn prevention strategies, skin cancer, and the importance of reducing sun exposure in youth. During the course of the season, coaches promoted sun protection to youths and parents, and served as positive role models.

In addition to informing the content of the training program, the pretest survey provided baseline data that project organizers used in conjunction with a post-test survey to evaluate the effectiveness of the pilot project. The evaluation showed that as a result of the program, coaches and parents were more likely to tell youths to wear sunscreen, and coaches were better able to get youths to practice sun-safe behaviors. For more information, contact Roxanne Parrott of the Office of Health Communication, University of Georgia, at <rparrott@arches.uga.edu>.

Young Adult Program: School-Based Education for Teenagers in Australia

Because teenagers are often susceptible to peer pressure, it is a particular challenge to influence them to adopt behaviors that their peers might find socially unacceptable. Researchers from the Center for Health Promotion and Cancer Prevention Research at the University of Queensland in Australia developed a school-based UV risk education curriculum that sought to address the peer pressures that teenagers face.

Health and physical education teachers at 13 schools in Queensland, Australia, taught the curriculum to students every year for 3 years, from 8th to 10th grade, during a 4- to 6-week period just prior to summer vacation. Through role playing, problem-solving, and student-directed activities, students explored the myths about sun exposure, the role of peer pressure in tanning, and motivations for acting in health-compromising or health-enhancing ways. Students also learned to plan ahead for sun safety and practiced critical thinking by analyzing how the mass media favors certain images. To help students put their newly acquired knowledge to work, teachers encouraged them to create advertisements that debunked media images and to brainstorm possible sun protection school policies that students might find acceptable.

To measure the effectiveness of the curriculum, researchers used surveys before and after each year's program to assess students' sun protection knowledge, attitudes, and behavior. To ensure the results of the surveys were due to the curriculum and not to any other factors, the researchers also surveyed students in 13 other schools in Queensland that did not receive the curriculum. In the 9th grade, the students receiving the curriculum showed a marked improvement in knowledge and some behavior change compared to students not receiving the curriculum; however, when the students were surveyed in the 10th grade, it appeared they were not practicing sun-safe behaviors as often as before. The researchers attribute the regression in behavior to the many social and cultural pressures teenage students face inside and outside of school, such as the priority given to sun protection by peers and the acceptability of wearing hats or long-sleeved shirts in public. For more information, contact Dr. John Lowe at the Center for Health Promotion and Cancer Prevention Research, Medical School at the University of Queensland in Australia at <j.lowe@mailbox.uq.edu.au>.

National and Community-Wide Program: Australia's SunSmart Program

Australia's SunSmart program, an initiative of the Anti-Cancer Council of Victoria, promotes awareness of skin cancer and sun protection measures to children, teenagers, and adults. The SunSmart program includes a media campaign, outreach programs, and research efforts. The media campaign includes advertisements in magazines and trade journals, television commercials, and press coverage of SunSmart activities and messages.

Through a variety of outreach programs, SunSmart provides technical assistance, research, training, and a variety of educational and promotional resources to organizations that can reach many at-risk individuals. SunSmart outreach programs target primary and secondary schools, child-care facilities, community health service organizations, local government, medical specialists, workplaces, community groups, sport and recreation clubs, and the tourism industry. One goal of SunSmart is to encourage these organizations to institute sun-safe policies, such as requiring participation in educational programs or the building of shade infrastructure.

To determine the effectiveness of its media and outreach activities and to guide future changes to the program, the Anti-Cancer Council of Victoria periodically evaluates SunSmart. In its most recent evaluation, the council determined the following to be key elements to SunSmart's success:

- **Consistency and continuity.** SunSmart has been successful because it has been able to sustain its efforts over the long term—SunSmart has been operating full-scale since 1988. SunSmart has achieved consistency and continuity because it has been hosted by a stable and supportive organization with common goals and a strong research capability, and it has had reliable and sufficient funding from its host organization and outside sources with similar health promotion goals.
- **Research and evaluation.** SunSmart has tailored its efforts based on research of its target audience's attitudes and behaviors towards sun protection and skin cancer and on aspects of society that could support or undermine health messages. In addition, the progress of SunSmart has been consistently evaluated, helping the organization reshape its focus when necessary to achieve its goals.

More information on SunSmart can be found at <www.sunsmart.com.au>.

Media-Based Program: Choose Your Cover

Through the Choose Your Cover media campaign, the CDC develops and distributes sun-safe public service announcements (PSAs) and press releases to broadcast and print outlets nationwide. The campaign also has included several strategic partnerships to further disseminate sun protection messages. For example, since 1999, CDC has worked with *Seventeen* magazine to sponsor photography and T-shirt contests that educate young adults about skin cancer and sun-safe behaviors. In addition, the campaign has included partnerships with the U.S. Olympic Synchronized Swimming Team and the Weather Channel.

Another important component of the Choose Your Cover campaign are educational materials, including posters, brochures, and a Web site. The Choose Your Cover Web site <www.cdc.gov/ChooseYourCover> includes facts and statistics about skin cancer, information about the program, and access to all campaign and educational materials, some of which can be ordered online. A number of state health programs have incorporated or modified Choose Your Cover materials into their own skin cancer prevention programs.

National Program: National Skin Cancer Prevention Education Program

The Choose Your Cover campaign is only one part of CDC's National Skin Cancer Prevention Education Program (NSCPEP) <www.cdc.gov/cancer/nscpep/index.htm>. In addition to the Choose Your Cover media campaign, CDC conducts research, funds outreach programs, and builds partnerships to extend the reach and improve the effectiveness of skin cancer prevention efforts in the United States. For example, CDC established the National Council on Skin Cancer Prevention, a coalition of organizations dedicated to fighting skin cancer on a nationwide basis. The goals of the coalition—which includes 24 organizations, including the American Academy of Dermatology and the American Cancer Society—are to:

- Increase skin cancer awareness and prevention behaviors among all populations, particularly those at high risk.
- Develop and support partnerships to extend and reinforce core messages for behavior change.
- Coordinate nationwide efforts to reduce skin cancer incidence and mortality.
- Develop a national skin cancer prevention and education plan.

CDC also established a Federal Council on Skin Cancer Prevention to promote sun-safe behaviors among federal agency employees and their families.

To support innovative state and national skin cancer prevention education initiatives, CDC funds a number of outreach programs through NSCPEP. One currently funded program, PoolCool, seeks to educate parents, lifeguards, pool managers, and young children about sun-safe behavior when they visit swimming pools. NSCPEP research focuses on determining national trends in sun protection behaviors and evaluating current skin cancer prevention efforts. CDC research also supports the *Guide to Community Preventive Services*, a federally sponsored initiative that will help communities develop effective skin cancer (and other disease) prevention education programs. For more information on this guide, see <www.thecommunityguide.org/guide_basics/guide_basics_f.html>.

Appendix C: Examples of Successful SunWise Programs

Raising Awareness About Your Skin (RAYS), Montgomery County, Ohio

RAYS is an active volunteer committee that educates students throughout Montgomery County, Ohio, about the dangers of ultraviolet radiation. The committee has reached 19,500 students in 35 school districts.

Consisting of more than 32 dermatologists, plastic surgeons, internists, obstetricians, optometrists, and neurologists, along with 25 other volunteers, the committee arranges assemblies and classroom presentations in middle and high schools throughout the year. Volunteers use SunWise lesson plans and a captivating slide presentation to teach students about the early signs of skin cancer and what risky behaviors to avoid. In addition, volunteers provide SunWise materials and information to schools and encourage teachers and administrators to join the SunWise Program. The committee's efforts have been tremendously successful. Not only has the program been highlighted on the news several times and won the prestigious Health Awareness Promotion (HAP) award, but its message has reached an incredible number of students.

The program got its start in 1999 when a group of dermatologists from the Ohio Medical Association passed a resolution to teach students throughout the state about the hazards of the sun and tanning salons. Volunteers from the Montgomery County Medical Alliance decided to take action on the resolution.

When the committee read about the SunWise Program in a newspaper article and used SunWise materials, it succeeded in attracting schools to the idea.

For more information about RAYS, send an e-mail to <RAYSTASKFORCE@aol.com>.

Center for Creative Learning, St. Louis, Missouri

For the past 4 years, students at the Center for Creative Learning in Missouri's Rockwood School District have learned about ozone depletion, sun safety, and skin cancer prevention. As part of their SunWise participation, students in Dottie Fundakowski's class have conducted videoconferences with EPA SunWise staff, allowing them to interact with a scientific expert. In addition to answering specific questions posed by the students, SunWise staff reminded students of their responsibility to protect their skin and eyes from UV radiation.

Two of Dottie's students even launched their own skin cancer awareness campaign as their final class project. The project, called "Got Sunscreen?" after the "Got Milk?" advertisements, was presented to parents, school administrators, and community experts. The two students designed T-shirts emblazoned with their campaign name and filmed a commercial showing the benefits of using sunscreen.

In addition, two other students of Dottie's petitioned the Rockwood School Board in an effort to change the district policy to allow students to carry and apply sunscreen at school, for example, during recess or on outdoor field trips. Sunscreen technically is considered an over-the-counter drug, similar to aspirin or cough drops, and in most state school districts, they are prohibited from student use without doctors' and parents' permission to allow nurses or aides to administer them. The two students pointed out that if it is difficult to use sunscreen, fewer students will apply it, and the risk for skin damage will increase. The students presented their case well, and the Rockwood School policy now allows students to apply sunscreen while on school grounds. They received national press coverage for their efforts.

Central Middle School, Tinley Park, Illinois

A group of Illinois students recently discovered that asking the right questions can also save lives. Debbie Brennan, the learning coordinator at Central Middle School in Tinley Park, Illinois, works with the top 5 percent of the seventh and eighth grade students as part of the school's gifted program. Brennan practices "inquiry learning," a loose system that allows students to ask questions about a topic of their choice and conduct activities to answer them.

"A few years ago in May, a group of my students noticed some high school kids lined up outside a tanning salon in preparation for their prom," Brennan said. "I overheard them complaining that tanning causes skin cancer, and I asked them how they knew for sure." To find the answer, the students began a research project on the effects of exposure to ultraviolet (UV) radiation. Not long after that, Brennan discovered EPA's SunWise Web site. She began working with EPA to create activities based on SunWise materials that fit the Illinois state learning standards, incorporating language, fine arts, science, and math.

For many of their activities, the students conduct both group and individual research and then find creative ways to share what they learn. One part of their research effort was to contact the American Cancer Society, which sent them information, bookmarks, and stickers related to sun safety. Brennan has also forged relationships with a local oncologist and a Chicago-based meteorologist, both of whom are available to answer students' questions.

To share what they learned, the students created flyers on sun safety and distributed them to local youth sports teams. The students also decorated and gave away visors and bandanas with UV-sensitive paint and performed experiments by applying sunscreen to necklaces they made from UV-sensitive beads. As part of a long-term activity, the students monitor and chart daily local UV intensity. The students also share their information by writing articles for the school newsletter, posting articles and notices on a school bulletin board, and posting information on their Web site <www.ccsd146.k12.il.us/central/projects.html>.

Science Explorer Program, University of Colorado at Boulder

For the University of Colorado at Boulder's (CU's) Science Explorer Program, teachers and students put new science curricula to the test. In a series of 30 one-day workshops held throughout the state, Colorado and New Mexico teachers and students tried out new science lessons focused on ground-level and stratospheric ozone, as well as UV radiation.

Teams comprised of one teacher and five students, from fifth through eighth grade, participated in three 75-minute classes throughout the workshops. Each class featured a variety of ozone-related, hands-on lessons; for example, the teams searched for ground-level ozone by using Schoenbein paper—a special paper made of cornstarch, distilled water, and potassium iodide—which turns blue or purple when in contact with ozone.

In another activity, students and teachers learned about the effects of stratospheric ozone depletion—such as increased UV radiation reaching Earth's surface. Using color-changing, UV-sensitive Frisbees, the teams evaluated the effectiveness of various sun-protection materials, including sunscreen, sunglasses, and fabrics. The teams also constructed chemical models of ozone molecules out of gumdrops and toothpicks. Studying the conditions of Antarctica, over which an ozone hole exists, is another topic for curricula activities. After participating in the Science Explorer activities, students and teachers took their new knowledge and materials back to their classrooms to share with fellow students and colleagues.

Designed to encourage student interest and aptitude in science, math, and technology in Colorado and the West, the CU-Boulder Science Discovery Program has been operating the Science Explorer Program for 15 years, introducing new curricula to about 300 teachers each year.

For more information about CU's Science Explorer program, contact Lannie Hagan at 303 492-0771.

Goddard Middle School, Glendora, California

Students in Glendora, California, are using technology to explore the science behind SunWise. Greg Morrison's science class at Goddard Middle School uses many tools, including the Internet, CD-ROMs, videos, and laboratory experiments to collect, report, and analyze UV-related data. In a favorite class activity, students use hand-held UV monitors, available from EPA, to measure the intensity of UV rays at ground level. After gathering this data, the students can upload their results to the SunWise Web site.

With the help of the local Rotary Club's Teacher Mini Grant Program, Morrison runs another popular experiment using UV-sensitive beads to teach students about the sun's UV rays and the effects of UV radiation on human skin and health. Outside, students observe the beads changing from clear, light colors to darker colors, corresponding to the strength of the sun's UV rays. The students then examine and record the effectiveness of different types of sun protection, covering the beads with sunscreens of various SPF levels, sunglasses, wet and dry clothing, and plastic.

In addition, Morrison uses video tapes of national newscasts about the ozone layer, which further demonstrate the scope and breadth of the subject. All these sun-science activities and students' work are featured on Morrison's class Web site, <www.morrisonlabs.com>.

Appendix D: How Is the UV Index Calculated?

The UV Index is calculated by collecting data on stratospheric ozone levels and forecasted cloud amounts and then transforming these data into a useful metric that describes how intense the next day's UV radiation will be.

The calculation begins with measurements of current total stratospheric ozone levels for the entire globe, obtained via two satellites operated by the National Oceanic and Atmospheric Administration (NOAA). These data are then used to produce a forecast of stratospheric ozone levels for the next day for various cities in the United States.

Next, a mathematical model is used to determine the amount of UV radiation expected to reach the Earth's surface based on the forecasted stratospheric ozone levels. This mathematical model—a radiative transfer model—takes into account the time of day, latitude of the city, and day of the year, and then determines the expected UV levels for wavelengths measuring 290 nanometers to 400 nanometers.

Because some UV wavelengths are more dangerous to human skin than others, another mathematical function is used to apply a greater emphasis or weight to the magnitude of the more dangerous UV wavelengths than the less dangerous UV wavelengths. The weighted UV wavelength levels are then integrated together to produce a new value that represents how dangerous the UV radiation is to human skin.

Cloud cover and elevation affect the level of UV radiation reaching the Earth's surface, so another calculation is made to take these factors into account. Cloudier skies limit the amount of UV radiation reaching the surface, and cities at higher elevations receive more UV radiation. (Although atmospheric pollutants, haze, and surface reflection (e.g., from sand, water, or snow) also affect the level of UV exposure, the UV Index currently does not account for these effects).

Lastly, to obtain the UV Index, the adjusted value is scaled down by dividing it by a conversion factor and rounding this number to the nearest whole number. Note: the UV Index is calculated differently in different countries around the world. This section only represents how the United States calculates the UV Index.

Each year, the National Weather Service (NWS) gathers data on the level of UV radiation reaching the Earth's surface to measure the accuracy of the UV Index. Several government agencies, private companies, hospitals, and universities collect and provide these surface UV data to NWS, which then conducts statistical analyses of the data to determine discrepancies. These validations have shown that the UV Index forecast is quite accurate.

Surface UV data are often collected using Brewer spectrophotometers. These monitoring devices are automated instruments that can infer the amount of total ozone in the stratosphere based on measurements of the UV radiation that reaches the Earth's surface. To ensure that all UV monitoring devices are taking similar and accurate measurements, NOAA's Central UV Calibration Facility compares UV readings from different monitoring devices and calibrates the devices as needed based on recommendations from the National Institutes of Standards and Technology.

Appendix E: Examples of UV Monitoring Networks and Scientific Studies in the United States

The National Oceanic and Atmospheric Administration monitoring and satellite equipment used for collecting data to help calculate the UV Index (see Appendix D: How is the UV Index Calculated?) is just one of several UV monitoring networks in the United States. A number of government agencies, universities, and institutions have developed other UV monitoring networks to study the effects of UV radiation on human health, ecological processes, wildlife, and climate. These data are sometimes publicly available on the Internet.

University of Georgia (UGA)/EPA Monitoring Network or UV-Net Program

The UGA/EPA Monitoring Network is used to validate the UV Index. This network consists of 21 monitoring devices located in 14 different national parks and 7 urban areas across the country. See <www.epa.gov/uvnet/> for more information and to access data.

Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet)

PRIMENet is a joint EPA/National Park Service program to assess the effects of environmental stressors, including UV radiation, on ecological systems nationwide. The UGA/EPA Monitoring Network's 14 monitoring devices are located in national parks and are used in PRIMENet. A major research aim of PRIMENet is to investigate the effects of UV radiation on frogs and other amphibians. For general information on PRIMENet, see <www2.nature.nps.gov/ard/prime/index.htm>. For information on PRIMENet amphibian studies, see <www2.nature.nps.gov/ard/prime/primeres.htm>.

U.S. Department of Agriculture (USDA) UV-B Monitoring Program

The USDA UV-B Monitoring Program uses a network of 36 monitoring devices located throughout the United States, including Hawaii and Alaska. These monitors quantify the atmospheric effects that influence UV radiation and assess the potential impacts of increased UV radiation levels on agricultural crops and forests. For more information and to access data, see <http://uvb.nrel.colostate.edu/UVB/>.

National Science Foundation (NSF) Polar UV Monitoring Network

The NSF Polar UV Monitoring Network includes six monitoring devices that measure UV spectral irradiance at the polar regions. These data are used by researchers studying the effects of ozone depletion on terrestrial and marine biological systems. For more information and access to data, see <www.biospherical.com/nsf/index.asp>.

Appendix F: Frequently Asked Questions

Q: Why is overexposure to the sun dangerous?

A: The sun emits powerful ultraviolet (UV) radiation that can cause a number of health problems as a result of overexposure. In addition to causing sunburn, UV radiation can cause health problems that might not become apparent until many years after sun exposure. These problems include skin cancer, premature aging of the skin, cataracts, and suppression of the immune system.

Q: Is skin cancer a significant problem in the United States?

A: Skin cancer is the most common form of cancer in the United States. In addition, the incidence of malignant melanoma, the most dangerous form of skin cancer, is increasing more quickly in the United States than for any other form of cancer. Although skin cancer can usually be cured if detected and treated early, if detected late or left untreated, skin cancer can cause considerable damage, disfigurement, and even death.

Q: If I have darker skin, do I still need to be concerned about skin cancer?

A: Although the incidence of skin cancer is lower in people with darker skin, the disease can still occur and often is not detected until it has reached a later, more dangerous stage. In addition to skin cancer, overexposure to the sun can cause other health problems in all populations, regardless of skin type. These include cataracts, premature aging of the skin, and immune suppression.

Q: How is the ozone layer related to UV radiation and skin cancer?

A: The ozone layer serves as a shield in the upper reaches of the atmosphere to protect the Earth from most of the UV radiation emitted by the sun. In recent years, scientists have documented seasonal depletions of the ozone layer over Antarctica, the Arctic, and mid-latitude regions such as North America. Because the depletion of the ozone layer allows more UV radiation to reach the Earth's surface, scientists are concerned that this phenomenon might create an increased threat to human health.

Q: What's causing ozone layer depletion and how can it be fixed?

A: Scientists have determined that a variety of synthetic halocarbon chemicals, such as chlorofluorocarbons, are responsible for depleting the ozone layer. Countries around the world have recognized this threat and signed a treaty—the Montreal Protocol on Substances that Deplete the Ozone Layer—to reduce the global production of ozone-depleting substances. With full compliance from participating countries, the ozone layer should be restored by the middle of the 21st century. Until that time, increased levels of UV radiation will reach the Earth's surface.

Q: How can I prevent the health problems associated with overexposure to UV radiation?

A: A number of sun-safe behaviors can help reduce the risks associated with overexposure to UV radiation. These include:

- Limiting your time in the sun between 10 a.m. and 4 p.m.
- Seeking shade whenever possible.
- Using a broad-spectrum sunscreen with a SPF of at least 15.
- Wearing a wide-brimmed hat and if possible, tightly woven, full-length clothing.
- Wearing UV-protective sunglasses.
- Avoiding sunlamps and tanning salons.
- Watching for the UV Index daily and taking appropriate precautions based on the Index level.

In addition, by educating children and others in your community, you can help them understand the risks of overexposure to UV radiation and can encourage them to adopt sun-safe behaviors as well.

Q. When I go out in the sun, my skin tends to tan, not burn. I like the way a tan looks, but is this safe for my skin?

A: There is no such thing as a healthy suntan. Any change in your natural skin color is a sign of skin damage. Every time your skin color changes after sun exposure, your risk of developing sun-related ailments increases.

Q: What is the UV Index and where can I find it?

A: Developed by the National Weather Service and EPA, the UV Index provides a daily forecast (on a 0 to 10+ scale) of the expected intensity of UV radiation from the sun and helps people determine appropriate sun-safe behaviors. The lower the number, the less UV radiation is reaching the Earth's surface. Lower numbers occur during overcast conditions or early and later in the day, while higher numbers occur during clear or partly cloudy conditions and in the middle of the day. The Index considers many factors, including latitude, day of the year, time of day, ozone, elevation, and predicted cloud conditions at solar noon. You can determine the UV Index for your ZIP code by accessing the following Web site at <www.epa.gov/sunwise/uvindex.html>.

Q: What is SunWise?

A: SunWise is a UV risk education program created by EPA to teach elementary and middle school students about the science of UV radiation and sun-safe behaviors. Schools participating in SunWise receive a variety of ready-made educational materials and gain access to the SunWise Internet database where students can enter and view UV measurement data. In addition to sponsoring classroom and schoolwide activities, SunWise schools are encouraged to form community partnerships and organize sun-safe events. For more information, visit <www.epa.gov/sunwise>.

Q: How do I get SunWise educational materials?

A: Join SunWise by signing up through the SunWise Web site at <www.epa.gov/sunwise/join.html>.

Q: Why does SunWise focus on children and schools?

A: Children spend many hours outdoors during recess, physical education classes, after-school activities, and sports programs. As a result, most of the average person's lifetime sun exposure occurs before the age of 18. Schools and teachers can play a major role in protecting children from overexposure to UV radiation by teaching sun-safe behaviors.

Q: In addition to SunWise, are there any other UV risk education programs that I could join?

A: In addition to SunWise, a number of local, state, and national UV risk education programs exist. See Appendix B: Case Studies of UV Risk Education Programs, for information on some of these programs. You can also contact your local or state health department for more information.

Appendix G
Glossary

Basal Cell Carcinoma: Skin cancer tumors that might appear as slow-growing, translucent, pearly nodules, which can crust, discharge pus, or even bleed. These tumors typically develop where you are most exposed to the sun—on the face, lips, tops of ears, and hands.

Chlorofluorocarbons (CFCs): Stable, low-toxic, and inexpensive chemicals that were most commonly used as refrigerants, solvents, and aerosol propellants until scientists discovered their destructive power. When strong UV radiation breaks down CFCs, they release atomic chlorine, which accelerates the natural destruction of ozone and contributes to ozone depletion. Nations around the world have agreed to reduce and eventually eliminate production of CFCs.

EMPACT: Environmental Monitoring for Public Access and Community Tracking, a program begun by EPA in 1996, helps communities collect, manage, and distribute environmental information, providing residents with up-to-date and easy-to-understand information they can use to make informed, day-to-day decisions.

Melanoma: The most fatal form of skin cancer. Malignant melanomas can appear suddenly without warning as a dark mole or other dark spot on the skin and can spread quickly.

Montreal Protocol: The Montreal Protocol on Substances that Deplete the Ozone Layer is an agreement adopted by international governments in 1987 to reduce and eventually eliminate the emissions of human-made ozone-depleting substances such as chlorofluorocarbons. The agreement has since been strengthened four times as scientists discovered the severity of ozone depletion.

National Weather Service (NWS): Government agency that provides weather, hydrologic, and climate forecasts and warnings for the United States. NWS issues the UV Index daily.

Ozone Depletion: Acceleration of the natural process of destroying and regenerating stratospheric ozone caused by human-made chemicals such as chlorofluorocarbons. The ozone found in the upper atmosphere (stratosphere) is destroyed and regenerated naturally, but certain human-made chemicals accelerate this process and damage the protective ozone layer. As this ozone layer breaks down, it absorbs smaller amounts of UV radiation, allowing the UV radiation to reach the Earth.

Spectrophotometer: An instrument for measuring the relative intensities of light in different parts of the spectrum. Scientists use spectrophotometers to measure the amount of UV radiation reaching the Earth.

Squamous Cell Carcinoma: Skin cancer tumors that might appear as nodules or red, scaly patches, which can develop into large masses and spread to other parts of the body.

Stratosphere: Portion of the atmosphere extending from about 10 km to about 50 km above the Earth. The stratosphere includes the stratospheric ozone layer, which absorbs most of the sun's harmful rays.

Stratospheric Ozone: A bluish gas composed of three oxygen atoms. Found in the upper atmosphere, it helps shield the Earth from the sun's UV radiation. Natural processes destroy and regenerate ozone in the atmosphere. When ozone-depleting substances such as chlorofluorocarbons accelerate the destruction of ozone, there is less ozone to block UV radiation from the sun, allowing more UV radiation to reach the Earth.

Sunscreen: A substance, usually a lotion, that is applied to skin to protect it from UV radiation. Sunscreen protects by reflecting UV radiation away from skin and by absorbing UV radiation before it can penetrate your skin.

SunWise School Program: EPA program that aims to teach grades K-8 school children and their caregivers how to protect themselves from overexposure to the sun. The program raises children's awareness of stratospheric ozone depletion and ultraviolet radiation, and encourages simple sun-safety practices.

SunWise Partner Schools: Participants in the SunWise School Program receive materials and tools for students to actively learn about the health and environmental effects of the sun. Schools sponsor cross-curricular classroom lessons, including measuring and posting UV Index measurements on the Internet.

UV Index: A tool developed by the National Weather Service that predicts the next day's UV intensity on a scale from 0 to 10+, helping people determine appropriate sun-protective behaviors. The lower the number, the less amount of radiation is reaching the Earth's surface. Based on this number, people should take appropriate sun-safe precautions.

UV Monitoring Networks: Combination of ground-based and satellite data monitoring stations that track changes in the ozone layer around the world and help validate the UV index. Using scientific data gathered by monitoring networks, scientists study a wide variety of health and environmental effects of UV radiation on humans, crops, forests, and ecological processes on land and in water.

UV Radiation: A portion of the electromagnetic spectrum with wavelengths shorter than visible light. UV radiation produced by the sun is responsible for sunburn and other adverse health effects. Scientists classify UV radiation into three types: UV-A, UV-B, and UV-C.

Environmental Curricula Handbook: Tools in Your Schools

EMPACT

Environmental Monitoring for Public Access & Community Tracking

Disclaimer

This document has been reviewed by the U.S. Environmental Protection Agency (EPA) and approved for publication.

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Environmental Curricula Handbook: Tools in Your Schools

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Contents

1.0 Introduction

Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, Tbilisi Declaration, 1978).

1.1 What Was EMPACT?

The U.S. Environmental Protection Agency (EPA) created the Environmental Monitoring for Public Access and Community Tracking (EMPACT) program to take advantage of new technologies that make it possible to provide environmental information to the public in near real-time. EPA partnered with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) to help achieve nationwide consistency in measuring environmental data, managing the information, and delivering it to the public. Through the use of grants, EMPACT helped local governments build monitoring infrastructure in metropolitan areas across the country, addressing questions such as:

- What is the ozone level in my city today?
- How is the water quality at the beach today?
- What is the UV Index in my area today?

EMPACT projects aim to help communities:

- Collect, manage, and distribute time-relevant environmental information.
- Provide their residents with easy-to-understand, practical information they can use to make informed, day-to-day decisions.

Some projects were initiated directly by EPA; others were launched by communities with the help of EPA-funded "Metro Grants." EMPACT projects helped local governments build monitoring infrastructures and disseminate environmental information to millions of people.

EMPACT projects have been initiated in 156 metropolitan areas. These projects cover a wide range of environmental issues, such as groundwater contamination, ocean pollution, smog, and overall ecosystem quality. Having met the program goals, EMPACT ended in 2001. Many projects continue to provide realtime environmental information to local residents.

Recognizing that educating our youth is vital to the future of our planet, many EMPACT projects have incorporated curricula- or school-based components. The curricula are hands-on in their approach and complement the objectives of their associated EMPACT projects. Therefore, the activities and lessons either involve the utilization of monitoring data collected under a particular project or encourage student monitoring to assist project efforts.

1.2 What Is the Purpose of This Handbook?

This handbook is designed to provide teachers and other educators with guidance on how to teach students about environmental issues related to air, water, and soil quality. It provides information to help educators incorporate environmental education into the classroom. The handbook is organized as follows:

- **Chapter 2: How Do EMPACT Programs Work in Schools** discusses why environmental education is important, how to incorporate the lessons and ideas highlighted in this handbook into age-appropriate curricula, and how to identify quality environmental education materials.
- **Chapter 3: Teaching the Teacher–How Do I Make an EMPACT on My Students?** provides background information on air, water, and soil and why we should be concerned about the quality of these substances.
- **Chapter 4: Air-Based Projects** covers the air-based EMPACT projects and their curriculum components.
- **Chapter 5: Water-Based Projects** covers the water-based EMPACT projects and their curriculum components.
- **Chapter 6: Land-Use and Soil-Based Projects** covers the land- and soil-based EMPACT projects and their curriculum components.

This handbook can assist educators in designing lesson plans and activities to teach the principles of environmental science. It highlights a host of EMPACT projects that have developed or are developing curricula or other classroom materials to foster student learning. The highlighted projects cover a variety of grade levels (see Appendix C: Activities by Grade Level). Therefore, this handbook can be used by any teacher, from kindergarten through grade 12. In addition, college-level materials have been developed for some projects. Moreover, in most cases, the activities and lessons geared towards one particular grade can easily be adapted for others. Teachers and educators can review the project descriptions and read about the activities, lesson plans, and tools they employ to develop ideas for their own classrooms. In addition, the handbook includes resources and contact information and in some cases a Web site where lesson plans and activities can be accessed directly.

This handbook also references supplementary sources of information, such as Web sites, publications, organizations, and contacts, that can help the user find more detailed guidance. (See Appendix A: Additional Resources)

2.0 How Do EMPACT Programs Work in Schools?

2.1 Environmental Education—Why Teach Students About the Environment?

Environmental information is important because it affects our daily lives. For example, if you know the air quality is poor on a particular day, you might choose to skip your daily jog or exercise early in the morning when air quality is usually better. Environmental education typically incorporates aspects of economics, culture, politics, and social equity, as well as natural processes and systems. Teaching young people about the environment can help them see the many ways in which people affect the world around them by their actions today, which have consequences for the future health of the environment.

Environmental education can foster in children of all ages an awareness and sensitivity to the natural world, inspiring students to increase their knowledge of the environment, identify environmental challenges, and become motivated about resolving these challenges.

Learning about environmental challenges can also show students first-hand how their individual and collective actions can affect their own health, the environment, the country, and society as a whole. As a result, learning about the environment can help young people make informed day-to-day decisions, influence their peers and caregivers, and grow up to be better citizens.

2.2 Lesson Creation 101—How to Incorporate EMPACT Lessons and Ideas Into Age-Appropriate Curricula

The EMPACT tools described in this handbook use real-time technologies to help develop children's research and reasoning skills. Lessons focus on inquiry-based, hands-on learning. Students not only learn about environmental issues but also are encouraged to explore how feelings, experiences, attitudes, and perceptions influence these issues. This type of teaching helps students develop

Reducing the Risks

Children can be exposed to a number of environmental hazards in their homes, schools, and playgrounds—from tobacco smoke to lead-based paint. Environmental education can help raise teacher, parent, and student awareness of these risks, thereby helping to reduce children's exposure to these hazards over time.

For example, asthma is currently the most common chronic childhood illness in the United States. Over the past 15 years, major advances have been made in understanding the complex interplay between asthma, environmental exposures, and other factors.

This knowledge is helping pediatricians, schools, children, and their caregivers take steps to not only mitigate asthma triggers, but also to learn how to manage this illness on a day-to-day basis (i.e., on high ozone days, asthmatics should not play outside).

the critical-thinking, problem-solving, and team-working skills needed in today's technology- driven world.

EMPACT lessons typically use hands-on, laboratory-based approaches, such as those favored by groups like the National Science Teachers Association (NSTA) and the National Science Foundation (NSF). As such, they often fit best in a science curriculum, but they are also often multidisciplinary, so that the lessons can be incorporated into many different subject areas.

While science forms the foundation for many of the EMPACT lessons in this handbook, social science, health, language arts, math, and other subjects are also covered, as they are critical to fully understanding environmental issues and their impacts on society. (See Appendix D: Activities by Subject.)

For example, the Northeast Ohio (NEO) EMPACT project teaches students about air quality and urban sprawl through a set of 10 hands-on exercises and science experiments. Also included in the lessons are activities that develop language arts skills, such as composing a letter about acid rain for local legislators or completing air quality word searches and crossword puzzles.

The tools referenced in this handbook also serve a range of ages and grades. EMPACT lessons at the primary grades are designed so that younger children can explore the environment and learn basic concepts. At the higher grades, children perform increasingly more sophisticated experiments and data gathering and interpreting tasks.

For example, in the ECOPLEX curriculum (K-8), kindergartners take ultraviolet-sensitive beads outside to see how the beads change colors, thereby discovering where and when the sun's ultraviolet rays are strongest. At the third grade level, students use construction paper and colored pattern blocks to learn how oxygen is converted to ozone. Eighth graders learn how chlorofluorocarbons (CFCs) contribute to ozone depletion through chemistry experiments that demonstrate how compounds separate in a chemical reaction.

A number of the EMPACT tools described in this handbook teach global issues via a local or regional environmental problem; others have a national scope, and some projects reinforce the national scope by enabling students to exchange data and observations with other classrooms across the country.

Finally, most EMPACT lessons have been developed with the help of both technical and curriculum experts, ensuring their accuracy and applicability to state and national education standards.

2.3 Making the Grade—How to Identify and Use Quality Environmental Education Materials

EMPACT tools, like all quality environmental education materials, encourage exploration. Acquiring information changes from a static to active learning process. Students participate in defining goals, gaining knowledge, and presenting results in a variety of formats.

How can schools recognize and use quality environmental education materials? According to the North American Association for Environmental Education

(NAAEE), quality environmental education materials should possess six key characteristics, as listed below. It is useful for educators to be aware of these characteristics and to reinforce them in the classroom when teaching students about the environment.

#1 Fairness and accuracy. Environmental education materials should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them. Materials should have factual accuracy, a balanced presentation of differing viewpoints and theories, openness to inquiry, and reflection of diversity.

#2 Depth. Environmental education materials should foster awareness of the natural and built environment, an understanding of environmental concepts, conditions, and issues, and an awareness of the feelings, values, attitudes, and perceptions at the heart of environmental issues, as appropriate for different developmental levels. Materials should focus on concepts that are set in a context that includes social and economic as well as ecological aspects and demonstrate attention to different scales.

#3 Emphasis on skills building. Environmental education materials should build lifelong skills that enable learners to prevent and address environmental issues. Materials should encourage the use of critical thinking and creative skills. Students should learn to arrive at conclusions about what needs to be done based on thorough research and study and should gain basic skills to participate in resolving environmental issues.

#4 Action orientation. Environmental education materials should promote civic responsibility, encouraging learners to use their knowledge, personal skills, and assessments of environmental issues as a basis for environmental problem solving and action. Materials should instill a sense of personal stake, responsibility, and self-efficacy.

#5 Instructional soundness. Environmental education materials should rely on instructional techniques that create an effective learning environment. Instruction should be learner-centered—materials should offer different ways of learning, and there should be a connection to everyday life. In addition, learning should occur in environments that extend beyond the boundaries of the classroom, and materials should recognize the disciplinary nature of environmental education. The goals and objectives of the materials should be clear, the materials should be appropriate for specific learning settings, and they should include a means for assessing learner progress.

#6 Usability. Environmental education materials should be well designed and easy to use. Materials should be clear and logical to both educators and learners, inviting and easy to use, long-lived, adaptable, and accompanied by instruction and support. In addition, materials should make substantiated claims and fit in with national, state, or local requirements.

For more information on NAAEE's *Environmental Education Materials: Guidelines for Excellence*, visit <www.naaee.org>.

3.0 Teaching the Teacher: How Do I Make an EMPACT on My Students?

3.1 Air

Why should we be concerned about air quality?

Air quality in many U.S. cities is being degraded by human activities such as driving, chemical manufacturing, the burning of fossil fuels, and other industrial and commercial operations. Air pollution also comes from smaller, everyday activities such as dry cleaning or filling your car with gas. As more people drive vehicles, require more electricity, and conduct other activities, more gases and particles are added to the air we breathe. This pollution can reach levels dangerous to humans and the environment.

While air pollution poses a health risk to all humans, it is especially dangerous for children and people with respiratory illnesses. The biggest air pollution-related health threat to children is asthma. Other problems associated with high levels of air pollutants, such as ozone, include irritated eyes or throat or breathing difficulties. Air pollution also contributes to acid rain, smog, haze, and climate change, all of which can drastically affect the environment.

Why should we be concerned about ultraviolet (UV) radiation?

The sun produces three types of UV radiation, much of which is absorbed by the Earth's atmosphere. However, UVA and some UVB are not absorbed and can cause sunburns and other health problems. UV radiation exposure has been linked to health effects including: skin cancers such as melanoma; other skin problems such as premature aging; cataracts and other eye damage; and immune system suppression. Many of these problems, however, can be prevented with proper protection from UV radiation.

Additional EPA resources

- EPA's Office of Air and Radiation: <www.epa.gov/oar/>.
- EPA's Clean Air Markets Web site has information on acid rain: <www.epa.gov/airmarkets/acidrain/index.html>.
- EPA's Office of Transportation and Air Quality has information on air pollution caused by mobile sources: <www.epa.gov/otaq/>.
- EPA's SunWise School Program has information on UV radiation and sun protection: <www.epa.gov/sunwise>.
- EPA's Web site for teachers: <www.epa.gov/teachers>.
- EPA's Air Web site for kids includes information, activities, and games about various issues: <www.epa.gov/kids/air.htm>.

3.2 Water

Why should we be concerned about water quality?

Perhaps the most important problem facing U.S. water bodies today is nonpoint source (NPS) pollution—pollution from many diffuse sources as opposed to one distinct source. NPS pollution is caused by rainfall or snowmelt picking up, carrying, and eventually depositing pollutants into lakes, rivers, wetlands, coastal waters, or underground sources of drinking water. These pollutants include: fertilizers, pesticides, and animal wastes from agricultural lands and residential areas; oil, grease, salts, and toxic chemicals from urban runoff; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks; minerals from abandoned mines; bacteria and nutrients from livestock, pet wastes, and faulty septic systems; and atmospheric deposition, such as acid rain.

Urban runoff can pose a dual threat to water quality. Natural areas such as forests and wetlands absorb rainwater and snowmelt so that it slowly filters into the ground, reaching waters gradually. In contrast, urban landscapes contain nonporous surfaces like roads, parking lots, and buildings that cause runoff containing toxic oil and grease to increase. Adding to this problem are storm sewer systems that channel large volumes of quickly flowing runoff into a water body, eroding streambanks and damaging streamside vegetation. Native fish and other aquatic life cannot survive in urban streams because of the urban runoff.

Another type of NPS pollution, acid rain deposition, also greatly impacts freshwater environments. When the rate of acids entering lakes and streams is faster than the rate at which the water and surrounding soil can neutralize it, the water becomes acidic. Increased acidity and its associated chemical reactions are highly toxic to many species of fish, insects, plants, and other aquatic species.

NPS pollution has led to beach closures, unsafe drinking water, fish kills, and other severe environmental and human health problems. For example, a large increase of nitrates in drinking water can pose a threat to young children, causing a condition known as "blue baby syndrome." If left untreated, the condition can be fatal. Even adults can be affected by continuous exposure to microbial contaminants at levels over EPA's safety standards. When this occurs, people can become ill, especially if their immune systems are already weak. Examples of the chronic effects of drinking water contaminants are cancer, liver or kidney problems, or reproductive difficulties.

Additional EPA resources

- EPA's Office of Water homepage: <www.epa.gov/OW/index.html>.
- EPA's Office of Water Nonpoint Source Pollution page: <www.epa.gov/owow/nps/>.
- EPA's Office of Water Quality page: <www.epa.gov/ow/national/>.
- EPA's Web site for teachers: <www.epa.gov/teachers>.

3.3 Soil and Land

Why should we be concerned about soil quality?

Soil contamination is a result of either solid or liquid hazardous substances mixing with the naturally occurring soil. Plants can be damaged when they take up contaminants through their roots. Contaminants in the soil can adversely impact the health of animals and humans when they ingest, inhale, or touch contaminated soil, or when they eat plants or animals that have been exposed to contaminated soil. Animals ingest and come into contact with contaminants when they burrow in contaminated soil. Humans can be exposed to toxic elements when they farm, handle, and distribute food and non-food crops. Young children are especially at risk when they play, ingest, or dig in contaminated soil. Certain contaminants, when they contact our skin, are absorbed into our bodies. When contaminants are attached to small surface soil particles they can become airborne as dust and can be inhaled.

Soil contamination can be caused by industrial and chemical byproducts seeping into the soil, spreading metallic substances such as lead, chromium, arsenic, and cadmium. This contamination can also occur from lead-based paints, irrigation, solid waste disposal, fertilizers, and pesticide application. Leaded paint continues to cause most of the severe lead poisoning in children in the United States. It has the highest concentration of lead per unit of weight and is the most widespread of the various sources, being found in approximately 21 million pre-1940 homes. Dust and soil lead—derived from flaking, weathering, and chalking paint—plus airborne lead fallout and waste disposal over the years, are the major sources of potential childhood lead exposure.

Why should we be concerned about land resources?

One of the most pressing land issues in America today is urban sprawl. Sprawl is “the unplanned, uncontrolled spreading of urban development into areas adjoining the edge of a city” (Source: Dictionary.com). This translates to a conversion of rural areas, such as forests and farmlands, into single family homes and strip malls. This type of development uses land inefficiently and increases vehicle miles traveled as people spend more time commuting to and from work.

Another issue affecting American landscapes is that of brownfields and Superfund sites. Superfund is a program administered by EPA to clean up areas where the dumping of chemical and other hazardous wastes might be affecting public health and the environment. Brownfields—abandoned or underutilized industrial or commercial properties with possible environmental contamination—are one type of Superfund site. The cleanup and possible development of brownfields will remove environmental hazards from, and increase the economic well-being of many communities.

Additional EPA resources

- Information on EPA’s Superfund Program: <www.epa.gov/superfund/index.htm>.
- Extensive information on brownfields, urban redevelopment news, and resources: <www.brownfields.com>.
- The Trust for Public Land, an organization devoted to land conservation: <www.tpl.org>.
- Information on brownfields on EPA’s Web site: <www.epa.gov/swerosps/bf/index.html>.

4.0 Air-Based Projects

4.1 Teacher Tips

Local air quality affects how we live and breathe. Like the weather, it can change from day to day or even hour to hour. EPA and other organizations make information about outdoor air quality as available to the public as information about the weather. A key tool in this effort is the Air Quality Index (AQI). EPA and local officials use the AQI to provide the public with timely and easy-to-understand information on local air quality. The AQI tells the public how clean or polluted the air is and what associated health concerns they should be aware of. The AQI focuses on health effects that can happen within a few hours or days of breathing polluted air. EPA uses the AQI for five major air pollutants regulated by the Clean Air Act—ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect against harmful health effects. The AQI uses a scale of values to indicate the level of health concern and associated color-coded warning. Many EMPACT projects that focus on air quality involve monitoring and collecting near real-time data for the AQI pollutants. In addition, some air projects monitor data related to ultraviolet (UV) radiation, due to its association with stratospheric ozone depletion. For more information on the AQI, go to <www.epa.gov/AIRNow>. For more information on UV radiation and stratospheric ozone depletion, go to <www.epa.gov/ozone>.

Air Quality Index (AQI)*

AQI Number	Health Concern	Color Code
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for sensitive groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very unhealthy	Purple

*Although ozone reports are primarily made for metropolitan areas, ozone can be carried by the wind to rural areas, where it can cause health problems.

The following are the most common pollutants for which air data is monitored and collected and a description of why the information is important. Throughout this section of the handbook you will read about how this air quality data plays a role in various EMPACT curricula.

- **Ozone (O_3):** Ozone is an odorless, colorless gas composed of three atoms of oxygen. It occurs both in the Earth's upper atmosphere (the stratosphere) and at ground-level. The ozone in the stratosphere is considered "good" ozone because it forms a protective layer that shields us from the sun's harmful UV rays. This ozone is gradually being destroyed by manmade chemicals, such as chlorofluorocarbons. A tool called the UV Index measures the intensity of the sun's rays and can help you plan outdoor activities safely.

  At ground level, ozone is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight. Ground-level ozone is unhealthful and is especially problematic during summer months when it is sunny and hot. Ozone can irritate the respiratory system, causing coughing, throat irritation, and/or an uncomfortable sensation in the chest. High risk groups include children or anyone who spends a lot of time outdoors in warm weather and people with respiratory diseases.

- **Particulate matter:** Particulate matter (PM) includes both solid particles and liquid droplets found in the air. Many manmade and natural sources emit PM directly or emit other pollutants that react in the atmosphere to form PM. These particles range in size, with those less than 10 micrometers in diameter posing the greatest health concern because they can be inhaled and accumulate in the respiratory system, causing health problems. Particles less than 2.5 micrometers in diameter are referred to as "fine" particles, and sources include all types of combustion. Particles between 2.5 and 10 micrometers are consider "coarse," and sources include crushing or grinding operations and dust from roads. Coarse particles can aggravate respiratory conditions such as asthma, and exposure to fine particles is associated with several serious health effects, including premature death.

- **Carbon monoxide:** Carbon monoxide (CO) is a colorless, tasteless, odorless gas that forms when the carbon in fuels does not completely burn. The major sources of CO pollution include cars, trucks, and buses; airplanes; trains; gas lawnmowers; snowmobiles; power plants; trash incinerators; and wildfires. CO concentrations are usually highest during cold weather because cold temperatures make combustion less complete and cause inversions that trap pollutants low to the ground. When CO is breathed, it replaces the oxygen that we normally breathe, which deprives the brain and heart of this necessary element. As a result, when exposed to CO, a person might notice shortness of breath or a slight headache. People with cardiovascular disease are most sensitive to risk from CO exposure, and in healthy individuals, exposure to higher levels of CO can affect mental alertness and vision.

- **Sulfur dioxide:** Sulfur dioxide (SO_2) is a colorless, reactive gas that is produced during the burning of sulfur-containing fuels such as coal and oil, during metal smelting, and by other industrial processes. Major sources include power plants and industrial boilers. Children and adults with asthma who are active outdoors are most vulnerable to the health effects of SO_2. The primary response to even a brief period of exposure is a narrowing of the airways, which may cause symptoms such as wheezing, chest tightness, and shortness of breath. When exposure ends, lung function typically returns to normal within an hour. At high levels, SO_2 may cause similar symptoms in non-asthmatics.

- **Nitrogen dioxide:** Nitrogen dioxide (NO_2) is a reddish-brown, highly reactive gas formed when nitric oxide combines with oxygen in the atmosphere. Once it has formed, NO_2 reacts with volatile organic compounds (VOCs), eventually resulting in the formation of ground-level ozone. Major sources of NO_2 include automobiles and power plants. In children and adults with respiratory disease, such as asthma, NO_2 can cause respiratory symptoms such as coughing, wheezing, and shortness of breath. In children, short-term exposure can increase the risk of respiratory illness.

4.2 The Tools

4.2.1 AirBeat (Roxbury, Massachusetts)

Introduction

The AirBeat EMPACT project centers around an air monitoring system—the first of its kind in Massachusetts. The monitoring system, which is sustained by a collaboration of universities, governments, and community organizations, enables residents to check real-time air pollution levels via a telephone hotline or the AirBeat Web site at <www.airbeat.org>. AirBeat measures ground-level ozone and fine particle pollution and focuses on reducing the health effects they have on Roxbury residents, who suffer from high rates of asthma and other respiratory illnesses.

Lessons, Tools, and Activities

Part of the outreach for AirBeat involves educating teachers and students about air quality and its health and environmental effects. Alternatives for Community and Environment (ACE)—a local nonprofit organization—integrated air monitoring into its environmental justice curriculum for local schools by developing an air quality flag warning system that is managed by a local school. Students use AirBeat data to assess air quality on a daily basis and hang flags that correspond to air quality at two locations. The flags advise Roxbury residents about air quality so they can take precautions if they suffer from asthma or other illnesses.

ACE also visits classrooms to administer its air pollution curriculum module, which includes these lessons:

- *How to Build Your Own Black Carbon Monitor*, adapted from the Lawrence Berkeley National Laboratory, teaches students to build a black carbon monitor from commonly available items and analyze its measurements.
- Students distribute the *Survey of Air Pollution Awareness* to local residents, then analyze the results to gauge residents' knowledge of air pollution and asthma.

Resources

For more information, contact Jodi Sugerman-Brozan of Alternatives for Community and Environment at 617 442-3343, ext. 23, or <jodi@ace-ej.org> and visit the AirBeat Web site at <www.airbeat.org>, where the above lessons can be downloaded.

4.2.2 Air CURRENTS (New York and New Jersey)

Introduction

Air CURRENTS is a curriculum designed to educate middle and high school students about air, air pollution, and air monitoring techniques. The project's name, which stands for Collaboration of Urban, Rural, and Regional Environmental Networks of Teachers and Students, reflects its focus on teachers, students, and learning. The curriculum emphasizes a hands-on, problem-solving approach, after which students implement what they've learned to make changes in the community or region. Teachers and students, in collaboration with community groups, use a portable air monitoring system to do outdoor air monitoring studies in their schools and communities. However, the curriculum can be taught with or without employing the air monitor.

The goal of the Air CURRENTS project is to provide the tools and information necessary for students, teachers, and community-based groups to obtain a general assessment of the air quality in their neighborhoods. Additional goals of the Air CURRENTS program are to integrate environmental learning into core math, science, and social studies curricula; engage students and teachers in scientifically meaningful air monitoring projects; use the Internet to connect participating schools to one another and to resources for air quality and health effects information; and work with schools to aid in developing a community understanding of the complexities of local environmental problems.

The development of the Air CURRENTS curriculum was a collaboration of state and federal agencies, universities, community-based organizations, and educators. The project was managed by Northeast States for Coordinated Air Use Management (NESCAUM), whose purpose is to exchange technical information and to promote cooperation and coordination of technical policy issues among member states. EPA provided a portion of the funding through the EMPACT program to bring the Air CURRENTS curriculum to four EMPACT cities: Buffalo and Brooklyn, NY, and Camden and Newark, NJ.

Lessons, Tools, and Activities

The Air CURRENTS curriculum helps students in grades 6 through 12 understand the causes, consequences, and political complexities of managing air quality. The curriculum is extensive. It contains over 30 consecutive lessons that complete what the Air CURRENTS educators refer to as the full "Science-Technology-Society" (STS) circle. Students complete the STS circle in three steps: (1) gain an understanding of the scientific concepts related to air quality through hands-on laboratory investigations; (2) collect and analyze data after mastering the use of an air quality monitor; and, (3) take appropriate social advocacy actions to support their data and conclusions. Educators believe that since the curriculum actively engages students in a process, it allows them to intimately understand various points of view, so they can create a well-informed opinion about air quality issues for themselves.

The first part of the curriculum introduces important concepts about air—proving that it exists and can be measured, even though students cannot see it.

Students learn about particulate matter and gases such as carbon monoxide. Lessons in the first section provide the conceptual framework for the use of the portable monitor in the second section. Students learn to operate and collect indoor and outdoor air quality data using the ACCESS™ (A Computerized Community-based Environmental Sampling System) portable air quality monitor. After developing a scientific hypothesis and testing it by collecting air quality data using the ACCESS system, students then analyze their data and develop reports describing their findings. While the Web site was active, students posted data files or reports on the Air CURRENTS Web site to share with other students. Students can create a report from a downloaded data file by using the ACCESS™ software from PAX Analytics. Finally, students learn a series of lessons in science, social studies, language arts, math, and arts to complete an advocacy program they could undertake in their community.

Although the curriculum is designed to be used with a portable monitor, the monitor is not required, and segments of the curriculum offer valuable lessons by themselves. The Air CURRENTS curriculum can be taught by a team of teachers across disciplines, but has the flexibility to be taught by science or social studies teachers alone. At the middle school level, the most effective model for this curriculum is where students have designated times for subject areas. At the high school level, teachers have worked in teams of two, either team teaching or working in a parallel model. The environmental sciences are the obvious choices for these curricula, where it can be a self-contained two- to three-month unit, but schools have implemented it into American government, economics, and technology courses.

The Air CURRENTS curriculum utilizes a constructivist approach, which requires teachers to foster an environment for inquiry-based learning. The constructivist approach is based on the premise that human nature dictates that we construct our own understandings of the world in which we live. This approach allows students to actively interact with objects and ideas to test their own preconceptions; then, through reflection of those interactions, develop an understanding. Teachers should establish cooperative learning groups, in which the constructivist model works well. Cooperative learning creates a structured natural environment that promotes collaboration. The teacher, or facilitator in this approach, floats from group to group, to provide guidance as well as ask thought-provoking questions that may encourage their investigations. Students who are exposed to the constructivist model should be given time and space to reflect. Therefore, teachers should encourage students to keep ongoing journals and have an opportunity to reflect on, modify, and redesign their investigations while they are not actively involved in them.

Resources

For more information, or to order a copy of the Air CURRENTS curriculum, contact Susan Green at NESCAUM at 617 367-8540. The NESCAUM Web site <www.nescaum.org> has additional information but does not offer the curriculum for downloading. NESCAUM exchanges technical information and promotes cooperation and coordination of technical policy issues regarding air quality control among member states. They sponsor air quality training programs, participate in national debates on air quality, assist in the exchange of information, and promote research.

The Air CURRENTS Web site <www.aircurrents.org> identifies partners and provides a form for completing the project plan, which can be submitted for review.

4.2.3 Air Info Now: Environmental Monitoring for Public Access and Community Tracking (Pima County, Arizona)

Introduction

The Air Info Now project provides current air quality information for the metropolitan Tucson area. The Web site <www.airinfonow.com> was developed under an EMPACT grant along with assistance from the University of Arizona, The American Lung Association, and the Pima Association of Governments. The project site provides information on air pollutants, their health effects, activities to help in understanding air pollution, and historic and current monitoring data.

Tucson, Arizona, is an urban area with a strong public appreciation for and commitment to the surrounding natural environment. The public has shown increasing concern over air pollution, both in terms of individual health and potential environmental impacts in the mountains and high desert lands that are valued locally and worldwide for their pristine condition. Many residents move to the area to alleviate health problems, and therefore, the area has a higher than average percentage of residents who are sensitive to air pollutants. In addition, there are economically disadvantaged areas within the city that have higher documented rates of asthma in children, so the timely dissemination of air pollution data is especially important.

The overall objective of the Air Info Now project is to produce media and public communication programs about air quality, the Tucson environment, health concerns, and local solutions to improve air quality. Other objectives of the project include the following:

- Collecting and disseminating accurate, understandable, and timely air pollution information.
- Expanding associated outreach and education programs to improve understanding of the relationships between air quality, climate, and health effects.
- Allow the community to address local air pollution problems and solutions based on credible scientific information.

The project employs 80 instruments at 18 air monitoring sites throughout the Tucson metropolitan area. In addition to monitoring carbon monoxide, ground-level ozone, sulfur dioxide, nitrogen oxides, and particulate matter (PM10 and PM 2.5), for which EPA has National Ambient Air Quality Standards, the project monitors various meteorological parameters that affect air pollution. These parameters include wind speed, wind direction, temperature, relative humidity, and UV radiation.

Lessons, Tools, and Activities

The Air Info Now project has developed several sets of activities and experiments designed to teach students about pollution prevention, the relationship between air quality and health, and data analysis. The classroom activities offer older students the opportunity to study the health risks that come from ambient airborne pollution in Tucson. The Web site also includes accompanying teacher guides.

Activities (Grades 7 to 12):

Through real-time data collection activities, students learn to analyze and interpret the real-time air quality data that is collected and displayed by the Air Info Now project site. Pollutants investigated include ground-level ozone, carbon monoxide, and particulate matter, and parameters include weather and climate (temperature, wind, rainfall), asthma attacks, visibility, time, and location. Students learn data collection and analysis techniques through practice with Excel spreadsheets and principles of statistics. Students are separated into groups, each representing a different aspect of air pollution. For example, one group represents "location" and tries to identify pollution trends according to location around a city. Another group represents "health effects," and they monitor the occurrences of asthma at several schools to see if there is a correlation with air pollution.

Students regularly share their data with their classmates and summarize their findings in a final paper or project that can be shared with the community.

Experiments (Grades 4 to 12):

Students construct and deploy particulate pollution detectors to test hypotheses: for example, older vehicles and those using leaded or diesel fuel will produce more particulate matter emissions. Students learn to identify gaseous and solid pollutants in the atmosphere; observe an experiment that illustrates how to capture particulate pollutants and identify which vehicle emits more pollutants; and conduct an experiment capturing particulate pollutants and determine which locations appear to have more pollution.

Students make smog in a shoe box or aquarium to demonstrate convection currents and temperature inversion layers and discuss the implications for pollution. They also monitor their family's energy consumption, calculate the amount of carbon dioxide produced, and discover how changes in consumption can affect the amount of pollution and greenhouse gases released.

The Air Info Now Web site also includes several online interactive games for kids that require Macromedia Flash Player.

Resources

For additional information on the Air Info Now project in Pima County or the associated student activities and teacher guides, contact Beth Gorman at Pima County Department of Environmental Quality (PDEQ), 520 740-3343 or <bgorman@deq.co.pima.az.us>. You can download the student activities and experiments, as well as the teacher guides, directly from the Air Info Now Web site at <www.airinfonow.com>. Click on Activities for online games and experiments, and click on Teachers for the data collection activities and teacher guides.

4.2.4 AIRNow (National)

Introduction

Through its Web site, the AIRNow program offers access to daily air quality forecasts as well as real- time air quality data for over 100 cities across the United States. While many EMPACT programs provide the public with easy access to local air quality information, the AIRNow Web site was developed by EPA to offer real-time air quality information for both regional and local areas across the United States and parts of Canada. For example, color maps show ozone levels across a specific regional geographic area. Plus, AIRNow displays air quality forecasts (good, moderate, unhealthy for sensitive groups, unhealthy) for "air action days" in major metropolitan areas around the country. Users can view local or regional air quality information such as ozone maps and air quality forecasts and learn more about how they should adjust their outdoor activity level when air quality is forecast to be poor. The Web site links to more detailed state and local air quality Web sites.

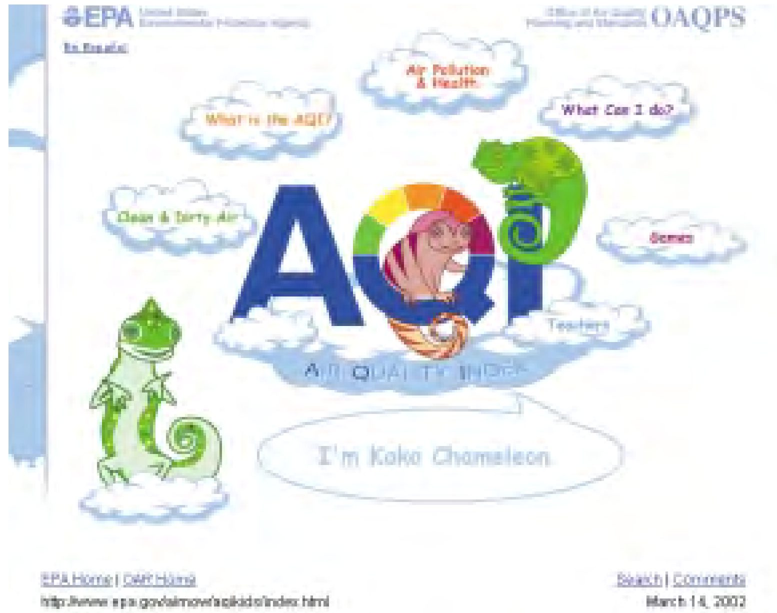
A central component to the daily air quality forecast is the Air Quality Index, or AQI. (See Section 3.1 for more on AQI.) The AIRNow Web site uses the AQI categories, colors, and descriptors to communicate information about air quality. Increasingly, TV, radio, and newsprint forecasters are providing information using the AQI. During summer months, for example, you may learn that it is a code red day for ozone, meaning the air quality is unhealthy. But how do you know what this means? Parents can learn by visiting the AIRNow Web site and reading about the AQI. To help teach children how to read and understand the AQI, the Web site offers an online and downloadable curriculum for school-aged children.

Lessons, Tools, and Activities

The AIRNow curriculum is geared toward children 7 to 10 years old. EPA developed more ozone segments for the 2002 ozone season (May through October), aimed at those 5 to 6 years old, as well as those 7 to 10 years old. A Spanish version of the current curriculum was launched in March 2002.

The AIRNow lessons can be used online or teachers can print a text version of the Air Quality Index Kid's Web site and curriculum for classroom use. The kids page includes two animated online games that can also be printed. The animated version requires a Flash 5 plug-in player, which is available on the Web site.

Lessons (Grades 2 to 5):



The Kids section of the AIRNow Web site is hosted by an animated trio of chameleons: K.C. Chameleon, Koko Chameleon, and Kool Chameleon. Kids navigate through four topic areas, learning about the AQI, clean and dirty air, and how health is affected by breathing dirty air. By viewing an animated cartoon, kids learn that ozone is formed by a combination of pollution and sunlight. They also learn where soot and dust come from and how particulate matter is formed. Once they learn about pollutants and how they affect our bodies, they learn how EPA and local governments present this information to the public using the AQI.

By navigating different parts of the AIRNow Web site, kids find the AQI forecast and an ozone map for their area. They learn the numbers, colors, and words that the AQI uses to describe air quality. By learning to identify groups that are sensitive to ozone—asthmatics, children, and the elderly—they can read an AQI forecast and understand what those groups should do differently on poor air quality days. Finally, kids learn what they can do to reduce pollution and improve air quality.

As kids navigate, they have the opportunity to explore and further their learning. As they encounter new words, each page links to a dictionary of air pollution related words such as "global", "pollution", and "smog". They also learn where on the Web site they can view ozone maps covering their local area. The Web site includes two games: AQI Color Game and the AQI Game Show. The AQI color game contains three levels of difficulty, from the easier word and color connecting game, to the more challenging game, in which an AQI numerical value is given and kids must look up the corresponding color.

In the AQI Game Show, three chameleons play the contestants, answering multiple choice questions about AQI and health. Kids click on the chameleon with the correct answer, and the game automatically keeps score. The online version includes 10 questions and the printed version includes 27 questions. The answers are provided and both games can be downloaded and played on hard copies.

From the AIRNow Web site, teachers can print colorful posters for each of the five most common color codes of the AQI. For each color code, one of the chameleons tells kids what level of outdoor activity is recommended for them that day. The posters will print in color on a color printer. For schools without color printers, a good exercise could be to color the posters the correct color. Teachers can contact the AIRNow program to request color copies.

Resources

For more information on AIRNow, contact John E. White of EPA at 919 541-2306 or at <white.johne@epamail.epa.gov>. The entire curriculum can be downloaded from the AIRNow Web site at <www.epa.gov/airnow/aqikids/teachers.html>.

4.2.5 Community Accessible Air Quality Monitoring Assessment (Northeast Ohio)

Introduction

The Northeast Ohio (NEO) EMPACT project focuses on developing an improved air monitoring data and network system and creating a land-use data and ecological computer modeling tool. The latest technology provides communities with real-time air quality reports. These help citizens make informed decisions on everyday quality of life issues such as environmental and health concerns that accompany urban living and growth. The NEO EMPACT air quality project also conducts community outreach to inform citizens about NEO air quality programs and resources.

Lessons, Tools, and Activities

As part of the NEO EMPACT project, a handbook was developed to introduce teachers and students to the importance of understanding air quality in their communities. Air Quality in Northeast Ohio is arranged in thematic and developmental order to provide students with a comprehensive understanding of air quality and its effects on health and the environment.

The 85-page handbook for educators and 4th through 8th grade students includes detailed background information, lessons, and activities focused on air quality. It progresses from conceptually developing an understanding of air quality to discussing concrete actions students and teachers can take to improve air quality. The main sections of the handbook include:

- **Educator's Notes** includes background information that prepares educators to administer the lessons and exercises in the handbook. The section describes air pollution, its origins, and its health and environmental effects. It also contains information on the Clean Air Act, specific pollutants (e.g., carbon monoxide, particulate matter), acid rain, and the effects that vehicles and weather have on air quality.

- The 10 **Experiments and Exercises** give students hands-on lessons in air quality. Geared towards specific grades, the exercises and experiments cover air quality vocabulary, visible and invisible air pollutants, smog, air pollution's effects on plants, and air quality data analysis and tracking.

- The **Internet-based Activities** teach students to access NEO EMPACT air quality data online.
- The **Air Quality Activities** focus on developing students' oral, visual, and writing skills. Activities include conducting a mock interview with an environmental professional, writing a clean air bill, composing a letter about acid rain for local legislators, completing air quality word searches and crossword puzzles, and designing air quality posters for display in the community.
- **Reducing Air Pollution—What Students Can Do** offers teachers and students some suggestions for reducing air pollution in the local community and at home.
- **Air Quality Resources and Materials for Educators** lists additional Internet, hard copy, and organizational resources for air quality information. It also includes ideas for no-cost educational materials and how to obtain them.

Resources

To obtain a free copy of the NEO Air Quality Curriculum Handbook, contact Adam Zeller of the Earth Day Coalition at 216 281-6468 or <azeller@earthdaycoalition.org>. For more information on the NEO EMPACT project, visit the NEO EMPACT Web site at <http://empact.nhlink.net> or the Northeast Ohio Air Quality Online Web site at <http://neoair.noaca.ohiou.edu>.

4.2.6 ECOPLEX (Dallas-Ft. Worth, Texas)

Introduction

Through the use of both innovative and proven environmental monitoring technologies, the ECOPLEX project collects real-time and time-relevant environmental data that informs citizens of the Dallas-Ft. Worth metropolitan area of current, historical, and near real-time forecasts of environmental conditions. The project involves a multimedia approach, collecting data related to air, water, soil, and weather. The data, as well as instructions on how to use it, are posted on the project's Web site at <www.ecoplex.unt.edu>.

Lessons, Tools, and Activities

As part of the ECOPLEX project, curricula were developed covering the topics of ultraviolet (UV) radiation, water quality, and water quantity. (See Section 5.0 Water-Based Projects for information on ECOPLEX water lessons.) The curricula are geared towards kindergarten through 8th grade and were completed in August 2001. Approximately 120 teachers in 37 schools have utilized the lesson plans included in the curricula.

Each lesson plan includes follow-on curriculum extensions, which explore the disciplines of math, language arts, technology, art and music, science, and social studies.

The air portion of the ECOPLEX curriculum introduces students to the dangers of UV rays and the connection to stratospheric ozone. Through simple, yet progressively challenging experiments, lessons, and activities, children in grades kindergarten through 3 learn ways to protect themselves from harmful UV rays and to develop a daily routine of UV protection, similar to brushing their teeth. Students learn about the shadow rule—if your shadow is taller than you, UV exposure is usually low, and if it is shorter than you, UV exposure is usually high—and ways to identify sun-safe areas on the playground. They are introduced to the ECOPLEX Web site and learn how to read the UV Index. Children witness how UV rays are affected by the time of day and the seasons, and they learn to identify the layers of the atmosphere, discussing how stratospheric ozone is depleted. They develop plans for reducing their personal exposure to UV rays and set goals for how they can reduce the formation of ground-level ozone.

Students in grades 4 through 6 learn that stratospheric ozone blocks UV rays and that certain materials deplete this type of ozone. Using the UV meter, students determine the dangers due to UVA and UVB and measure UV levels throughout the day. Then they create a comparison between the UV meter readings and ECOPLEX UV data over a period of time, graphing the results. Students explore the electromagnetic spectrum, finding where UV light fits in, and they view the refraction of light using a prism, identifying the invisible rays: infrared, heat waves, and UV rays. Using bacteria culture, students observe which types of light best prevent bacteria growth. With their findings, students create an informative brochure to distribute to family and friends.

In grades 7 through 8, the ECOPLEX curriculum helps students understand how the angle of the sun on earth affects temperature. They conduct light experiments using a flashlight on a world map to mimic the sun on the earth, and they record their estimations of direct and indirect solar energy, demonstrating how direct solar energy is affected by the seasons and the time of day. Children learn about how chlorofluorocarbons (CFCs) destroy ozone through chemistry experiments and they become aware of how the use of certain products releases CFCs into the atmosphere.

Resources

For more information on the ECOPLEX UV curriculum, contact Ruthanne (Rudi) Thompson at <rudi@unt.edu> or 940 565-2994 and visit the ECOPLEX Web site at <www.ecoplex.unt.edu>. Click on the Teacher's Corner to download lessons as PDF files.

4.2.7 SunWise School Program (Nationwide)

Introduction

The SunWise School Program is a national environmental and health education program that aims to teach children in grades kindergarten through 8 and their caregivers how to protect themselves from overexposure to the sun. Through the use of classroom-based, school-based, and community-based components, SunWise seeks to develop sustained sun-safe behaviors in schoolchildren and foster an appreciation of the environment around them.

The program's leading components build on a solid combination of traditional and innovative education practices already in use in many U.S. elementary and middle schools. Through the program, students and teachers increase their awareness of the harmful effects of ultraviolet (UV) radiation and learn simple ways to protect themselves and their family. Children will also acquire scientific knowledge and develop an understanding of the environmental concepts related to sun protection.

The program encourages schools to implement a sun-safe infrastructure, including shade structures, such as canopies and trees, and policies, such as using hats, sunscreen, and sunglasses on a regular basis. Designed to provide maximum flexibility, the SunWise program elements can be used as stand-alone teaching tools or to complement existing school curricula. Registering to become a SunWise school can easily be accomplished on the SunWise Web site at <www.epa.gov/sunwise>.

Lessons, Tools, and Activities

A useful resource for SunWise school partners is the SunWise Tool Kit, which contains cross-curricular lessons and background information for kindergarten through 8th grades. The Tool Kit consists of a variety of fun, developmentally appropriate activities that combine education about sun protection and the environment with other aspects of learning. The SunWise Web site, a very helpful tool, provides downloadable information, storybooks, and activity books, some of which are available in Spanish. The SunWise curriculum includes age-appropriate, progressively challenging material to teach students of all levels the importance of sun protection.

Younger students in kindergarten through 2nd grade are introduced to the concept of UV rays and their potentially harmful effects, and they begin to learn simple ways to protect themselves from the sun. They make wacky sunglasses out of paper and cellophane in various colors to emphasize the importance of wearing sunglasses. Educators tell fun stories and legends about the sun and play interactive games like "Sunny Says," following the format of "Simon Says." Students learn which products at the store are sun safe, and they participate in activities such as shadow tracing, which introduces the importance of the "No shadow, seek shade" rule. Using maps, magazines, and photos of various places and peoples around the world, children learn that numerous societies practice sun safety in a variety of ways.

Intermediate students in 3rd through 5th grades perform word games such as word scrambles and crossword puzzles using keywords that emphasize sun safety and protection. The SunWise Tool Kit provides a special UV sensitive frisbee that changes color when exposed to UV radiation. As an experiment, students place different materials, such as tanning lotion and sunscreen, onto the frisbee and expose it to the sun. The students watch as the unprotected portions of the frisbee change color and the protected areas remain the same; they then record their findings on a data chart. Students have the opportunity to go on the

Internet and discover the variety of existing sun myths, understanding how different cultures perceive the origins and history of the sun. They learn the difference between "good" and "bad" ozone, and perform experiments such as witnessing the sun's effects on fruit and newspapers. They assess the risk factors of their own skin and put on a SunWise fashion show, identifying the differences between sun safe and unsafe clothes.

Students in grades 6 through 8 perform numerous activities that correspond to a variety of subjects. They brainstorm, using their creativity and imagination to write songs, public service announcements, and news stories exploring the risks of UV exposure. They create a puppet show to teach younger school kids about protecting themselves from the sun. They act as architects and submit a design proposal for a new SunWise playground. Through Internet searches, students deepen their understanding of the various cultures and myths around the world, going on virtual vacations, picking destinations and identifying sun safe items to pack in their suitcases. They research skin cancer statistics and interpret their findings state by state. They pretend they are Galileo or Copernicus and write journal entries about their beliefs and what the future will be like. Seasonal Affective Disorder (SAD), the disorder applied to people who suffer depression during winter, is explored and discussed, and students reexamine the benefits and the risks of sun exposure.

Resources

For additional information on the SunWise School Program, visit <www.epa.gov/sunwise> or contact Kristin Kenausis of EPA at 202 564-2289. Only K-8 schools who register for the program can receive the Tool Kit, but many other educational materials and publications are available for downloading from the Web site or from the clearinghouse (800 490-9198). Visit the "Publications" page on the SunWise Web site for more details.

5.0 Water-Based Projects

5.1 Teacher Tips

Scientists that study lakes and reservoirs—limnologists—are interested in obtaining data for several water quality parameters. Many of these parameters can be measured remotely, without having to bring samples to a laboratory for analysis. The following are the most common parameters for which data is collected and a description of why the information is important. Throughout this section of the handbook you will read about how this water quality data is utilized in various EMPACT curricula.

- **Chlorophyll:** Chlorophyll are complex molecules found in all photosynthetic plants, including aquatic plants called phytoplankton. Chlorophyll allows plants to use sunlight as part of their metabolism. The distribution and concentration of phytoplankton is of major water quality and ecologic concern. Certain inputs of critical plant nutrients, such as phosphorus, can lead to excess concentrations of phytoplankton. Because the amount of phytoplankton affects the clarity and color of water in lakes and reservoirs, it is of concern to scientists and environmental managers. The most common method of determining the amount of phytoplankton in a body of water is to measure chlorophyll concentration, which is done either by using an analytical/instrumentation technique (e.g., spectrophotometer, fluorometer, high-pressure liquid chromatography) on filtered samples or using fluorescence technology, which allows for semi-quantitative measurement of chlorophyll in phytoplankton cells without extraction or chemical treatment, thereby allowing in situ (in-lake) measurements.

- **Turbidity:** Turbidity refers to the extent that water lacks clarity. It is therefore, tightly linked with the aesthetics and perception of water because the public wants water of high clarity for recreation. Turbidity is caused by a mixed population of suspended particles, which may include clay, silt, finely divided organic matter (detritus), phytoplankton, and other microscopic organisms. In general, these particles are a composite of sediments received from inflowing tributaries, resuspended sediments, and particles produced within the body of water (particularly phytoplankton). Thus, the variations in measured turbidity may reflect the dynamics of phytoplankton growth as well as tributary runoff (driven by rainfall events). Until recently, turbidity was measured using a nephelometer, where a beam of light is directed along the axis of a cylindrical glass cell containing the sample. Light scattered by particles from the beam is measured by a detector. New technology has led to the development of turbidity probes that can be constructed on remote sampling units. These probes are constructed in a similar manner as the nephelometer, except that the scattered light detector is located within the water as opposed to outside a glass sample cell.

- **Temperature:** Temperature is a measure of molecular vibrational energy. It has extremely important ecological consequences. Temperature exerts influence on aquatic organisms with respect to selection and occurrence and level of activity of the organism. In general, increasing water temperature results in greater biological activity and more rapid growth. All aquatic organisms have a preferred temperature in which they can survive and reproduce optimally. Temperature is also an important influence on water chemistry, as rates of chemical reaction increase with increasing temperature. Temperature regulates the solubility of gases and minerals (solids)—warm water contains less dissolved oxygen and more solids than cold water. Thermal stratification refers to the layering that occurs, particularly in the warm months. Typically, a warmer, less dense layer called the epilimnion overlies a colder, denser layer called the hypolimnion. In between these two layers is a third layer called the metalimnion where strong differences in temperature and density exist. Seasonal changes cause mixing of the layers. Usually, a thermometer is used to determine temperature, although when taking measurement below the surface, methods such as thermocouples and thermistors can be used. A thermocouple measures the current generated by two different metals at different temperatures. A thermistor measures voltage produced by a semi-conducting material that decreases in resistance with increasing temperature.

- **Conductivity:** Electrical conductivity is a measure of water's ability to conduct electricity, and is therefore a measure of the water's ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the conductivity. Wide variations in water temperatures affect conductivity, making it difficult to make comparisons of this feature across different waters, or changes in this parameter for a particular body of water. The use of specific conductance, which is the conductivity normalized to 25° C, eliminates this problem and allows comparisons to be made. Specific conductance is a reliable measure of the concentration of total dissolved solids (TDS) and salinity. It also is a valuable tracer of water movement. By definition, specific conductivity is the reciprocal of the specific resistance of a solution measured between two electrodes (opposite electrical charges) placed in the water. For a known electrical current, the voltage drop across the electrodes reveals the water's resistance. Since the resistance of aqueous solution changes with temperature (resistance drops with increasing temperature), the resistance is corrected to the resistance of the solution at 25°C.

- **Dissolved Oxygen:** The concentration of dissolved oxygen (DO) is probably the single most important feature of water quality, as it is an important regulator of chemical processes and biological activity. Plant photosynthesis produces oxygen within the region below the water surface with adequate light. Microbial respiration and organic decay consume oxygen. At the surface, oxygen can move between the water and air, and the rate of exchange is dependent on wind speed and the surface water DO saturation. The saturation concentration of DO is regulated by temperature. Concentrations above the saturation value (supersaturation) indicate high photosynthetic activity, for example, during an algal bloom. Undersaturated conditions occur when oxygen-demanding processes exceed the sources of DO. DO is measured using a probe that consists of electrodes of opposing charges, which are separated from the surrounding water by a Teflon membrane. DO diffuses across the membrane and is reduced to hydroxide at the cathode and silver chloride is formed at the anode. The current associated with this process is proportional to the DO in the surrounding water.

- **pH:** pH is defined as - log [H+], where [H+] = concentration of hydrogen ions. The pH scale ranges from 0 to 14, corresponding to various degrees of acidity or alkalinity. A value of 7 is neutral; values below 7 and approaching 0 indicate increasing acidity (higher H+ concentrations), while values above 7 approaching 14 indicate increasing alkalinity. A wide range of pH values is encountered in different water bodies, associated primarily with the different ionic chemistries of the respective watersheds/tributaries. Inorganic carbon constituents are the major pH buffering system in most fresh waters. pH is an important regulator of chemical reactions and an important influence on aquatic biota (including composition). Photosynthetic uptake of CO2 tends to increase pH (e.g., during phytoplankton blooms) while decomposition/respiration tends to decrease pH. Values of pH are generally highest in the epilimnion and decline with increasing depth. Measuring pH involves taking an electrode consisting of a proton selective glass reservoir filled with a pH 7 reference solution. Protons interact with the glass, setting up a voltage potential across the glass. Since the H+ concentration of the reference solution does change, the difference between the voltage potentials is proportional to the observed pH.

5.2 The Tools

5.2.1 Boulder Area Sustainability Information Network (BASIN) (Boulder, Colorado)

Introduction

The Boulder Area Sustainability Information Network (BASIN) project is an EMPACT-funded project designed to help deliver a variety of environmental information about the Boulder area to its residents. BASIN's initial focus is on water in the region, including watershed and consumption issues. The objectives of the project include the following:

- To improve existing environmental monitoring to provide credible, timely, and usable information about the Boulder Creek Watershed to the public.
- To create a state-of-the-art information management and public access infrastructure using advanced, Web-based computer technologies.
- To build strong partnerships and an ongoing alliance of governmental, educational, nonprofit, and private entities involved in watershed monitoring, management, and education.
- To 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.

Lessons, Tools, and Activities

As part of the project, organizers adapted an existing online learning tool called the WatershED program, to the BASIN project Web site. Geared toward grades 4 through 12, WatershED aims to help teachers, students, and citizens in the Boulder area learn more about their local creeks and wetlands. It provides users with suggestions for what schools or neighborhood groups can do to preserve and protect local waterways and how they can become stewards of water resources.

The WatershED curriculum was developed by the Boulder Creek Initiative and the City of Boulder's Stormwater Quality Office with the help of teachers in the Boulder area. It was modified for students, teachers, and the general public for the BASIN Web site. The tool consists of a series of learning activities in addition to a Teacher's Guide.

The WatershED project can help participants:

- Get to know their watershed address as defined by creeks, wetlands, and lakes.
- Discover the plants, animals, and birds they might see in or around the creek or wetland in their neighborhood.
- Organize a StreamTeam to protect and enhance a local waterway.

The online resource includes background information on ecology and ecosystems and water quality. The activities cover the following topics, which are broken out by level of complexity as follows:

Introductory Level Activities:

- Water, Colorado's Precious Resource
- The Water Cycle
- The Boulder Water Story
- Water Law and Supply
- Water Conservation

Intermediate Level Activities:

- Stream Teams—An Introduction
- Mapping Your Watershed
- Watershed Walk
- Watershed Cleanup: A Treasure Hunt
- Storm Drain Stenciling
- Raise and Release: Aquarium Setup

Advanced Level Activities:

- Water Quality (Introduction)
- Phytoplankton—Trends & Diversity
- Nutrients: Building Ecosystems in a Bottle
- Macroinvertebrates—Long-term Ecosystem Health
- Stream Gauging: A Study of Flow
- Water Quality (Intermediate and Advanced)

Resources

For additional information on the WatershED online learning tool affiliated with the BASIN EMPACT Project, contact Curry Rosato at 303 413-7365 or Donna Scott at 303 413-7364. In addition, all the activities listed above are available online at <bcn.boulder.co.us/basin/learning/introduction.html>.

5.2.2 Burlington Eco Info (Burlington, Vermont)

The goal of the Burlington Eco Info EMPACT project is to provide the public with clearly communicated, real-time, useful, accurate environmental monitoring data in an ongoing and sustainable manner. The project is a 2-year pilot project that will enable residents and policymakers alike to have expanded access to important environmental information, providing for improved decision-making. The project's partners include the City of Burlington Community and Economic Development Office, the University of Vermont (UVM) School of Natural Resources, the Green Mountain Institute for Environmental Democracy, the Center for Lake Champlain (formerly called the Lake Champlain Basin Science Center), and the U.S. Environmental Protection Agency. The project's Web site provides information on the air, water, land, and energy in Burlington and the surrounding area. Visitors can learn about city beaches, view the daily air quality forecast, see a live image of the waterfront, or get data from a dust monitoring station.

Lessons, Tools, and Activities

Although the Burlington Eco Info project is multi-media in nature, the curriculum portion of the project focuses on water quality issues in the Lake Champlain Basin. Through its partnership with the Center for Lake Champlain, the project has incorporated an environmental monitoring program for grades 7 through 12. The program utilizes the UVM's Ecosystem Science Lab (Rubenstein Lab) to perform analyses. The purposes of the environmental monitoring program are the following:

- For students and teachers to participate in and perform authentic scientific research techniques in a university lab setting.

- To promote watershed awareness and action focusing on water quality issues in the Lake Champlain Basin.
- To collect data and allow teachers and students to become involved with local watershed resources with the goal of contributing data that meets EPA's standards for water quality testing.
- To build stronger connections between students and teachers and their local watersheds.

The Center for Lake Champlain markets the program to middle and high school science educators in Vermont and New York schools and organizations located in the Lake Champlain watershed. Interested educators sign up for a teacher training led by the Center staff. After the training, teachers begin the program by teaching water quality related scientific activities at their schools. Following these activities, the class collects local water samples and visits the Rubenstein Ecosystems Lab at UVM to process them. Teachers and students then return to their schools for completion of the processing of their data and other followup activities.

Pre-visit Activities at School

Prior to taking the water samples, students use activities provided by the program and/or found in existing curricula (This Lake Alive!, Project Wild, Project WET, Aquatic WILD, etc.) to get necessary lab skills and knowledge of ecological principles. Trained UVM Resource Assistants visit classrooms to go over safety procedures and understanding of watershed issues. An interactive watershed model is used to help students visualize watershed concepts. In addition, students explore the geography of the Lake Champlain Basin and study the properties of water (pH, water cycle, etc.) to build a stronger connection between the field, lab work, and environmental health. Finally, students generate a focus question for their study.

Field Work Component

Students and teachers collect water samples and other information from a local site of their choice according to established protocols. Teachers also have the option to add a waterfront field component to their class time spent with the Center staff. The 1-hour waterfront option explores "in the field" sampling techniques and includes parameters such as temperature, pH, dissolved oxygen, conductivity, and turbidity.

Rubenstein Lab Activities

In the lab, students perform high-level tests on the water samples they collect in the field. The data generated by the tests are sent to local, state, and federal databases. The first part of the lab activity begins with students practicing lab techniques using glass and plastic pipettes and droppers. Through simple activities, such as color mixing and water drops on a penny, students immediately become actively engaged in the learning process. More sophisticated water sample analysis follows, which includes phosphorous and bacteria testing and a slide presentation designed for the program.

To date, 28 educators from 16 different schools and organizations in the Champlain Basin have participated in the teacher workshop in preparation for bringing their classes to the Rubenstein Lab to conduct water testing, and 267 middle and high school students from 13 schools have participated in the environmental monitoring program. Through three postcard and flyer mailings sent during fall 2000, fall 2001, and spring 2002, the Center reached more than 750 Vermont and New York middle and high school educators.

The Center for Lake Champlain offers a Watershed Investigation Kit for interested teachers, which was not funded through EMPACT, but rather a different EPA grant. The Kit contains everything needed for a thorough water quality study, including books, articles, maps, posters, videos and CD-ROMs, flashcards, and sampling test kits and materials. The Kit is recommended for middle and high school students and for community groups to use in asking questions and discovering more about their place in the Lake Champlain watershed.

Resources

For additional information on the environmental monitoring curriculum offered by the Center for Lake Champlain in association with the Burlington Eco Info EMPACT project, contact Julie Silverman at 802 864-1848 or <juliesilverman@yahoo.com>, or Kara Lenorovitz at <klenorovitz@hotmail.com>.

5.2.3 ECOPLEX (Dallas-Ft. Worth, Texas)

Introduction

Through the use of both innovative and proven environmental monitoring technologies, the ECOPLEX project collects real-time and time-relevant environmental data that informs citizens of the Dallas-Ft. Worth metropolitan area of current, historical, and near real-time forecasts of environmental conditions. The project involves a multi-media approach, collecting data related to air, water, soil, and weather. The data, as well as instructions on how to use it, are posted on the project's Web site at <www.ecoplex.unt.edu>.

Lessons, Tools, and Activities

As part of the ECOPLEX project, curricula were developed covering the topics of ultraviolet (UV) radiation, water quality, and water quantity. (See Section 4.2.6 for information on the UV curriculum.) The curricula are geared towards kindergarten through 8th grade and were completed in August 2001. Approximately 120 teachers in 37 schools have utilized the lesson plans included in the curricula. Each lesson plan includes follow-on curriculum extensions, which explore the disciplines of math, language arts, technology, art and music, science, and social studies.

For kindergartners through 3rd grade, the ECOPLEX curriculum teaches students the quality, importance, and availability of water to life on earth. Students are introduced to the term "water quality" and learn the difference between drinking, fresh, and salt water. They learn how much of people's bodies and certain foods, such as fruit, consist of water. While visiting the ECOPLEX Web site to study water monitoring tests, students brainstorm ways to create good water quality. Students explore the dehydration process in foods, and they learn about precipitation, evaporation, and condensation, and how water can be a solid, liquid, or gas. Introduced to the concept of water conservation, children realize that the amount of water on earth is finite and that most of it is not available for public consumption. They discover how all the water we use is piped to a wastewater treatment system, so that it can be reused. They learn the differences between point and nonpoint source pollution and the physical and chemical aspects of water. And finally, they study the formation of reservoirs and lakes and discover the importance of wetlands as natural filters.

Intermediate students in 4th through 6th grades are introduced to the concepts of food webs and chains. Students learn how pollutants can enter water, affect aquatic organisms, and disrupt food chains. The curriculum covers topics such as groundwater and aquifer recharge, allowing students to discuss from where they get their water and chemical pollutants that cause serious concern, such as DDT, polychlorinated biphenyls (PCBs), and mercury. They discuss bioaccumulation and describe how DDT entered the eagle food chain. Water conservation is reemphasized, as students discuss ways that families can conserve. Students learn how aquatic organisms get oxygen, define photosynthesis and its reliance upon sunlight, and determine the effect of temperature on dissolved oxygen.

Older students in 7th and 8th grade further examine water quality by analyzing macroinvertibrates in the water. They learn that an ecosystem is a community of living and non-living components and that photosynthesis is important to both plants and animals. Students then conduct an experiment to see how fertilizers affect algae growth in bodies of water. Through collecting water samples from a local source, students record the numbers of macroinvertibrates and determine water quality. The ECOPLEX

WOW is highlighted in this handbook because of its affiliation with the Lake Access EMPACT project <www.nrri.umn.edu/empact>—in 2000, EMPACT funded the deployment of two additional RUSS units in Lake Minnetonka, a large, heavily used complex in the suburban Minneapolis area.

curriculum enables students to determine where their water comes from and the quantity of water used by individuals, families, and cities. Students learn about alternative solutions for future fresh water supplies, building upon previous lessons on the watercycle, watersheds, surface water, and fresh water conservation. Using world maps or globes, students discuss how water is redistributed around the globe via the watercycle, and they discuss the effects of population on water supplies and alternative solutions to collect and store water.

5.2.4 Lake Access (Water on the Web) (Minneapolis, Minnesota)

Introduction

Water on the Web (WOW) is a National Science Foundation-funded, award-winning, Internet-based science curriculum for high school and college level students. The project, operated by the University of Minnesota-Duluth's Natural Resources Research Institute, uses real-time, environmental lake data with the goal of equipping students with real world skills they can use in college and beyond. The program employs several remote underwater sampling stations, or RUSS units, in four Minnesota lakes and bays that represent a wide range in terms of size, depth, seasonal dynamics, and other characteristics. The RUSS units collect vertical profiles of temperature, dissolved oxygen, pH, conductivity, and turbidity every few hours and upload their data onto the WOW and Lake Access Web sites each morning.

WOW is based on real, scientific data, monitored and maintained by quality control protocols. Unlike canned data sets created to support a curriculum, the WOW data reflect the realities and complexities of real ecosystems, which means they do not often fit students' or teachers' preconceived ideas of how a lake behaves. WOW data are provided in several different formats in the data section of the WOW Web site. Raw data for a lake can be viewed in an archived data set. Weekly data sets can also be downloaded and reviewed in Excel spreadsheets, which also include graphing templates that assist students in plotting and understanding selected data. For many students, however, it is difficult to see and interpret patterns in numerical data, so WOW offers interactive data visualization tools. Some teachers use these tools to illustrate trends or relationships among the data, and other teachers have students explore the data using the tools. To provide students with the background information and context for understanding scientific data, the WOW Web site includes a variety of aids, including the following:

- Background information on each lake, its watershed, and its behavior during the period of sampling.
- A Lake Ecology Primer, which provides a context for understanding water quality parameters and how they relate to each other.

- A Geographic Information Systems (GIS) resource that describes the fundamentals of the technology.
- A section called "The RUSS," which provides students with an introduction to RUSS technology, WOW water quality measurements, reporting limits, and instrument accuracy.
- A glossary providing definitions of complex scientific terms.

Lessons, Tools, and Activities

The WOW curriculum provides a collection of individual, yet integrated, lessons designed to enrich and enhance student learning in general science courses. Most lessons appear in two different formats—a "Studying" lesson and an "Investigating" lesson. "Studying" lessons allow students to apply and learn concepts through direct, guided experiences. "Investigating" lessons provide students with opportunities to discover the same concepts and involve more solving. Each lesson is organized into a thinking framework of six sequential parts that are critical for improving scientific and technological literacy—knowledge base, experimental design, data collection, data management and analysis, interpretation of results, and reporting results. Using this format for scientific inquiry, teachers guide students through directed study or inquiry lessons depending on the students' abilities and the science curriculum.

Since the program's inception in 1998, several thousand students have used WOW and its materials. Students have learned the fundamentals of science based on real-time data, and teachers have been trained in advanced technology, including computerized mapping and modeling systems, remote sensing, instrumentation, and the use of the Internet.

A project is currently underway to create an online curriculum geared toward college students in 2- to 4-year institutions. This curriculum will serve as a capstone experience for students who are completing a technician program, or a gateway for students who are stimulated by the issues and interested in pursuing water science, water resource management, or environmental resource management degrees at four-year institutions. Students will learn and apply their knowledge and skills through inquiry-based problems derived from real-world, real-time data collected by state-of-the-art water quality monitoring technology. The curriculum will be designed as a two semester lab sequence, consisting of six key units

Messages from teachers indicate the WOW lessons and Web site are being used in a variety of ways. One teacher used a tutorial and lessons to help students learn how to work with spreadsheets. Another adapted a lesson on fish stocking to illustrate that organisms are limited by environmental factors. Still other teachers have chosen ideas from the lessons and Web site and created their own lessons based on WOW data and resources.

"I found the Water on the Web site to be of great value and interest to the students...It was a wonderful source of detailed information and provided the students with access to nearly real-time water quality data. I was able to use the information to devise very realistic problems for the students to work through and discuss."

—George W. Kipphut,
Murray State University, Kentucky

"Thank you for the wonderful data and project...This project puts symmetry on the year for us...The focus and quiet as they delve into the data and resources are great."

—Ilona Rouda,
The Blake School,
Minneapolis, Minnesota

that cover the range of knowledge and skills needed by future water science technicians. Each unit will consist of a series of 3 to 8 interactive modules that cover specific topics (e.g., the Data Analysis Unit will include Web-based modules on Exploratory Data Analysis, Trend Analysis, Spatial Analysis, and Modeling). The curriculum will receive extensive pilot and beta testing by a group of over 100 community college teachers and will be designed to be disseminated through a commercial publisher.

Resources

For more information on the WOW project and curricula, contact:

George E. Host, Ph.D.
Senior Research Associate
Biostatistics-Forest Ecology
University of Minnesota-Duluth Campus
Center for Water and the Environment
Natural Resources Research Institute
Phone: 218 720-4264
Fax: 218 720-4328
E-mail: <ghost@nrri.umn.edu>

or

Bruce Munson
University of Minnesota-Duluth Campus
Phone: 218 726-6324
E-mail: <bmunson@d.umn.edu>

WOW information and lessons are all downloadable from the project's Web site at http://wow.nrri.umn.edu/wow/.

5.2.5 Monitoring Your Sound (MY Sound) (Long Island Sound, New York)

Introduction

The MY Sound project provides real-time water quality monitoring data from Long Island Sound to a broad spectrum of users, including government, academia, industry, organizations, and the general public. The project recognizes that water quality in Long Island Sound is an issue that affects everyone, not just those who live along the coast. If water quality is poor, the value of the Sound as an economic, recreational, and natural resource decreases; if water quality is good, people use it and it is a vital resource. A major goal of the project is to enhance and broaden the user's appreciation, knowledge, and use of Long Island Sound. The project, which was coordinated by a stakeholder committee comprised of project partners and stakeholder representatives, uses the Internet, local media, information kiosks, orientation briefings, and printed material.

The project has established five water quality monitoring stations near New London and Bridgeport Harbors. The EMPACT focus areas include Bridgeport

Harbor and the greater CT-NY-Long Island metropolitan area. The monitoring stations collect data for the following parameters:

- Water temperature
- Conductivity/salinity
- Transmissivity
- Dissolved oxygen
- Nutrients/nitrate
- Chlorophyll
- Surface hydrocarbons
- Current speed and direction
- Selected meteorological parameters

Lessons, Tools, and Activities

At the time of publishing this handbook, the MY Sound project was developing curriculum support tools that can be used by teachers of environmental science, physics, and math courses. The materials will be geared toward students in grades 8 through 12. Specific components under development include:

- Fact sheets on topics related to the environmental health of Long Island Sound.
- Student exercises that use time series and statistical data on Long Island Sound phenomena to illustrate science and math principles and enhance knowledge of the Sound.
- Guided Internet explorations that lead teachers and students through key Web sites to investigate marine science topics.

Examples of future student exercises include:

- A Long Island Sound lobster mortality exercise that illustrates the use of statistics in investigating lobster population decline in recent years (will involve both manual calculations and spreadsheet development).
- A sunken oil barge salvage exercise that illustrates hydrodynamic principals important in re-floating a sunken oil barge in eastern Long Island Sound.
- A small boat drift exercise using MY Sound wind and current data that illustrates the use of vector addition in conducting a search and rescue operation.
- An ocean data analysis exercise using wind and dissolved oxygen time series data that illustrate the concepts of hypoxia, temperature stratification, and vertical mixing on a Summer 2000 event in western Long Island Sound.

Examples of guided Internet investigations include:

- Waste water pollution (municipal and industrial)

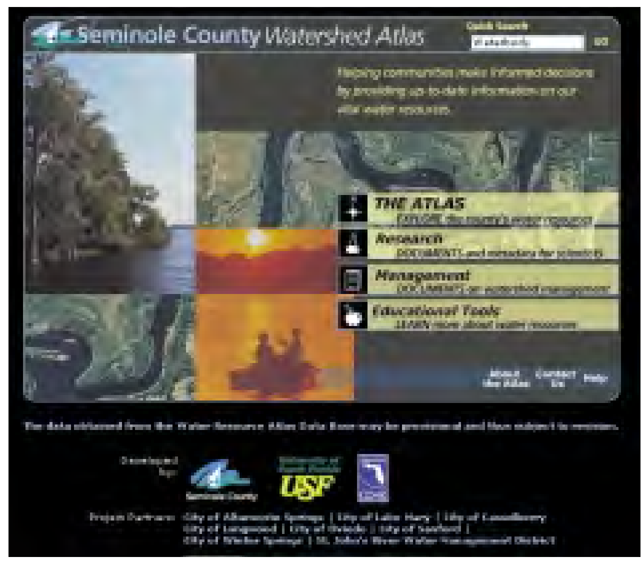
- Oil and hazardous chemical spills
- Non-point source pollution
- Invasive species
- Marine debris
- Habitat modification and restoration

Resources

For additional information on the MY Sound project and status of the curriculum component, contact Pete Tebeau at 860 446-0193 or visit the MY Sound Web site at <www.MYSound.uconn.edu>.

5.2.6 Online Dynamic Watershed Atlas (Seminole County, Florida)

Introduction



The Seminole County Watershed Atlas is designed to provide citizens, scientists, and planners of the Seminole County region with comprehensive and current water quality, hydrologic, and ecological data, as well as a library of scientific and educational resources on ecology and management. The Atlas was created to provide a “one stop information shop” for concerned citizens and scientists who live and work on water bodies and have found it difficult to gather the information they need from the many agencies that collect the related data. The Atlas functions as a warehouse for a variety of water resources information, including documents and educational links. The Atlas also is a rich resource that educates citizens about the data presented and gives scientists easy access to the specialized information they need.

Lessons, Tools, and Activities

As part of the Atlas project, Seminole County initiated a water quality and hydrology curriculum component in September 2001. The curriculum, which is being developed in conjunction with the University of South Florida and the Seminole County School Board, along with several other minor partners, is expected to be completed by January 2004. Designed for grades 5 through 12, the curriculum will be provided to county schools, a local environmental studies center, and other interested environmental education groups. The curriculum will cross several disciplines, including math, science, and social studies. Project organizers are expecting that in the future, other counties will develop their own watershed databases and could adapt the Seminole County curriculum to meet their needs.

Teachers will work with county staff to design the curriculum and will then train other teachers how to use it. Curriculum staff will develop both teacher and student guides. Teachers and students will need Internet access to use the curriculum, and optional field activities are under consideration, which might require environmental monitoring equipment.

Resources

For additional information on the Seminole County Watershed Atlas project or curriculum, contact Kim Ornberg at 407 665-5738 or visit the project Web site at <www.seminole.wateratlas.usf.edu>.

5.2.7 Onondaga Lake/Seneca River (Syracuse, New York)

Introduction

The Onondaga Lake/Seneca River EMPACT project provides environmental information on the health of the Onondaga Lake/Seneca River ecosystems to students, researchers, and the local Syracuse community. Onondaga Lake is one of the most polluted lakes in the United States, with fishing and swimming prohibited and several water quality standards routinely violated. The lake pollution affects adjoining waterways, including the Seneca River. In 1998, local, state, and federal authorities agreed on a 15-year staged program to address the impacts of sewage pollution on the lake and river, and in 1999, the project was awarded an EMPACT grant. The program, a partnership between the Syracuse City School District, the Upstate Freshwater Institute, State University of New York–School of Environmental Science and Forestry, Syracuse University, and local businesses, collects and delivers critical near real-time data from remote underwater sample stations, or RUSS units, in the lake and river. The goals of the project include:

- Applying and advancing innovative remote monitoring technology to meet the acute present and future monitoring needs for the lake and river.
- Addressing the community's lack of understanding concerning the degraded conditions of the ecosystems.
- Promoting excellence in teaching, learning, and research.

The lasting benefits of the projects will include:

- Addition of critical capabilities to the long-term monitoring program.
- Creation of vehicles to communicate important characteristics and findings to all stakeholders.
- A community that is more engaged in critical environmental decision-making.

Lessons, Tools, and Activities

Three educational resources have been developed to support classroom instruction and connect school curricula to the Onondaga Lake-Seneca River EMPACT Project. Grade-level course guides for early primary (K–3), elementary (4–6), intermediate (7–9), and commencement (10–12) students have been developed to supplement project efforts. The lessons in the guides were designed to be implemented as part of a regular science course. For example, students could learn weather principles by studying the RUSS meteorological data. There are some teachers who are using the materials in special Onondaga Lake Units. These types of units are taught in the spring and review all the concepts of a course.

Several essential understandings form the basis of the course guides. A committee of teachers representing all grade levels and content areas of the Syracuse City School District analyzed the issues and concepts impacting Onondaga Lake and its watershed. Through their analysis, they identified the following essential understandings:

- Several dynamic processes are constantly reshaping the Onondaga Lake Watershed, including:
  - Succession: The continuing process in which an ecosystem evolves to maximize the cycling and utilization of resources.
  - Seasonal changes: The processes involved with the motion of the earth and moon about the sun, and the processes that occur in response to their motion.
  - Human processes: The processes involved with human activity and the environmental impacts that result.
- The earth is a closed system.
  - Life is sustained by and is part of a set of cyclic processes.
  - All resources used by humans were developed through a series of cyclic processes.
  - All waste products, if not transformed, will remain in the global system.
- Humans make decisions. Human action is directed primarily by thought and decisionmaking in an effort to improve the quality of life.
- Efficient and effective communication skills are necessary for success at any task or performance.

In addition to the essential understandings that were developed under the project, teachers developed essential questions to drive classroom inquiry and research. The primary question to drive inquiry in all classrooms and content areas is "How do we make the decisions necessary to develop and maintain a healthy community?" The Onondaga Lake and Seneca River are two components of the watershed ecosystem. Because all components of the ecosystem are interconnected, monitoring changes in water quality provides insight into the overall health of the watershed and the communities it supports. As a result, students are challenged to assess their community and their impact upon it. The key questions for driving inquiry for each essential understanding of the project are:

- What are the processes that impact our community?
- How does material enter and leave our community?
- What happens to these materials when they interact with our community?
- How do these materials impact upon and/or affect our community?
- How do humans, individually and in groups, make decisions?
- How do people make the decisions necessary to communicate effectively with each other?

For each grade level, there are lessons covering each essential understanding and key question. For example, to address the key understanding of dynamic processes and the key question, “What are the processes that impact our community?” the Onondaga Lake curriculum includes the lesson “Shake, Rattle, and Role: Earth’s Dynamic Processes.” The theme, topics, and project work vary by grade level. As an example, for 10th grade, the theme of the lesson is cycles and cyclic processes; the curriculum topics include biological interactions with dynamic changes, lake biology, and Onondaga Creek Watershed ecology; students assume the role of research botanists, microbiologists, zoologists, entomologists, and environmental engineers and present a physical model as a project.

Resources

For more information on the Onondaga Lake/Seneca River project, contact Richard List at 315 435-5842 or at <rlist@freeside.scsd.k12.ny.us> and visit the project Web site at <www.ourlake.org>.

6.0 Land-Use and Soil-Based Projects

6.1 Teacher Tips

Soil is a dynamic resource that supports plant life. It is comprised of a number of different materials, including sand, silt, clay, organic matter, and many species of living organisms. Therefore, soil has biological, chemical, and physical properties, some of which can change depending on how the soil is managed. The Soil Science Society of America defines soil quality as "the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation." Management that enhances soil quality benefits cropland, rangeland, and woodland productivity. In addition, enhanced soil quality benefits water quality, air quality, and wildlife habitat. Soil provides several essential services or functions:

> EPA's Office of Research and Development (ORD) conducts research in innovative monitoring and measurement technologies, as well as in tools to interpret data streams and to increase the quality and the number of environmental parameters that can be monitored and reported in EMPACT communities. Although there are currently no research grants researching soil monitoring technologies, teaching students about soil quality is important, so this handbook provides background information as a resource for the teacher.

- Soil supports the growth and diversity of plants and animals by providing a physical, chemical, and biological environment for the exchange of water, nutrients, energy, and air.
- Soil regulates the distribution of rain or irrigation water between infiltration and runoff, and it regulates the flow and storage of water and the materials found in it, such as nitrogen, phosphorus, pesticides, and nutrients.
- Soil stores, moderates the release of, and cycles plant nutrients and other elements.
- Soil acts as a filter to protect the quality of water, air, and other resources.

Soil quality is evaluated using indicators that reflect changes in the capacity of the soil to function. Useful indicators are those that are sensitive to change and that change in response to management. Some examples include soil erosion, sediment deposition, soil biodiversity, water capacity, and pesticides. Monitoring of soil quality indicators over time identifies changes or trends in the functionality or quality of the soil. Monitoring can be used to determine the success of management practices or the need for changes or adjustments.

Most soil-related EMPACT projects focus either on lead exposure from residential soils or the status of brownfield properties. (See <www.epa.gov/empact/soil.htm> for more information on these projects, which do not currently have curriculum components.)

Another topic associated with soil is land use and urban sprawl. Urban sprawl can be defined as the unplanned, unlimited extension of neighborhoods outside of a city's limits, usually associated with low density residential and commercial settlements, dominance of transportation by automobiles, and widespread strip commercial development. Over the past 50 years, American cities have been experiencing an accelerated urbanization and suburbanization process resulting from rapid technological advancement and relatively steady economic growth. Some argue that urban sprawl leads to inefficient land use patterns. Communities can implement a number of growth management programs to encourage more efficient and environmentally sound development patterns.

6.2 The Tools

6.2.1 Northeast Ohio Urban Growth Simulator

Introduction

The Northeast Ohio (NEO) EMPACT project compiled urban sprawl data to create a land-use computer modeling tool. Developed by Kent State University, Cleveland State University, and the University of Akron, it provides citizens with local urban sprawl information and development scenarios for Northeast-Ohio. This information helps decision-making on how the region should grow and provides possible land use consequences that might arise from different kinds of growth (i.e., farmland loss, wetland destruction).

Lessons, Tools, and Activities

As part of the NEO EMPACT project, a handbook was developed to introduce teachers and students to the importance of understanding urban sprawl in their communities. Urban Sprawl in Northeast Ohio is arranged in thematic and developmental order to provide students with a comprehensive understanding of urban sprawl and its effects on the environment.

The handbook for educators and students includes detailed background information, lessons, and activities focused on urban sprawl. It progresses from developing an understanding of urban sprawl to discussing concrete actions students and teachers can take to raise awareness of urban sprawl. The major sections of the handbook include:

- The introductory section, *All About Urban Sprawl—Notes for Educators,* provides detailed background information on urban sprawl and how it relates to other environmental problems such as air and water pollution and acid rain.
- The 10 *Experiments and Exercises* on urban sprawl provide hands-on lessons in urban sprawl. Geared towards specific grades, the experiments and exercises cover land use planning, various types of air pollution (e.g., particulates, carbon dioxide), soil buffering, air quality as it relates to combustion byproducts, habitat destruction, water pollution, and city planning.

- The *Students, Urban Sprawl, and the Internet* section is complemented by the online *Urban Growth Simulator* and its *Self-Guided Workbook*, which allow students to simulate how their community would change with future development. The workbook describes the Urban Growth Simulator Web site, and includes four guided simulation exercises.
- The *Urban Sprawl Activities for Younger Students* focus on developing students' oral, visual, and writing skills. Activities include conducting a mock interview with a famous environmentalist, a word search and crossword puzzle, writing an urban sprawl bill, determining the authority of various levels of government (i.e., federal, state, local) to pass land use laws, and designing urban sprawl posters for display in the community.
- *Urban Sprawl—What Students Can Do* offers teachers and students suggestions for reducing sprawl and its side effects in the local community and at school.
- *Urban Sprawl World Wide Web Resources for Educators* lists sources of additional information on urban sprawl for educators and students.

Resources

For additional information on the NEO Urban Sprawl curriculum handbook, contact Adam Zeller of the Earth Day Coalition at 216 281-6468 or <azeller@earthdaycoalition.org> and visit the NEO EMPACT Web site at <http://empact.nhlink.net>.

Appendix A: Additional Resources

U.S. Environmental Protection Agency (EPA) Office of Solid Waste

<www.epa.gov/epaoswer/osw/teacher.htm>

This Web site provides educational tools and a list of related publications, including:

- *Let's Reduce and Recycle: Curriculum for Solid Waste Awareness*
- *School Recycling Programs: A Handbook for Educators*
- *Adventures of the Garbage Gremlin*

EPA also lists a wealth of activities including the "Planet Protectors Coloring Book."

The Globe Program: Global Learning and Observations To Benefit the Environment

<www.globe.gov>

This Web site provides science and education resources including teacher guides, workshops, and tools, such as a geography quiz and cloud identification quiz.

Natural Resource Conservation Service

<www.nrcs.usda.gov/feature/education>

This Web site includes ideas and educational tools for teachers.

U.S. Department of Agriculture (USDA) for Kids

<www.usda.gov/news/usdakids/index.html>

"USDA for Kids" Web site is a great resource for educational tools, including a food pyramid guide, Smokey the Bear, and "Food for Thought."

National Soil Survey Center

<www.statlab.iastate.edu/soils/nssc>

This Web site provides information on soil science education.

National Geographic Society

<www.nationalgeographic.com>

This Web site provides extensive teacher resources related to geography and science.

North American Association of Environmental Education (NAAEE)

1255 23rd Street NW., Suite 400
Washington, DC 20037-1199
202 884-8912
Fax: 202 884-8701
<www.naaee.org>

NAAEE was established in 1971 as a network of professionals and students working in environmental education. NAAEE's members are located throughout North America and in more than 40 countries around the world; they believe that education is the key to ensuring a healthy, sustainable environment and improving the quality of life on earth. Members can join various sections: Elementary and Secondary Education, College and University Environmental Programs, and Non-formal Education.

Association for Supervision and Curriculum Development (ASCD)

1250 North Pitt Street
Alexandria, VA 22314
703 549-9110
<www.ascd.org>

ASCD, an education association, serves its members through publications, professional development opportunities, research and information searches, the Curriculum and Technology Resource Center, and affiliates in each state and several foreign countries. Resources include information on staff development practices, cooperative learning, peer coaching, and science and social studies content for schools.

National Science Teachers Association (NSTA)

1840 Wilson Boulevard
Arlington, VA 22201-3000
703 243-7100
Fax: 703 243-7177
<www.nsta.org>

The National Science Teachers Association (NSTA) is committed to improving science education at all levels, preschool through college. NSTA produces several publications, conducts national and regional conventions, and provides scholarships, teacher-training workshops, educational tours, and an employment registry. The Web site provides an extensive range of resources for teachers of students of all levels; journals and books on science education and instruction are also available.

National School Boards Association (NSBA)

1680 Duke Street
Alexandria, VA 22314
703 838-6722
<www.nsba.org>

The National School Boards Association is a national federation of state school boards. NSBA produces “Electronic School,” a free online technology publication for K-12 educators. NSBA houses the Institute for the Transfer of Technology to Education (ITTE), a program to help advance the wise use of technology in public education.

Appendix B: Glossary of Terms

Air Terms

Acid rain: Air pollution produced when acid compounds formed in the atmosphere are incorporated into rain, snow, fog, or mist. The acid compounds come from sulfur oxides and nitrogen oxides, products of burning coal and other fuels and from certain industrial processes. Acid rain can impact the environment and human health and damage property.

Atmosphere: A thin layer of gases surrounding the Earth, composed of 78 percent nitrogen, 21 percent oxygen, 0.9 percent argon, 0.03 percent carbon dioxide, and trace amounts of other gases. There is no exact place where the atmosphere ends; it just gets thinner and thinner, until it merges with outer space.

Basal cell carcinoma: Skin cancer tumors that might appear as slow-growing, translucent, pearly nodules, which might crust, discharge pus, or even bleed. These tumors typically develop where you are most exposed to the sun—on the face, lips, tops of ears, and hands.

Carbon monoxide (CO): A colorless, odorless, poisonous gas produced by the incomplete burning of solid, liquid, and gaseous fuels. Appliances fueled with natural gas, liquified petroleum (LP gas), oil, kerosene, coal, or wood may produce CO. Burning charcoal produces CO and car exhaust contains CO.

Chlorofluorocarbons (CFCs): Stable, low toxic, and inexpensive chemicals that were most commonly used as refrigerants, solvents, and aerosol propellants. CFCs and their relatives, when released into the air, rise into the stratosphere and take part in chemical reactions that result in reduction or depletion of the stratospheric ozone layer. The 1990 Clean Air Act includes provisions for reducing releases (emissions) and eliminating production and use of these ozone-destroying chemicals.

Clean Air Act: The original Clean Air Act was passed in 1963, but our national air pollution control program is actually based on the 1970 version of the law. The 1990 Clean Air Act Amendments are the most far-reaching revisions of the 1970 law.

Criteria air pollutants: A group of very common air pollutants regulated by EPA on the basis of criteria (information on health and/or environmental effects of pollution).

Emission: Release of pollutants into the air from a source. Continuous emission monitoring systems (CEMS) are machines that some large sources are required to install, to make continuous measurements of pollutant release.

EMPACT: Environmental Monitoring for Public Access and Community Tracking, a program begun by EPA in 1997, helps communities collect, manage, and distribute environmental information, providing residents with up-to-date and easy-to-understand information they can use to make informed, day-to-day decisions.

Greenhouse effect: A natural phenomenon whereby clouds and greenhouse gases, such as water vapor and carbon dioxide, trap some of the Sun's heat in the atmosphere. The greenhouse effect helps regulate the temperature of the Earth. Human activities are adding greenhouse gases to the natural mix.

Greenhouse gases: Human activities, such as fuel burning, are adding greenhouse gases to the atmosphere. Because these gases remain in the atmosphere for decades to centuries (depending on the gas) global temperatures will rise.

Melanoma: The most fatal form of skin cancer. Malignant melanomas may appear suddenly without warning as a dark mole or other dark spot on the skin and can spread quickly.

Monitoring (monitor): Measurement of air pollution is referred to as monitoring. Continuous emission monitoring systems (CEMS) will measure, on a continuous basis, how much pollution is being released into the air. The 1990 Clean Air Act requires states to monitor community air in polluted areas to check on whether the areas are being cleaned up according to schedules set out in the law.

Nitrogen oxides (NOx): A criteria air pollutant. Nitrogen oxides are produced from burning fuels, including gasoline and coal, and react with volatile organic compounds to form smog. Nitrogen oxides are also major components of acid rain.

Ozone (O3): An ozone molecule consists of three oxygen atoms. Stratospheric ozone shields the Earth against harmful rays from the sun, particularly ultraviolet B. Ground-level ozone contributes to smog.

Ozone depletion: The ozone layer is damaged when substances such as chlorofluorocarbons accelerate the natural process of destroying and regenerating stratospheric ozone. As the ozone layer breaks down, it absorbs smaller amounts of UV radiation, allowing more of it to reach the earth.

Particulates, particulate matter: A criteria air pollutant. Particulate matter includes dust, soot, and other tiny bits of solid materials that are released into and move around in the air.

Pollutants (pollution): Unwanted chemicals or other materials found in the air.

Smog: A mixture of pollutants, principally ground-level ozone, produced by chemical reactions in the air involving smog-forming chemicals. A major portion of smog-formers come from burning of petroleum- based fuels such as gasoline. Major smog occurrences are often linked to heavy motor vehicle traffic, sunshine, high temperatures, and calm winds or temperature inversion (weather condition in which warm air is trapped close to the ground instead of rising).

Source: Any place or object from which pollutants are released.

Spectrophotometer: An instrument for measuring the relative intensities of light in different parts of the spectrum used to measure the amount of UV radiation reaching the earth.

Squamous cell carcinoma: Skin cancer tumors that might appear as nodules or red, scaly patches, which can develop into large masses and spread to other parts of the body.

Stratosphere: The stratosphere starts just above the troposphere and extends to 50 kilometers (31 miles) high. The temperature in this region increases gradually to -3 degrees Celsius, due to the absorption of ultraviolet radiation. The ozone layer, which absorbs and scatters the solar ultraviolet radiation, is in this layer. Ninety-nine percent of air is located in the troposphere and stratosphere.

Stratospheric ozone: A bluish gas composed of three oxygen atoms. Natural processes destroy and regenerate ozone in the atmosphere. When ozone-depleting substances such as chlorofluorocarbons accelerate the destruction of ozone, there is less ozone to block UV radiation from the sun, allowing more UV radiation to reach the earth.

Sulfur dioxide: A criteria air pollutant. Sulfur dioxide is a gas produced by burning coal, most notably in power plants. Sulfur dioxide plays an important role in the production of acid rain.

Sunscreen: A substance, usually a lotion, that you can apply to protect your skin from UV radiation. It works by reflecting UV radiation away from your skin in addition to absorbing UV radiation before it can penetrate your skin.

SunWise School Program: EMPACT program that aims to teach grades K-8 school children and their caregivers how to protect themselves from overexposure to the sun. The program raises children's awareness of stratospheric ozone depletion and ultraviolet radiation and encourages simple sun safety practices.

Troposphere: The troposphere is the lowest region in the Earth's (or any planet's) atmosphere, starting at ground (or water) level up and reaching up to about 11 miles (17 kilometers) high. The weather and clouds occur in the troposphere.

Ultraviolet B (UVB): A type of sunlight. Ultraviolet B exposure has been associated with skin cancer, eye cataracts, and damage to the environment. The ozone in the stratosphere, high above the Earth, filters out ultraviolet B rays and keeps them from reaching the Earth. Thinning of the ozone layer in the stratosphere results in increased amounts of ultraviolet B reaching the Earth.

UV Index: A tool developed by the National Weather Service that predicts the next day's UV intensity on a scale from 0 to 10+, helping people determine appropriate sun-protective behaviors.

UV radiation: A portion of the electromagnetic spectrum with wavelengths shorter than visible light. UV radiation produced by the sun is responsible for sunburn and other adverse health effects. Scientists classify UV radiation into three types: UVA, UVB, and UVC.

Volatile organic compounds (VOCs): Chemicals that produce vapors readily at room temperature and normal atmospheric pressure, so that vapors escape easily from volatile liquid chemicals. Organic chemicals all contain the element carbon and are the basic chemicals found both in living things and in products derived from living things, such as coal, petroleum and refined petroleum products. Many volatile organic chemicals are also hazardous air pollutants.

Water Terms

Abiotic: Not alive; non-biological. For example, temperature and mixing are abiotic factors that influence the oxygen content of lake water, whereas photosynthesis and respiration are biotic factors that affect oxygen solubility.

Acid: A solution that is a proton (H+) donor and has a pH less than 7 on a scale of 0-14. The lower the pH the greater the acidity of the solution.

Acidity: A measure of how acidic a solution may be. A solution with a pH of less than 7.0 is considered acidic. Solutions with a pH of less than 4.5 contain mineral acidity (due to strong inorganic acids), while a solution having a pH greater than 8.3 contains no acidity.

Acid rain: Precipitation having a pH lower than the natural range of ~5.2 - 5.6; caused by sulfur and nitrogen acids derived from human-produced emissions.

Acidification: The process by which acids are added to a water body, causing a decrease in its buffering capacity (also referred to as alkalinity or acid neutralizing capacity), and ultimately a significant decrease in pH that may lead to the water body becoming acidic (pH < 7).

Algae: Simple single-celled, colonial, or multi-celled aquatic plants. Aquatic algae are (mostly) microscopic plants that contain chlorophyll and grow by photosynthesis and lack roots, stems (non- vascular), and leaves.

Alkalinity: Acid neutralizing or buffering capacity of water; a measure of the ability of water to resist changes in pH caused by the addition of acids or bases. Therefore, it is the main indicator of susceptibility to acid rain. A solution having a pH below about 5 contains no alkalinity.

Anoxia: Condition of being without dissolved oxygen.

Anthropogenic: A condition resulting from human activities.

Aquatic respiration: Refers to the use of oxygen in an aquatic system, including the decomposition of organic matter and the use of oxygen by fish, algae, zooplankton, aquatic macrophytes, and microorganisms for metabolism.

Base: A substance which accepts protons (H+) and has a pH greater than 7 on a scale of 0-14; also referred to as an alkaline substance.

Basin: Geographic land area draining into a lake or river; also referred to as drainage basin or watershed.

Benthic: Refers to being on the bottom of a lake.

Bioaccumulation: The increase of a chemical's concentration in organisms that reside in environments contaminated with low concentrations of various organic compounds. Also used to describe the progressive increase in the amount of a chemical in an organism resulting from rates of absorption of a substance in excess of its metabolism and excretion. Certain chemicals, such as PCBs, mercury, and some pesticides, can be concentrated from very low levels in the water to toxic levels in animals through this process.

Biochemical oxygen demand (BOD): Sometimes referred to as Biological Oxygen Demand (BOD). A measure of the amount of oxygen removed (respired) from aquatic environments by aerobic microorganisms either in the water column or in the sediments. Primarily of concern in wastewater "streams" or systems impacted by organic pollution.

Biomass: The weight of a living organism or group of organisms.

Biotic: Referring to a live organism; see abiotic.

Buffer: A substance that tends to keep pH levels fairly constant when acids or bases are added.

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

Clarity: Transparency; routinely estimated by the depth at which you can no longer see a Secchi disk. The Secchi disk, an 8-inch diameter, weighted metal plate, is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi depth.

Conductivity (electrical conductivity and specific conductance): Measures water's ability to conduct an electric current and is directly related to the total dissolved salts (ions) in the water. Called EC for electrical conductivity, it is temperature-sensitive and increases with higher temperature.

Dissolved oxygen (DO or O2): The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms.

Dissolved solids concentration: The total mass of dissolved mineral constituents or chemical compounds in water; they form the residue that remains after evaporation and drying.

Ecosystem: All of the interacting organisms in a defined space in association with their interrelated physical and chemical environment.

Epilimnion: The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed at some point during the day, and, because of its exposure, can freely exchange dissolved gases (such as O2 and CO2) with the atmosphere.

Eutrophication: Unhealthy increases in the growth of phytoplankton. Symptoms of eutrophication include algal blooms, reduced water clarity, periods of hypoxia, and a shift toward species adapted toward these conditions.

Evaporation: The process of converting liquid to vapor.

Food chain: The transfer of food energy from plants through herbivores to carnivores. For example, algae are eaten by zooplankton, which in turn are eaten by small fish, which are then eaten by larger fish, and eventually by people or other predators.

Food web: Food chains connected into a complex web.

Hydrogen: Colorless, odorless, and tasteless gas; combines with oxygen to form water.

Hydrology: The study of water's properties, distribution, and circulation on Earth.

Hypolimnion: The bottom and most dense layer of a stratified lake. It is typically the coldest layer in the summer and warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur.

Hypoxia: A deficiency of oxygen reaching the tissues of the body.

Isothermal: Constant in temperature.

Leach: To remove soluble or other constituents from a medium by the action of a percolating liquid, as in leaching salts from the soil by the application of water.

Metalimnion: The middle or transitional zone between the well-mixed epilimnion and the colder hypolimnion layers in a stratified lake.

Nonpoint source: Diffuse source of pollutant(s); not discharged from a pipe; associated with land use such as agriculture, contaminated groundwater flow, or onsite septic systems.

Nutrient loading: Discharging of nutrients from the watershed (basin) into a receiving water body (lake, stream, wetland).

Oxygen: An odorless, colorless gas; combines with hydrogen to form water; essential for aerobic respiration. See respiration.

Oxygen solubility: The ability of oxygen gas to dissolve into water.

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

pH: A measure of the concentration of hydrogen ions.

Phosphorus: Key nutrient influencing plant growth in lakes.

Photosynthesis: The process by which green plants convert carbon dioxide (CO2) dissolved in water to sugars and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base and is an important source of oxygen for many lakes.

Phytoplankton: Microscopic floating plants, mainly algae, that live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current.

Respiration: The metabolic process by which organic carbon molecules are oxidized to carbon dioxide and water with a net release of energy.

Solubility: The ability of a substance to dissolve into another.

Solution: A homogenous mixture of two substances.

Solvent: A substance that has the ability to dissolve another.

Stormwater discharge: Precipitation and snowmelt runoff (e.g., from roadways, parking lots, roof drains) that is collected in gutters and drains; a major source of nonpoint source pollution to water bodies.

Temperature: A measure of whether a substance is hot or cold.

Total Dissolved Solids (TDS): The amount of dissolved substances, such as salts or minerals, in water remaining after evaporating the water and weighing the residue.

Turbidity: Degree to which light is blocked because water is muddy or cloudy.

Turnover: Fall cooling and spring warming of surface water make density uniform throughout the water column, allowing wind and wave action to mix the entire lake. As a result, bottom waters contact the atmosphere, raising the water's oxygen content.

Water Column: A conceptual column of water from lake surface to bottom sediments.

Watershed: All land and water areas that drain toward a river or lake; also called a drainage basin or water basin.

Soil Terms

Bedrock: Consolidated rock.

Brownfields: Abandoned, idled, or underused industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.

Clay: Soil composed mainly of fine particles of hydrous aluminum silicates and other minerals. Soil composed chiefly of this material has particles less than a specified size.

Erosion: The wearing away of the land surface by running water, wind, ice, other geological agents, or human activity.

Infiltration: The downward entry of water through the soil surface.

Limestone: A white to gray, fine-grained rock made of calcium carbonate.

Percolation: Water that moves through the soil at a depth below the root zone.

Sand: A loose granular material that results from the disintegration of rocks. It consists of particles smaller than gravel but coarser than silt

Sandstone: A very grainy rock that comes in many colors, including gray, red, or tan.

Sedimentary rock: Rock that has formed from compressed sediment, like sand, mud, and small pieces of rocks.

Shale: Dark-colored rock that is usually black, deep red, or gray-green. It has a fine grain and is usually found below sandstone, not on the surface. Shale was formed from fine silt and clay.

Silt: Predominantly quartz mineral particles that are between the size of sand and clay in diameter. Silt, like clay and sand, is a product of the weathering and decomposition of preexisting rock.

Soil: Soil is made up of minerals (rock, sand, clay, silt), air, water, and organic (plant and animal) material. There are many different types of soils, and each one has unique characteristics, like color, texture, structure, and mineral content.

Soil contamination: Pollution caused by a number of activities, including the dumping of hazardous substances, pesticide and fertilizer use, and industrial or chemical processes. Pollutants in soils can also be transported to groundwater sources and into the air. Contaminated soils are often a major concern at brownfield and Superfund sites. Common soil contaminants include arsenic, benzene, cyanide, lead, and mercury.

Soil formation: Soil is formed slowly as rock erodes into tiny pieces near the Earth's surface. Organic matter decays and mixes with rock particles, minerals, and water to form soil.

Soil texture: Distribution of individual particles of soil.

Soil washing: A technology that uses liquids (usually water, sometimes combined with chemical additives) and a mechanical process to scrub soils of contaminants.

Superfund: The Federal government's program to clean up the nation's uncontrolled hazardous waste sites.

Topsoil: Soil consisting of a mixture of sand, silt, clay, and organic matter. Topsoil is rich in nutrients and supports plant growth.

Urban sprawl: The unplanned, unlimited extension of neighborhoods outside of a city's limits, usually associated with low density residential and commercial settlements, dominance of transportation by automobiles, and widespread strip commercial development.

Appendix C: Activities by Grade Level

							Grade							
Curriculum	**K**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**12+**
Airbeat					X	X	X	X	X	X	X	X	X	
Air Currents							X	X	X	X	X	X	X	
Air Info Now: Environmental Monitoring for Public Access and Community Tracking					X	X	X	X	X	X	X	X	X	
AIRNow			X	X	X	X								
Boulder Area Sustainability Information Network					X	X	X	X	X	X	X	X	X	
Burlington Eco-Info								X	X	X	X	X	X	
Community Accessible Air Quality Monitoring Assessment (Northeast Ohio)					X	X	X	X	X					
ECOPLEX	X	X	X	X	X	X	X	X	X					
Lake Access (WOW)												X	X	X
Monitoring Your Sound									X	X	X	X	X	
Online Dynamic Watershed Atlas (Seminole County, FL)						X	X	X	X	X	X	X	X	
Onondaga Lake/Seneca River	X	X	X	X	X	X	X	X	X	X	X	X	X	
Northeast Ohio Urban Growth Simulator					X	X	X	X	X					

Appendix D: Activities by Subject

Curriculum	Math	Language Arts	Subject Science	Social Studies	Art
Airbeat	X	X	X		
Air CURRENTS	X	X	X	X	X
Air Info Now: Environmental Monitoring for Public Access and Community Tracking		X	X		
AIRNow	X		X		X
Boulder Area Sustainability Information Network			X	X	
Burlington Eco-Info			X		
Community Accessible Air Quality Monitoring Assessment (Northeast Ohio)		X	X		X
ECOPLEX	X		X		X
Lake Access	X		X		
Monitoring Your Sound	X		X		
Online Dynamic Watershed Atlas (Seminole County, FL)	X		X	X	
Onondaga Lake/Seneca River			X		
Northeast Ohio Urban Growth Simulator			X	X	

Appendix E: Selected Lesson Plans and Activities

AirInfo Now

- Group Details – Blue Group: Weather (PDF)
  Data Sheet – Blue Group: Weather (Excel)
- Group Details – Brown Group: Visibility (PDF)
  Data Sheet – Brown Group: Visibility (Excel)
- A Guide to CO-City (PDF)
- So What's Making it Look Brown Outside? Collecting and Measuring Particulate Matter (PDF)
- What's the Connection Between Convection and Inversion? Convection Currents and Temperature Inversion (PDF)
- Getting a Handle on Greenhouse Gases: Your Family's Impact on the Greenhouse Effect (PDF)
- Helping to Find a Solution to Air Pollution! (PDF)
- Green Group: Location (PDF)
  Green Group: Location (Excel)
- Real-Time Air Quality Activity: Groups (PDF)
- Practice Data Sheet (Excel)
- Group Details – Red Group: Time (PDF)
  Data Sheet – Red Group: Time (Excel)
- Real-Time Air Quality Activity: Student Sheets(PDF)
  Real-Time Air Quality Activity: Teacher Sheets(PDF)
- Group Details – Yellow Group: Health (PDF)
  Data Sheet – Yellow Group: Health (Excel)

Airnow

- Air Quality Index Poster: Are you breathing clean air? (PDF)
- Air Quality Index: A Guide to Air Quality and Your Health (PDF)
- Air Quality Index Kids Website: Teacher's Reference (PDF)
- Green Day Poster (PDF)
- Orange Day Poster (PDF)
- Air Quality Index Posters (PDF)
- Purple Day Poster (PDF)
- Red Day Poster (PDF)
- Yellow Day Poster (PDF)

ECOPLEX

- **UV**
  - UV/7-2: Spotlight the Sun Data Table (PDF)
  - Ozone Chemistry: Formation & Depletion(PDF)
  - 8th Grade Lesson Plan – UV: Chemistry of Ozone Depletion(PDF)
  - 5th Grade Lesson Plan – UV: Check It Out! (PDF)
  - First Grade UV: Catching and Counting UV Rays! (PDF)
  - 4th Grade UV Lesson: What Depletes Our Ozone? Me and My Zone! (PDF)
  - Kindergarten UV: UV and Me! (PDF)
  - Second Grade UV: The Air Out There – UV and Ozone (PDF)

- UV/7-1: Distribution of the Sun's Rays (PDF)
- 6th Grade UV: Friend or Foe (PDF)
- 3rd Grade UV Lesson: When Good Ozone Goes Bad (PDF)

- **Water Quality**
  - Third Grade Water Quality: Test, Test, Is This Water Safe? (PDF)
  - Fourth Grade Water Quality: Chain, Chain, Chain, Chain of Food (PDF)
  - Fifth Grade Water Quality: Tick Tock Toxins (PDF)
  - 6th Grade Water Quality Lesson: Water O2 and You! (PDF)
  - 7th Grade Water Quality Lesson: Taxa-Rich and Taxa-Poor! (PDF)
  - Water Quality 1-1 Record Sheet (PDF)
  - Water Quality 2-1 Record Sheet (PDF)
  - Water Quality 4-1 Datasheet (PDF)
  - Water Quality 5-1 Datasheet (PDF)
  - First Grade Water Quality: Water – It's a Gas…Sometimes! (PDF)
  - Kindergarten Water Quality: Water in Me (PDF)
  - Second Grade Water Quality: Amazing Water (PDF)

- **Water Quantity**
  - 7th Grade Water Quantity: Water Use and Abuse (PDF)
  - 3rd Grade Water Quantity: Name That Surface Water (PDF)
  - 4th Grade Water Quantity: H2O is Underground Too! (PDF)
  - 5th Grade Water Quantity: What-A-Shed (PDF)
  - WQT/6-1: Water vs. Land and Sea (PDF)
  - WQT/6-2: Diagram for Stream Table (PDF)
  - 6th Grade Water Quantity: The Ups and Downs of Your Watershed (PDF)
  - 8th Grade Water Quantity: Water to Supply an Ever-growing Population (PDF)
  - First Grade Water Quantity Lesson: Here I Go 'Round My Watershed! (PDF)
  - Water Quantity Letter (PDF)
  - Kindergarten Water Quantity Lesson: Drip! Drop! Water Does Not Stop! (PDF)
  - Second Grade Water Quantity Lesson: Now You See It – Now You Don't! (PDF)
  - Water Quantity: What to Do and How to Do It (PDF)
  - WQT/7-1: Water Use Chart (PDF)

MY Sound

- The Impact of Atmospheric Nitrogen Deposition on Long Island Sound (PDF)
- Alternative Strategies for Hypoxia Management: Creative Ideas to Complement Advanced Treatment (PDF)
- Fact Sheet #1: Hypoxia in Long Island Sound (PDF)
- Toxic Contamination in Long Island Sound (PDF)
- Nutrient Reduction: New Solutions to Old Problems (PDF)
- Pathogens (PDF)
- The Impact of Septic Systems on the Environment (PDF)
- Water Conservation and Marine Water Quality (PDF)
- Wastewater Treatment (PDF)
- Supporting the Sound (PDF)
- Floatable Debris (PDF)
- How Low Dissolved Oxygen Conditions Affect Marine Life in Long Island Sound(PDF)
- Puttting the Plan in Motion (PDF)

SunWise

SunWise Monitor, November 1999 (PDF)
SunWise Monitor, April 2000 (PDF)
SunWise Monitor, April 2001 (PDF)

- Mission: SunWise – Activity Book (PDF)
  Mission: SunWise – Activity Book (Spanish) (PDF)
- Sun Safety for Kids: The SunWise School Program (PDF)|
  The SunWise School Program Guide (PDF)
- Mission: SunWise (PDF)
  Mission: SunWise (Spanish) (PDF)
- Summertime Safety: Keeping Kids Safe from Sun and Smog (PDF)
- Action Steps for Sun Protection (PDF)
- Sunscreen: The Burning Facts (PDF)
- The Sun, UV, and You: A Guide to SunWise Behavior (PDF)
- What Is the UV Index? (PDF)
- UV Radiation (PDF)
- Ozone Depletion (PDF)

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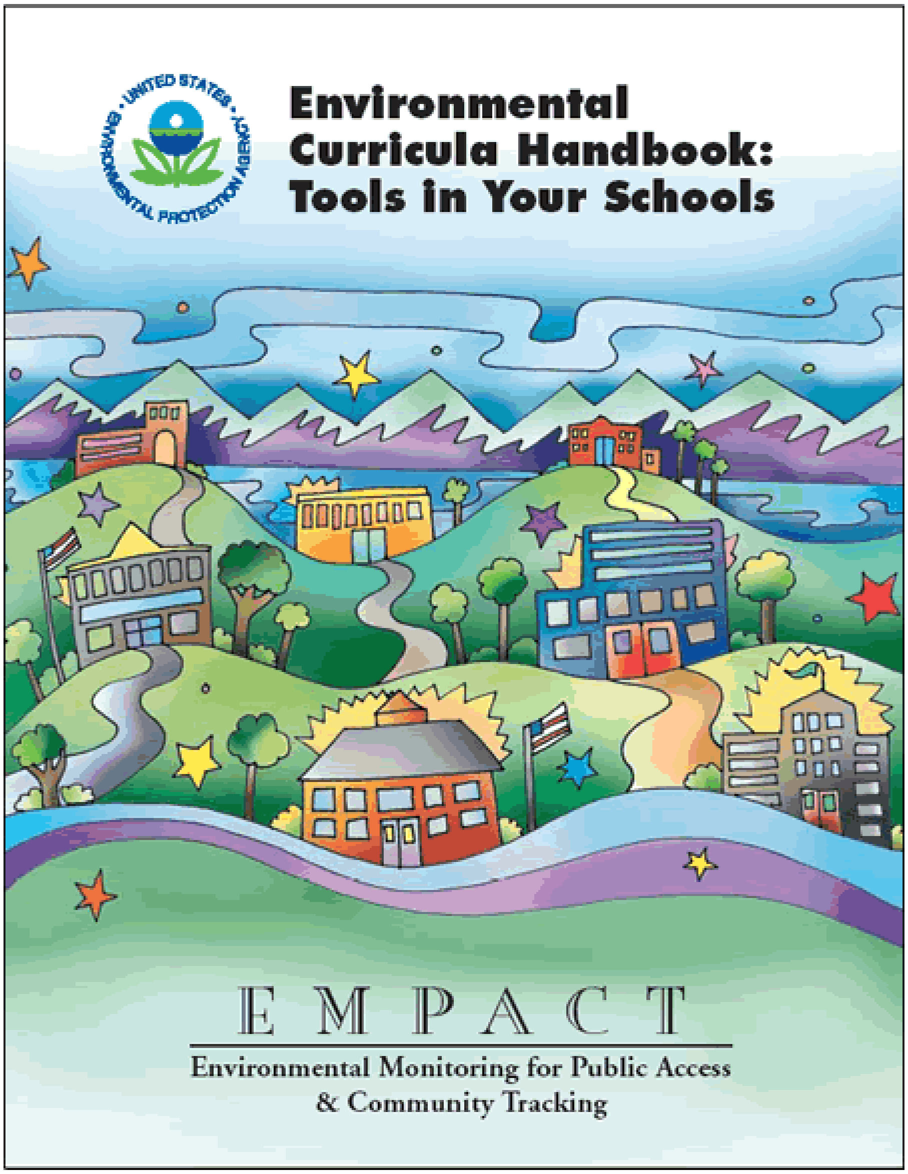
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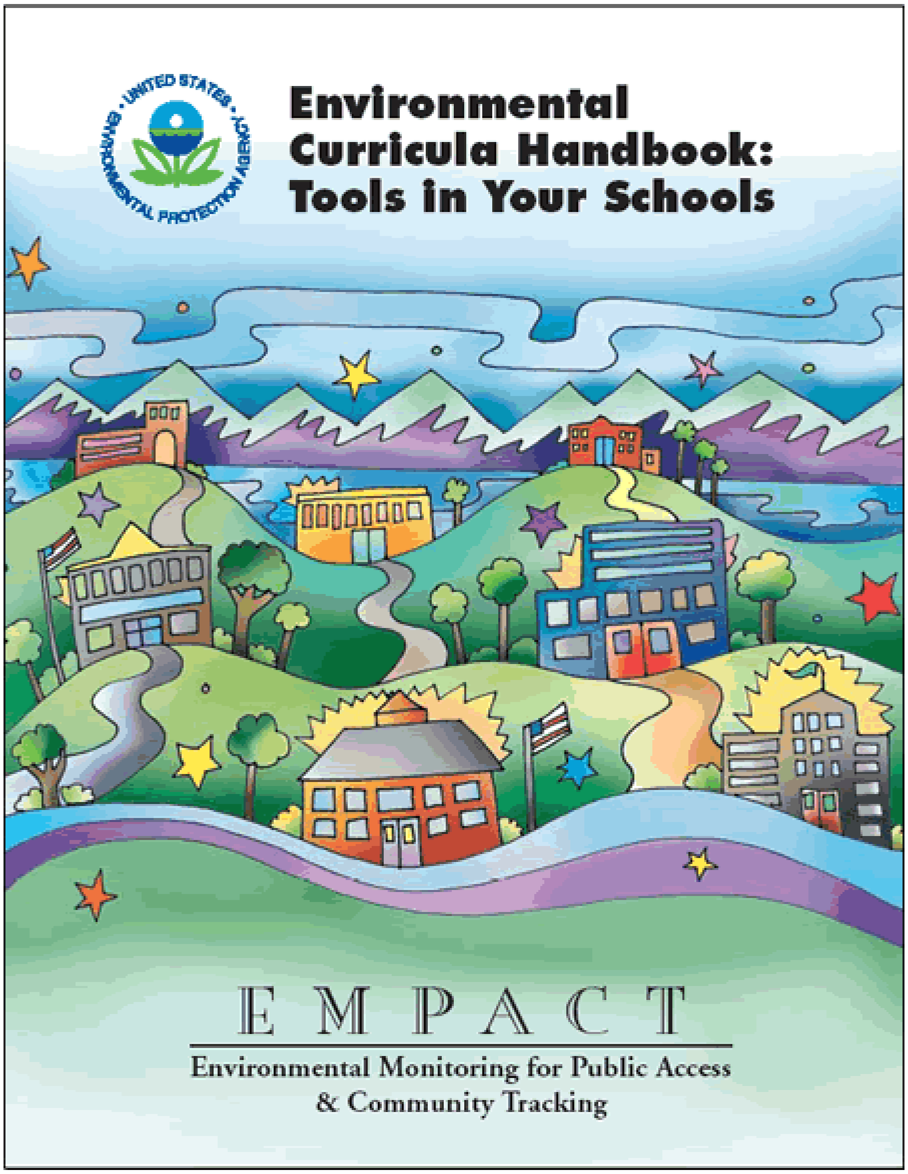
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1.0 Introduction

Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, Tbilisi Declaration, 1978).

1.1 What Was EMPACT?

The U.S. Environmental Protection Agency (EPA) created the Environmental Monitoring for Public Access and Community Tracking (EMPACT) program to take advantage of new technologies that make it possible to provide environmental information to the public in near real-time. EPA partnered with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) to help achieve nationwide consistency in measuring environmental data, managing the information, and delivering it to the public. Through the use of grants, EMPACT helped local governments build monitoring infrastructure in metropolitan areas across the country, addressing questions such as:

- What is the ozone level in my city today?
- How is the water quality at the beach today?
- What is the UV Index in my area today?

EMPACT projects aim to help communities:

- Collect, manage, and distribute time-relevant environmental information.
- Provide their residents with easy-to-understand, practical information they can use to make informed, day-to-day decisions.

Some projects were initiated directly by EPA; others were launched by communities with the help of EPA-funded "Metro Grants." EMPACT projects helped local governments build monitoring infrastructures and disseminate environmental information to millions of people.

EMPACT projects have been initiated in 156 metropolitan areas. These projects cover a wide range of environmental issues, such as groundwater contamination, ocean pollution, smog, and overall ecosystem quality. Having met the program goals, EMPACT ended in 2001. Many projects continue to provide realtime environmental information to local residents.

Recognizing that educating our youth is vital to the future of our planet, many EMPACT projects have incorporated curricula- or school-based components. The curricula are hands-on in their approach and complement the objectives of their associated EMPACT projects. Therefore, the activities and lessons either involve the utilization of monitoring data collected under a particular project or encourage student monitoring to assist project efforts.

1.2 What Is the Purpose of This Handbook?

This handbook is designed to provide teachers and other educators with guidance on how to teach students about environmental issues related to air, water, and soil quality. It provides information to help educators incorporate environmental education into the classroom. The handbook is organized as follows:

- **Chapter 2: How Do EMPACT Programs Work in Schools** discusses why environmental education is important, how to incorporate the lessons and ideas highlighted in this handbook into age-appropriate curricula, and how to identify quality environmental education materials.

- **Chapter 3: Teaching the Teacher–How Do I Make an EMPACT on My Students?** provides background information on air, water, and soil and why we should be concerned about the quality of these substances.

- **Chapter 4: Air-Based Projects** covers the air-based EMPACT projects and their curriculum components.

- **Chapter 5: Water-Based Projects** covers the water-based EMPACT projects and their curriculum components.

- **Chapter 6: Land-Use and Soil-Based Projects** covers the land- and soil-based EMPACT projects and their curriculum components.

This handbook can assist educators in designing lesson plans and activities to teach the principles of environmental science. It highlights a host of EMPACT projects that have developed or are developing curricula or other classroom materials to foster student learning. The highlighted projects cover a variety of grade levels (see Appendix C: Activities by Grade Level). Therefore, this handbook can be used by any teacher, from kindergarten through grade 12. In addition, college-level materials have been developed for some projects. Moreover, in most cases, the activities and lessons geared towards one particular grade can easily be adapted for others. Teachers and educators can review the project descriptions and read about the activities, lesson plans, and tools they employ to develop ideas for their own classrooms. In addition, the handbook includes resources and contact information and in some cases a Web site where lesson plans and activities can be accessed directly.

This handbook also references supplementary sources of information, such as Web sites, publications, organizations, and contacts, that can help the user find more detailed guidance. (See Appendix A: Additional Resources)

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2.0 How Do EMPACT Programs Work in Schools?

2.1 Environmental Education—Why Teach Students About the Environment?

Environmental information is important because itaffects our daily lives. For example, if you know the air quality is poor on a particular day, you might choose to skip your daily jog or exercise early in the morning when air quality is usually better. Environmental education typically incorporates aspects of economics, culture, politics, and social equity, as well as natural processes and systems. Teaching young people about the environment can help them see the many ways in which people affect the world around them by their actions today, which have consequences for the future health of the environment.

Environmental education can foster in children of all ages an awareness and sensitivity to the natural world, inspiring students to increase their knowledge of the environment, identify environmental challenges, and become motivated about resolving these challenges.

Learning about environmental challenges can also show students first-hand how their individual and collective actions can affect their own health, the environment, the country, and society as a whole. As a result, learning about the environment can help young people make informed day-to-day decisions, influence their peers and caregivers, and grow up to be better citizens.

2.2 Lesson Creation 101—How to Incorporate EMPACT Lessons and Ideas Into Age-Appropriate Curricula

The EMPACT tools described in this handbook use real-time technologies to help develop children's research and reasoning skills. Lessons focus on inquiry-based, hands-on learning. Students not only learn about environmental issues but also are encouraged to explore how feelings, experiences, attitudes, and perceptions influence these issues. This type of teaching helps students develop the critical-thinking, problem-solving, and team-working skills needed in today's technology-driven world.

EMPACT lessons typically use hands-on, laboratory-based approaches, such as those favored by groups like the National Science Teachers Association (NSTA) and the National Science Foundation (NSF). As such, they often fit best in a science curriculum, but they are also often multidisciplinary, so that the lessons can be incorporated into many different subject areas.

While science forms the foundation for many of the EMPACT lessons in this handbook, social science, health, language arts, math, and other subjects are also

Reducing the Risks

Children can be exposed to a number of environmental hazards in their homes, schools, and playgrounds—from tobacco smoke to lead-based paint. Environmental education can help raise teacher, parent, and student awareness of these risks, thereby helping to reduce children's exposure to these hazards over time.

For example, asthma is currently the most common chronic childhood illness in the United States. Over the past 15 years, major advances have been made in understanding the complex interplay between asthma, environmental exposures, and other factors.

This knowledge is helping

covered, as they are critical to fully understanding environmental issues and their impacts on society. (See Appendix D: Activities by Subject.)

pediatricians, schools, children, and their caregivers take steps to not only mitigate asthma triggers, but also to learn how to manage this illness on a day-to-day basis (i.e., on high ozone days, asthmatics should not play outside).

For example, the Northeast Ohio (NEO) EMPACT project teaches students about air quality and urban sprawl through a set of 10 hands-on exercises and science experiments. Also included in the lessons are activities that develop language arts skills, such as composing a letter about acid rain for local legislators or completing air quality word searches and crossword puzzles.

The tools referenced in this handbook also serve a range of ages and grades. EMPACT lessons at the primary grades are designed so that younger children can explore the environment and learn basic concepts. At the higher grades, children perform increasingly more sophisticated experiments and data gathering and interpreting tasks.

For example, in the ECOPLEX curriculum (K-8), kindergartners take ultraviolet-sensitive beads outside to see how the beads change colors, thereby discovering where and when the sun's ultraviolet rays are strongest. At the third grade level, students use construction paper and colored pattern blocks to learn how oxygen is converted to ozone. Eighth graders learn how chlorofluorocarbons (CFCs) contribute to ozone depletion through chemistry experiments that demonstrate how compounds separate in a chemical reaction.

A number of the EMPACT tools described in this handbook teach global issues via a local or regional environmental problem; others have a national scope, and some projects reinforce the national scope by enabling students to exchange data and observations with other classrooms across the country.

Finally, most EMPACT lessons have been developed with the help of both technical and curriculum experts, ensuring their accuracy and applicability to state and national education standards.

2.3 Making the Grade—How to Identify and Use Quality Environmental Education Materials

EMPACT tools, like all quality environmental education materials, encourage exploration. Acquiring information changes from a static to active learning process. Students participate in defining goals, gaining knowledge, and presenting results in a variety of formats.

How can schools recognize and use quality environmental education materials? According to the North American Association for Environmental Education (NAAEE), quality environmental education materials should possess six key characteristics, as listed below. It is useful for educators to be aware of these characteristics and to reinforce them in the classroom when teaching students about the environment.

#1 Fairness and accuracy. Environmental education materials should be fair and accurate in describing environmental problems, issues, and conditions, and in reflecting the diversity of perspectives on them. Materials should have factual accuracy, a balanced presentation of differing viewpoints and theories, openness to inquiry, and reflection of diversity.

#2 Depth. Environmental education materials should foster awareness of the natural and built environment, an understanding of environmental concepts, conditions, and issues, and an awareness of the feelings, values, attitudes, and perceptions at the heart of environmental issues, as appropriate for different developmental levels. Materials should focus on concepts that are set in a context that includes social and economic as well as ecological aspects and demonstrate attention to different scales.

#3 Emphasis on skills building. Environmental education materials should build lifelong skills that enable learners to prevent and address environmental issues. Materials should encourage the use of critical thinking and creative skills. Students should learn to arrive at conclusions about what needs to be done based on thorough research and study and should gain basic skills to participate in resolving environmental issues.

#4 Action orientation. Environmental education materials should promote civic responsibility, encouraging learners to use their knowledge, personal skills, and assessments of environmental issues as a basis for environmental problem solving and action. Materials should instill a sense of personal stake, responsibility, and self-efficacy.

#5 Instructional soundness. Environmental education materials should rely on instructional techniques that create an effective learning environment. Instruction should be learner-centered—materials should offer different ways of learning, and there should be a connection to everyday life. In addition, learning should occur in environments that extend beyond the boundaries of the classroom, and materials should recognize the disciplinary nature of environmental education. The goals and objectives of the materials should be clear, the materials should be appropriate for specific learning settings, and they should include a means for assessing learner progress.

#6 Usability. Environmental education materials should be well designed and easy to use. Materials should be clear and logical to both educators and learners, inviting and easy to use, long-lived, adaptable, and accompanied by instruction and support. In addition, materials should make substantiated claims and fit in with national, state, or local requirements.

For more information on NAAEE's *Environmental Education Materials: Guidelines for Excellence*, visit http://www.naaee.org.

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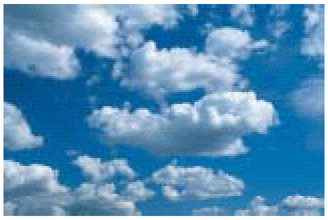
3.0 Teaching the Teacher: How Do I Make an EMPACT on My Students?

3.1 Air



Why should we be concerned about air quality?

Air quality in many U.S. cities is being degraded by human activities such as driving, chemical manufacturing, the burning of fossil fuels, and other industrial and commercial operations. Air pollution also comes from smaller, everyday activities such as dry cleaning or filling your car with gas. As more people drive vehicles, require more electricity, and conduct other activities, more gases and particles are added to the air we breathe. This pollution can reach levels dangerous to humans and the environment.

While air pollution poses a health risk to all humans, it is especially dangerous for children and people with respiratory illnesses. The biggest air pollution-related health threat to children is asthma. Other problems associated with high levels of air pollutants, such as ozone, include irritated eyes or throat or breathing difficulties. Air pollution also contributes to acid rain, smog, haze, and climate change, all of which can drastically affect the environment.

Why should we be concerned about ultraviolet (UV) radiation?

The sun produces three types of UV radiation, much of which is absorbed by the Earth's atmosphere. However, UVA and some UVB are not absorbed and can cause sunburns and other health problems. UV radiation exposure has been linked to health effects including: skin cancers such as melanoma; other skin problems such as premature aging; cataracts and other eye damage; and immune system suppression. Many of these problems, however, can be prevented with proper protection from UV radiation.

Additional EPA resources

- EPA's Office of Air and Radiation: http://www.epa.gov/oar/.
- EPA's Clean Air Markets Web site has information on acid rain: http://www.epa.gov/airmarkets/acidrain/index.html.
- EPA's Office of Transportation and Air Quality has information on air pollution caused by mobile sources: http://www.epa.gov/otaq/.
- EPA's SunWise School Program has information on UV radiation and sun protection: http://www.epa.gov/sunwise.
- EPA's Web site for teachers: http://www.epa.gov/teachers.
- EPA's Air Web site for kids includes information, activities, and games about various issues:

http://www.epa.gov/kids/air.htm.

3.2 Water

Why should we be concerned about water quality?

Perhaps the most important problem facing U.S. water bodies today is nonpoint source (NPS) pollution—pollution from many diffuse sources as opposed to one distinct source. NPS pollution is caused by rainfall or snowmelt picking up, carrying, and eventually depositing pollutants into lakes, rivers, wetlands, coastal waters, or underground sources of drinking water. These pollutants include: fertilizers, pesticides, and animal wastes from agricultural lands and residential areas; oil, grease, salts, and toxic chemicals from urban runoff; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks; minerals from abandoned mines; bacteria and nutrients from livestock, pet wastes, and faulty septic systems; and atmospheric deposition, such as acid rain.

Urban runoff can pose a dual threat to water quality. Natural areas such as forests and wetlands absorb rainwater and snowmelt so that it slowly filters into the ground, reaching waters gradually. In contrast, urban landscapes contain nonporous surfaces like roads, parking lots, and buildings that cause runoff containing toxic oil and grease to increase. Adding to this problem are storm sewer systems that channel large volumes of quickly flowing runoff into a water body, eroding streambanks and damaging streamside vegetation. Native fish and other aquatic life cannot survive in urban streams because of the urban runoff.

Another type of NPS pollution, acid rain deposition, also greatly impacts freshwater environments. When the rate of acids entering lakes and streams is faster than the rate at which the water and surrounding soil can neutralize it, the water becomes acidic. Increased acidity and its associated chemical reactions are highly toxic to many species of fish, insects, plants, and other aquatic species.

NPS pollution has led to beach closures, unsafe drinking water, fish kills, and other severe environmental and human health problems. For example, a large increase of nitrates in drinking water can pose a threat to young children, causing a condition known as “blue baby syndrome.” If left untreated, the condition can be fatal. Even adults can be affected by continuous exposure to microbial contaminants at levels over EPA’s safety standards. When this occurs, people can become ill, especially if their immune systems are already weak. Examples of the chronic effects of drinking water contaminants are cancer, liver or kidney problems, or reproductive difficulties.

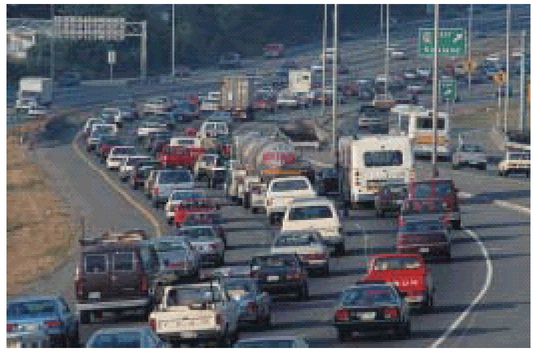
Additional EPA resources

- EPA’s Office of Water homepage: http://www.epa.gov/OW/index.html.
- EPA’s Office of Water Nonpoint Pollution page: http://www.epa.gov/owow/nps.
- EPA’s Office of Water Quality page: http://www.epa.gov/ow/national/.
- EPA’s Web site for teachers: http://www.epa.gov/teachers.

3.3 Soil and Land

Why should we be concerned about soil quality?

Soil contamination is a result of either solid or liquid



hazardous substances mixing with the naturally occurring soil. Plants can be damaged when they take up contaminants through their roots. Contaminants in the soil can adversely impact the health of animals and humans when they ingest, inhale, or touch contaminated soil, or when they eat plants or animals that have been exposed to contaminated soil. Animals ingest and come into contact with contaminants when they burrow in contaminated soil. Humans can be exposed to toxic elements when they farm, handle, and distribute food and non-food crops. Young children are especially at risk when they play, ingest, or dig in contaminated soil. Certain contaminants, when they contact our skin, are absorbed into our bodies. When contaminants are attached to small surface soil particles they can become airborne as dust and can be inhaled.

Soil contamination can be caused by industrial and chemical byproducts seeping into the soil, spreading metallic substances such as lead, chromium, arsenic, and cadmium. This contamination can also occur from lead-based paints, irrigation, solid waste disposal, fertilizers, and pesticide application. Leaded paint continues to cause most of the severe lead poisoning in children in the United States. It has the highest concentration of lead per unit of weight and is the most widespread of the various sources, being found in approximately 21 million pre-1940 homes. Dust and soil lead—derived from flaking, weathering, and chalking paint—plus airborne lead fallout and waste disposal over the years, are the major sources of potential childhood lead exposure.

Why should we be concerned about land resources?

One of the most pressing land issues in America today is urban sprawl. Sprawl is “the unplanned, uncontrolled spreading of urban development into areas adjoining the edge of a city” (Source: Dictionary.com). This translates to a conversion of rural areas, such as forests and farmlands, into single family homes and strip malls. This type of development uses land inefficiently and increases vehicle miles traveled as people spend more time commuting to and from work.

Another issue affecting American landscapes is that of brownfields and Superfund sites. Superfund is a program administered by EPA to clean up areas where the dumping of chemical and other hazardous wastes might be affecting public health and the environment. Brownfields—abandoned or underutilized industrial or commercial properties with possible environmental contamination—are one type of Superfund site. The cleanup and possible development of brownfields will remove environmental hazards from, and increase the economic well-being of many communities.

Additional EPA resources

- Information on EPA’s Superfund Program: http://www.epa.gov/superfund/index.htm.
- Extensive information on brownfields, urban redevelopment news, and resources: http://www.brownfields.com.
- The Trust for Public Land, an organization devoted to land conservation: http://www.tpl.org.
- Information on brownfields on EPA’s Web site: http://www.epa.gov/swerosps/bf/index.html.

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4.0 Air-Based Projects

4.1 Teacher Tips

Air Quality Index (AQI)*

AQI Number	Health Concern	Color Code
0 to 50	**Good**	**Green**
51 to 100	**Moderate**	**Yellow**
101 to 150	**Unhealthy for sensitive groups**	**Orange**
151 to 200	**Unhealthy**	**Red**
201 to 300	**Very unhealthy**	**Purple**

*Although ozone reports are primarily made for metropolitan areas, ozone can be carried by the wind to rural areas, where it can cause health problems.

Local air quality affects how we live and breathe. Like the weather, it can change from day to day or even hour to hour. EPA and other organizations make information about outdoor air quality as available to the public as information about the weather. A key tool in this effort is the Air Quality Index (AQI). EPA and local officials use the AQI to provide the public with timely and easy-to-understand information on local air quality. The AQI tells the public how clean or polluted the air is and what associated health concerns they should be aware of. The AQI focuses on health effects that can happen within a few hours or days of breathing polluted air. EPA uses the AQI for five major air pollutants regulated by the Clean Air Act—ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect against harmful health effects. The AQI uses a scale of values to indicate the level of health concern and associated color-coded warning. Many EMPACT projects that focus on air quality involve monitoring and collecting near real-time data for the AQI pollutants. In addition, some air projects monitor data related to ultraviolet (UV) radiation, due to its association with stratospheric ozone depletion. For more information on the AQI, go to depletion, go to http://www.epa.gov/ozone.

The following are the most common pollutants for which air data is monitored and collected and a description of why the information is important. Throughout this section of the handbook you will read about how this air quality data plays a role in various EMPACT curricula.

- **Ozone (O_3):** Ozone is an odorless, colorless gas composed of three atoms of oxygen. It occurs both in the Earth's upper atmosphere (the stratosphere) and at ground-level. The ozone in the stratosphere is considered "good" ozone because it forms a protective layer that shields us from the sun's harmful UV rays. This ozone is gradually being destroyed by manmade chemicals, such as chlorofluorocarbons. A tool called the UV Index measures the intensity of the sun's rays and can help you plan outdoor activities safely.

  At ground level, ozone is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight. Ground-level ozone is unhealthful and is especially problematic during summer months when it is sunny and hot. Ozone can irritate the respiratory system, causing coughing, throat irritation, and/or an uncomfortable sensation in the chest. High risk groups include children or anyone who spends a lot of time outdoors in warm weather and people with respiratory diseases.

- **Particulate matter:** Particulate matter (PM) includes both solid particles and liquid droplets found in the air. Many manmade and natural sources emit PM directly or emit other pollutants that react in the atmosphere to form PM. These particles range in size, with those less than 10 micrometers in diameter posing the greatest health concern because they can be inhaled and accumulate in the respiratory system, causing health problems. Particles less than 2.5 micrometers in diameter are referred to as “fine” particles, and sources include all types of combustion. Particles between 2.5 and 10 micrometers are consider “coarse,” and sources include crushing or grinding operations and dust from roads. Coarse particles can aggravate respiratory conditions such as asthma, and exposure to fine particles is associated with several serious health effects, including premature death.

- **Carbon monoxide:** Carbon monoxide (CO) is a colorless, tasteless, odorless gas that forms when the carbon in fuels does not completely burn. The major sources of CO pollution include cars, trucks, and buses; airplanes; trains; gas lawnmowers; snowmobiles; power plants; trash incinerators; and wildfires. CO concentrations are usually highest during cold weather because cold temperatures make combustion less complete and cause inversions that trap pollutants low to the ground. When CO is breathed, it replaces the oxygen that we normally breathe, which deprives the brain and heart of this necessary element. As a result, when exposed to CO, a person might notice shortness of breath or a slight headache. People with cardiovascular disease are most sensitive to risk from CO exposure, and in healthy individuals, exposure to higher levels of CO can affect mental alertness and vision.

- **Sulfur dioxide:** Sulfur dioxide (SO_2) is a colorless, reactive gas that is produced during the burning of sulfur-containing fuels such as coal and oil, during metal smelting, and by other industrial processes. Major sources include power plants and industrial boilers. Children and adults with asthma who are active outdoors are most vulnerable to the health effects of SO_2. The primary response to even a brief period of exposure is a narrowing of the airways, which may cause symptoms such as wheezing, chest tightness, and shortness of breath. When exposure ends, lung function typically returns to normal within an hour. At high levels, SO_2 may cause similar symptoms in non-asthmatics.

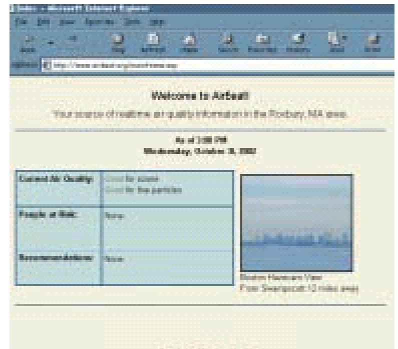
- **Nitrogen dioxide:** Nitrogen dioxide (NO_2) is a reddish-brown, highly reactive gas formed when nitric oxide combines with oxygen in the atmosphere. Once it has formed, NO_2 reacts with volatile organic compounds (VOCs), eventually resulting in the formation of ground-level ozone. Major sources of NO_2 include automobiles and power plants. In children and adults with respiratory disease, such as asthma, NO_2 can cause respiratory symptoms such as coughing, wheezing, and shortness of breath. In children, short-term exposure can increase the risk of respiratory illness.

4.2 The Tools

4.2.1 AirBeat (Roxbury, Massachusetts)

Introduction

The AirBeat EMPACT project centers around an air monitoring system—the first of its kind in Massachusetts. The monitoring system, which is sustained by a collaboration of universities, governments, and community organizations, enables residents to check real-time air pollution levels via a telephone hotline or the AirBeat Web site at http://www.airbeat.org. AirBeat measures ground-level ozone and fine particle pollution and focuses on



reducing the health effects they have on Roxbury residents, who suffer from high rates of asthma and other respiratory illnesses.

Lessons, Tools and Activities

Part of the outreach for AirBeat involves educating teachers and students about air quality and its health and environmental effects. Alternatives for Community and Environment (ACE)—a local nonprofit organization—integrated air monitoring into its environmental justice curriculum for local schools by developing an air quality flag warning system that is managed by a local school. Students use AirBeat data to assess air quality on a daily basis and hang flags that correspond to air quality at two locations. The flags advise Roxbury residents about air quality so they can take precautions if they suffer from asthma or other illnesses.

ACE also visits classrooms to administer its air pollution curriculum module, which includes these lessons:

- *How to Build Your Own Black Carbon Monitor*, adapted from the Lawrence Berkeley National Laboratory, teaches students to build a black carbon monitor from commonly available items and analyze its measurements.
- Students distribute the *Survey of Air Pollution Awareness* to local residents, then analyze the results to gauge residents' knowledge of air pollution and asthma.

Resources

For more information, contact Jodi Sugerman-Brozan of Alternatives for Community and Environment at 617 442-3343, ext. 23, or jodi@ace-ej.org and visit the AirBeat Web site at http://www.airbeat.org, where the above lessons can be downloaded.

4.2.2 Air CURRENTS (New York and New Jersey)

Introduction

Air CURRENTS is a curriculum designed to educate middle and high school students about air, air pollution, and air monitoring techniques. The project's name, which stands for Collaboration of Urban, Rural, and Regional Environmental Networks of Teachers and Students, reflects its focus on teachers, students, and learning. The curriculum emphasizes a hands-on, problem-solving approach, after which students implement what they've learned to make changes in the community or region. Teachers and students, in collaboration with community groups, use a portable air monitoring system to do outdoor air monitoring studies in their schools and communities. However, the curriculum can be taught with or without employing the air monitor.

The goal of the Air CURRENTS project is to provide the tools and information necessary for students, teachers, and community-based groups to obtain a general assessment of the air quality in their neighborhoods. Additional goals of the Air CURRENTS program are to integrate environmental learning into core math, science, and social studies curricula; engage students and teachers in scientifically meaningful air monitoring projects; use the Internet to connect participating schools to one another and to resources for air quality and health effects information; and work with schools to aid in developing a community understanding of the complexities of local environmental problems.

The development of the Air CURRENTS curriculum was a collaboration of state and federal agencies, universities, community-based organizations, and educators. The project was managed by Northeast States for Coordinated Air Use Management (NESCAUM), whose purpose is to exchange technical information and to promote cooperation and coordination of technical policy issues among member states. EPA provided a portion of the funding through the EMPACT program to bring the Air CURRENTS curriculum to four EMPACT cities: Buffalo and Brooklyn, NY, and Camden and Newark, NJ.

Lessons, Tools, and Activities

The Air CURRENTS curriculum helps students in grades 6 through 12 understand the causes, consequences, and political complexities of managing air quality. The curriculum is extensive. It contains over 30 consecutive lessons that complete what the Air CURRENTS educators refer to as the full "Science-Technology-Society" (STS) circle. Students complete the STS circle in three steps: (1) gain an understanding of the scientific concepts related to air quality through hands-on laboratory investigations; (2) collect and analyze data after mastering the use of an air quality monitor; and, (3) take appropriate social advocacy actions to support their data and conclusions. Educators believe that since the curriculum actively engages students in a process, it allows them to intimately understand various points of view, so they can create a well-informed opinion about air quality issues for themselves.

The first part of the curriculum introduces important concepts about air—proving that it exists and can be measured, even though students cannot see it.

Students learn about particulate matter and gases such as carbon monoxide. Lessons in the first section provide the conceptual framework for the use of the portable monitor in the second section. Students learn to operate and collect indoor and outdoor air quality data using the ACCESS™ (A Computerized Community-based Environmental Sampling System) portable air quality monitor. After developing a scientific hypothesis and testing it by collecting air quality data using the ACCESS system, students then analyze their data and develop reports describing their findings. While the Web site was active, students posted data files or reports on the Air CURRENTS Web site to share with other students. Students can create a report from a downloaded data file by using the ACCESS™ software from PAX Analytics. Finally, students learn a series of lessons in science, social studies, language arts, math, and arts to complete an advocacy program they could undertake in their community.

Although the curriculum is designed to be used with a portable monitor, the monitor is not required, and segments of the curriculum offer valuable lessons by themselves. The Air CURRENTS curriculum can be taught by a team of teachers across disciplines, but has the flexibility to be taught by science or social studies teachers alone. At the middle school level, the most effective model for this curriculum is where students have designated times for subject areas. At the high school level, teachers have worked in teams of two, either team teaching or working in a parallel model. The environmental sciences are the obvious choices for these curricula, where it can be a self-contained two- to three-month unit, but schools have implemented it into American government, economics, and technology courses.

The Air CURRENTS curriculum utilizes a constructivist approach, which requires teachers to foster an environment for inquiry-based learning. The constructivist approach is based on the premise that human nature dictates that we construct our own understandings of the world in which we live. This approach allows students to actively interact with objects and ideas to test their own preconceptions; then, through reflection of those interactions, develop an understanding. Teachers should establish cooperative learning groups, in which the constructivist model works well. Cooperative learning creates a structured natural environment that promotes collaboration. The teacher, or facilitator in this approach, floats from group to group, to provide guidance as well as ask thought-provoking questions that may encourage their investigations. Students who are exposed to the constructivist model should be given time and space to reflect. Therefore, teachers should encourage students to keep ongoing journals and have an opportunity to reflect on, modify, and redesign their investigations while they are not actively involved in them.

Resources

For more information, or to order a copy of the Air CURRENTS curriculum, contact Susan Green at NESCAUM at 617 367-8540. The NESCAUM Web site http://www.nescaum.org has additional information but does not offer the curriculum for downloading. NESCAUM exchanges technical information and promotes cooperation and coordination of technical policy issues regarding air quality control among member states. They sponsor air quality training programs, participate in national debates on air quality, assist in the exchange of information, and promote research.

The Air CURRENTS Web site http://www.aircurrents.org identifies partners and provides a form for completing the project plan, which can be submitted for review.

4.2.3 Air Info Now: Environmental Monitoring for Public Access and Community Tracking (Pima County, Arizona)

Introduction

The Air Info Now project provides current air quality information for the metropolitan Tucson area. The Web site http://www.airinfonow.com was developed under an EMPACT grant along with assistance from the University of Arizona, The American Lung Association, and the Pima Association of Governments. The project site provides information on air pollutants, their health effects, activities to help in understanding air pollution, and historic and current monitoring data.

Tucson, Arizona, is an urban area with a strong public appreciation for and commitment to the surrounding natural environment. The public has shown increasing concern over air pollution, both in terms of individual health and potential environmental impacts in the mountains and high desert lands that are valued locally and worldwide for their pristine condition. Many residents move to the area to alleviate health problems, and therefore, the area has a higher than average percentage of residents who are sensitive to air pollutants. In addition, there are economically disadvantaged areas within the city that have higher documented rates of asthma in children, so the timely dissemination of air pollution data is especially important.

The overall objective of the Air Info Now project is to produce media and public communication programs about air quality, the Tucson environment, health concerns, and local solutions to improve air quality. Other objectives of the project include the following:

- Collecting and disseminating accurate, understandable, and timely air pollution information.

Expanding associated outreach and education programs to improve understanding of the relationships between air quality, climate, and health effects.

- Allow the community to address local air pollution problems and solutions based on credible scientific information.

The project employs 80 instruments at 18 air monitoring sites throughout the Tucson metropolitan area. In addition to monitoring carbon monoxide, ground-level ozone, sulfur dioxide, nitrogen oxides, and particulate matter (PM10 and PM 2.5), for which EPA has National Ambient Air Quality Standards, the project monitors various meteorological parameters that affect air pollution. These parameters include wind speed, wind direction, temperature, relative humidity, and UV radiation.

Lessons, Tools, and Activities

The Air Info Now project has developed several sets of activities and experiments designed to teach students about pollution prevention, the relationship between air quality and health, and data analysis. The classroom activities offer older students the opportunity to study the health risks that come from ambient airborne pollution in Tucson. The Web site also includes accompanying teacher guides.

Activities (Grades 7 to 12):

Through real-time data collection activities, students learn to analyze and interpret the real-time air quality data that is collected and displayed by the Air Info Now project site. Pollutants investigated include ground-level ozone, carbon monoxide, and particulate matter, and parameters include weather and climate (temperature, wind, rainfall), asthma attacks, visibility, time, and location. Students learn data collection and analysis techniques through practice with Excel spreadsheets and principles of statistics. Students are separated into groups, each representing a different aspect of air pollution. For example, one group represents “location” and tries to identify pollution trends according to location around a city. Another group represents “health effects,” and they monitor the occurrences of asthma at several schools to see if there is a correlation with air pollution.

Students regularly share their data with their classmates and summarize their findings in a final paper or project that can be shared with the community.

Experiments (Grades 4 to 12):

Students construct and deploy particulate pollution detectors to test hypotheses: for example, older vehicles and those using leaded or diesel fuel will produce more particulate matter emissions. Students learn to identify gaseous and solid pollutants in the atmosphere; observe an experiment that illustrates how to capture particulate pollutants and identify which vehicle emits more pollutants; and conduct an experiment capturing particulate pollutants and determine which locations appear to have more pollution.

Students make smog in a shoe box or aquarium to demonstrate convection currents and temperature inversion layers and discuss the implications for pollution. They also monitor their family’s energy consumption, calculate the amount of carbon dioxide produced, and discover how changes in consumption can affect the amount of pollution and greenhouse gases released.

The Air Info Now Web site also includes several online interactive games for kids that require Macromedia Flash Player.

Resources

For additional information on the Air Info Now project in Pima County or the associated student activities and teacher guides, contact Beth Gorman at Pima County Department of Environmental Quality (PDEQ), 520 740-3343 or bgorman@deq.co.pima.az.us. You can download the student activities and experiments, as well as the teacher guides, directly from the Air Info Now Web site at http://www.airinfonow.com. Click on Activities for online games and experiments, and click on Teachers for the data collection activities and teacher guides.

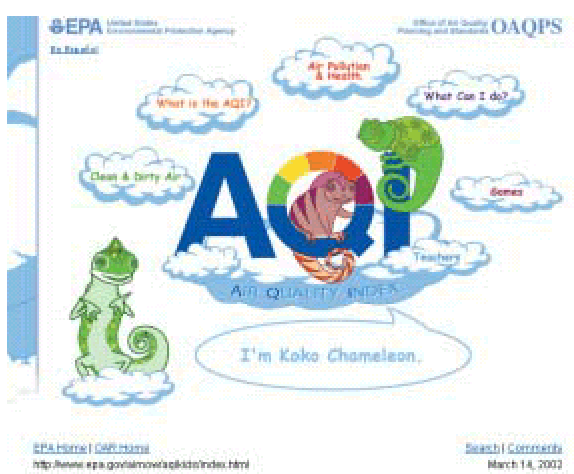
4.2.4 AIRNow (National)

Introduction

Through its Web site, the AIRNow program offers access to daily air quality forecasts as well as real-time air quality data for over 100 cities across the United States. While many EMPACT programs provide the public with easy access to local air quality information, the AIRNow Web site was developed by EPA to offer real-time air quality information for both regional and local areas across the United States and parts of Canada. For example, color maps show ozone levels across a specific regional geographic area. Plus, AIRNow displays air quality forecasts (good, moderate, unhealthy for sensitive groups, unhealthy) for “air action days” in major metropolitan areas around the country. Users can view local or regional air quality information such as ozone maps and air quality forecasts and learn more about how they should adjust their outdoor activity level when air quality is forecast to be poor. The Web site links to more detailed state and local air quality Web sites.

A central component to the daily air quality forecast is the Air Quality Index, or AQI. (See Section 3.1 for more on AQI.) The AIRNow Web site uses the AQI categories, colors, and descriptors to communicate information about air quality. Increasingly, TV, radio, and newsprint forecasters are providing information using the AQI. During summer months, for example, you may learn that it is a code red day for ozone, meaning the air quality is unhealthy. But how do you know what this means? Parents can learn by visiting the AIRNow Web site and reading about the AQI. To help teach children how to read and understand the AQI, the Web site offers an online and downloadable curriculum for school-aged children.

Lessons, Tools, and Activities



The AIRNow curriculum is geared toward children 7 to 10 years old. EPA developed more ozone segments for the 2002 ozone season (May through October), aimed at those 5 to 6 years old, as well as those 7 to 10 years old. A Spanish version of the current curriculum was launched in March 2002. The AIRNow lessons can be used online or teachers can print a text version of the Air Quality Index Kid’s Web site and curriculum for classroom use. The kids page includes two animated online games that can also be printed. The animated version requires a Flash 5 plug-in player, which is available on the Web site.

Lessons (Grades 2 to 5):

The Kids section of the AIRNow Web site is hosted by an animated trio of chameleons: K.C. Chameleon, Koko Chameleon, and Kool Chameleon. Kids navigate through four topic areas, learning about the AQI, clean and dirty air, and how health is affected by breathing dirty air. By viewing an animated cartoon, kids learn that ozone is formed by a combination of pollution and sunlight. They also learn where soot and dust come from and how particulate matter is formed. Once they learn about pollutants and how they affect our bodies, they learn how EPA and local governments present this information to the public using the AQI.

By navigating different parts of the AIRNow Web site, kids find the AQI forecast and an ozone map for their area. They learn the numbers, colors, and words that the AQI uses to describe air quality. By learning to identify groups that are sensitive to ozone—asthmatics, children, and the elderly—they can read an AQI forecast and understand what those groups should do differently on poor air quality days. Finally, kids learn what they can do to reduce pollution and improve air quality.

As kids navigate, they have the opportunity to explore and further their learning. As they encounter new words, each page links to a dictionary of air pollution related words such as “global”, “pollution”, and “smog”. They also learn where on the Web site they can view ozone maps covering their local area. The Web site includes two games: AQI Color Game and the AQI Game Show. The AQI color game contains three levels of difficulty, from the easier word and color connecting game, to the more challenging game, in which an AQI numerical value is given and kids must look up the corresponding color.

In the AQI Game Show, three chameleons play the contestants, answering multiple choice questions about AQI and health. Kids click on the chameleon with the correct answer, and the game automatically keeps score. The online version includes 10 questions and the printed version includes 27 questions. The answers are provided and both games can be downloaded and played on hard copies.

From the AIRNow Web site, teachers can print colorful posters for each of the five most common color codes of the AQI. For each color code, one of the chameleons tells kids what level of outdoor activity is recommended for them that day. The posters will print in color on a color printer. For schools without color printers, a good exercise could be to color the posters the correct color. Teachers can contact the AIRNow program to request color copies.

Resources

For more information on AIRNow, contact John E. White of EPA at 919 541- 2306 or at white.johne@epamail.epa.gov. The entire curriculum can be downloaded from the AIRNow Web site at http://www.epa.gov/airnow/aqikids/teachers.html.

4.2.5 Community Accessible Air Quality Monitoring Assessment (Northeast Ohio)

Introduction

The Northeast Ohio (NEO) EMPACT project focuses on developing an improved air monitoring data and network system and creating a land-use data and ecological computer modeling tool. The latest technology provides communities with real-time air quality reports. These help citizens make informed decisions on everyday quality of life issues such as environmental and health concerns that accompany urban living and growth. The NEO EMPACT air quality project also conducts community outreach to inform citizens about NEO air quality programs and resources.

Lessons, Tools, and Activities

As part of the NEO EMPACT project, a handbook was developed to introduce teachers and students to the importance of understanding air quality in their communities. Air Quality in Northeast Ohio is arranged in thematic and developmental order to provide students with a comprehensive understanding of air quality and its effects on health and the environment.

The 85-page handbook for educators and 4th through 8th grade students includes detailed background information, lessons, and activities focused on air quality. It progresses from conceptually developing an understanding of air quality to discussing concrete actions students and teachers can take to improve air quality. The main sections of the handbook include:

- **Educator's Notes** includes background information that prepares educators to administer the lessons and exercises in the handbook. The section describes air pollution, its origins, and its health and environmental effects. It also contains information on the Clean Air Act, specific pollutants (e.g., carbon monoxide, particulate matter), acid rain, and the effects that vehicles and weather have on air quality.

- The 10 **Experiments and Exercises** give students hands-on lessons in air quality. Geared towards specific grades, the exercises and experiments cover air quality vocabulary, visible and invisible air pollutants, smog, air pollution's effects on plants, and air quality data analysis and tracking.

- The **Internet-based Activities** teach students to access NEO EMPACT air quality data online.

- The **Air Quality Activities** focus on developing students' oral, visual, and writing skills. Activities include conducting a mock interview with an environmental professional, writing a clean air bill, composing a letter about acid rain for local legislators, completing air quality word searches and crossword puzzles, and designing air quality posters for display in the community.

- **Reducing Air Pollution—What Students Can Do** offers teachers and students some suggestions for reducing air pollution in the local community and at home.

- **Air Quality Resources and Materials for Educators** lists additional Internet, hard copy, and organizational resources for air quality information. It also includes ideas for no-cost educational materials and how to obtain them.

Resources

To obtain a free copy of the NEO Air Quality Curriculum Handbook, contact Adam Zeller of the Earth Day Coalition at 216 281-6468 or azeller@earthdaycoalition.org. For more information on the NEO EMPACT project, visit the NEO EMPACT Web site at http://empact.nhlink.net or the Northeast Ohio Air Quality Online Web site at http://neoair.noaca.ohiou.edu.

4.2.6 ECOPLEX (Dallas-Ft.Worth, Texas)

Introduction

Through the use of both innovative and proven environmental monitoring technologies, the ECOPLEX project collects real-time and time-relevant environmental data that informs citizens of the Dallas-Ft. Worth metropolitan area of current, historical, and near real-time forecasts of environmental conditions. The project involves a multimedia approach, collecting data related to air, water, soil, and weather. The data, as well as instructions on how to use it, are posted on the project's Web site at http://www.ecoplex.unt.edu.

Lessons, Tools, and Activities

As part of the ECOPLEX project, curricula were developed covering the topics of ultraviolet (UV) radiation, water quality, and water quantity. (See Section 5.0 Water-Based Projects for information on ECOPLEX water lessons.) The curricula are geared towards kindergarten through 8th grade and were completed in August 2001. Approximately 120 teachers in 37 schools have utilized the lesson plans included in the curricula.

Each lesson plan includes follow-on curriculum extensions, which explore the disciplines of math, language arts, technology, art and music, science, and social studies.

The air portion of the ECOPLEX curriculum introduces students to the dangers of UV rays and the connection to stratospheric ozone. Through simple, yet progressively challenging experiments, lessons, and activities, children in grades kindergarten through 3 learn ways to protect themselves from harmful UV rays and to develop a daily routine of UV protection, similar to brushing their teeth. Students learn about the shadow rule—if your shadow is taller than you, UV exposure is usually low, and if it is shorter than you, UV exposure is usually high—and ways to identify sun-safe areas on the playground. They are introduced to the ECOPLEX Web site and learn how to read the UV Index.

Children witness how UV rays are affected by the time of day and the seasons, and they learn to identify the layers of the atmosphere, discussing how stratospheric ozone is depleted. They develop plans for reducing their personal exposure to UV rays and set goals for how they can reduce the formation of ground-level ozone.

Students in grades 4 through 6 learn that stratospheric ozone blocks UV rays and that certain materials deplete this type of ozone. Using the UV meter, students determine the dangers due to UVA and UVB and measure UV levels throughout the day. Then they create a comparison between the UV meter readings and ECOPLEX UV data over a period of time, graphing the results. Students explore the electromagnetic spectrum, finding where UV light fits in, and they view the refraction of light using a prism, identifying the invisible rays: infrared, heat waves, and UV rays. Using bacteria culture, students observe which types of light best prevent bacteria growth. With their findings, students create an informative brochure to distribute to family and friends.

In grades 7 through 8, the ECOPLEX curriculum helps students understand how the angle of the sun on earth affects temperature. They conduct light experiments using a flashlight on a world map to mimic the sun on the earth, and they record their estimations of direct and indirect solar energy, demonstrating how direct solar energy is affected by the seasons and the time of day. Children learn about how chlorofluorocarbons (CFCs) destroy ozone through chemistry experiments and they become aware of how the use of certain products releases CFCs into the atmosphere.

Resources

For more information on the ECOPLEX UV curriculum, contact Ruthanne (Rudi) Thompson at rudi@unt.edu or 940 565-2994 and visit the ECOPLEX Web site at http://www.ecoplex.unt.edu. Click on the Teacher's Corner to download lessons as PDF files.

4.2.7 SunWise School Program (Nationwide)

Introduction

The SunWise School Program is a national environmental and health education program that aims to teach children in grades kindergarten through 8 and their caregivers how to protect themselves from overexposure to the sun. Through the use of classroom-based, school-based, and community-based components, SunWise seeks to develop sustained sun-safe behaviors in schoolchildren and foster an appreciation of the environment around them.

The program's leading components build on a solid combination of traditional and innovative education practices already in use in many U.S. elementary and middle schools. Through the program, students and teachers increase their awareness of the harmful effects of ultraviolet (UV) radiation and learn simple ways to protect themselves and their family. Children will also acquire scientific knowledge and develop an understanding of the environmental concepts related to sun protection.

The program encourages schools to implement a sun-safe infrastructure, including shade structures, such as canopies and trees, and policies, such as using hats, sunscreen, and sunglasses on a regular basis. Designed to provide maximum flexibility, the SunWise program elements can be used as stand-alone teaching tools or to complement existing school curricula. Registering to become a SunWise school can easily be accomplished on the SunWise Web site at http://www.epa.gov/sunwise.

Lessons, Tools, and Activities

A useful resource for SunWise school partners is the SunWise Tool Kit, which contains cross-curricular lessons and background information for kindergarten through 8th grades. The Tool Kit consists of a variety of fun, developmentally appropriate activities that combine education about sun protection and the environment with other aspects of learning. The SunWise Web site, a very helpful tool, provides downloadable information, storybooks, and activity books, some of which are available in Spanish. The SunWise curriculum includes age-appropriate, progressively challenging material to teach students of all levels the importance of sun protection.

Younger students in kindergarten through 2nd grade are introduced to the concept of UV rays and their potentially harmful effects, and they begin to learn simple ways to protect themselves from the sun. They make wacky sunglasses out of paper and cellophane in various colors to emphasize the importance of wearing sunglasses. Educators tell fun stories and legends about the sun and play interactive games like "Sunny Says," following the format of "Simon Says." Students learn which products at the store are sun safe, and they participate in activities such as shadow tracing, which introduces the importance of the "No shadow, seek shade" rule. Using maps, magazines, and photos of various places and peoples around the world, children learn that numerous societies practice sun safety in a variety of ways.

Intermediate students in 3rd through 5th grades perform word games such as word scrambles and crossword puzzles using keywords that emphasize sun safety and protection. The SunWise Tool Kit provides a special UV sensitive frisbee that changes color when exposed to UV radiation. As an experiment, students place different materials, such as tanning lotion and sunscreen, onto the frisbee and expose it to the sun. The students watch as the unprotected portions of the frisbee change color and the protected areas remain the same; they then record their findings on a data chart. Students have the opportunity to go on the Internet and discover the variety of existing sun myths, understanding how different cultures perceive the origins and history of the sun. They learn the difference between “good” and “bad” ozone, and perform experiments such as witnessing the sun’s effects on fruit and newspapers. They assess the risk factors of their own skin and put on a SunWise fashion show, identifying the differences between sun safe and unsafe clothes.

Students in grades 6 through 8 perform numerous activities that correspond to a variety of subjects. They brainstorm, using their creativity and imagination to write songs, public service announcements, and news stories exploring the risks of UV exposure. They create a puppet show to teach younger school kids about protecting themselves from the sun. They act as architects and submit a design proposal for a new SunWise playground. Through Internet searches, students deepen their understanding of the various cultures and myths around the world, going on virtual vacations, picking destinations and identifying sun safe items to pack in their suitcases. They research skin cancer statistics and interpret their findings state by state. They pretend they are Galileo or Copernicus and write journal entries about their beliefs and what the future will be like. Seasonal Affective Disorder (SAD), the disorder applied to people who suffer depression during winter, is explored and discussed, and students reexamine the benefits and the risks of sun exposure.

Resources

For additional information on the SunWise School Program, visit http://www.epa.gov/sunwise/ or contact Kristin Kenausis of EPA at 202 564-2289. Only K-8 schools who register for the program can receive the Tool Kit, but many other educational materials and publications are available for downloading from the Web site or from the clearinghouse (800 490-9198). Visit the “Publications” page on the SunWise Web site for more details.

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5.0 Water-Based Projects

5.1 Teacher Tips

Scientists that study lakes and reservoirs—limnologists—are interested in obtaining data for several water quality parameters. Many of these parameters can be measured remotely, without having to bring samples to a laboratory for analysis. The following are the most common parameters for which data is collected and a description of why the information is important. Throughout this section of the handbook you will read about how this water quality data is utilized in various EMPACT curricula.

- **Chlorophyll:** Chlorophyll are complex molecules found in all photosynthetic plants, including aquatic plants called phytoplankton. Chlorophyll allows plants to use sunlight as part of their metabolism. The distribution and concentration of phytoplankton is of major water quality and ecologic concern. Certain inputs of critical plant nutrients, such as phosphorus, can lead to excess concentrations of phytoplankton. Because the amount of phytoplankton affects the clarity and color of water in lakes and reservoirs, it is of concern to scientists and environmental managers. The most common method of determining the amount of phytoplankton in a body of water is to measure chlorophyll concentration, which is done either by using an analytical/instrumentation technique (e.g., spectrophotometer, fluorometer, high-pressure liquid chromatography) on filtered samples or using fluorescence technology, which allows for semi-quantitative measurement of chlorophyll in phytoplankton cells without extraction or chemical treatment, thereby allowing in situ (in-lake) measurements.

- **Turbidity:** Turbidity refers to the extent that water lacks clarity. It is therefore, tightly linked with the aesthetics and perception of water because the public wants water of high clarity for recreation. Turbidity is caused by a mixed population of suspended particles, which may include clay, silt, finely divided organic matter (detritus), phytoplankton, and other microscopic organisms. In general, these particles are a composite of sediments received from inflowing tributaries, resuspended sediments, and particles produced within the body of water (particularly phytoplankton). Thus, the variations in measured turbidity may reflect the dynamics of phytoplankton growth as well as tributary runoff (driven by rainfall events). Until recently, turbidity was measured using a nephelometer, where a beam of light is directed along the axis of a cylindrical glass cell containing the sample. Light scattered by particles from the beam is measured by a detector. New technology has led to the development of turbidity probes that can be constructed on remote sampling units. These probes are constructed in a similar manner as the nephelometer, except that the scattered light detector is located within the water as opposed to outside a glass sample cell.

- **Temperature:** Temperature is a measure of molecular vibrational energy. It has extremely important ecological consequences. Temperature exerts influence on aquatic organisms with respect to selection and occurrence and level of activity of the organism. In general, increasing water temperature results in greater biological activity and more rapid growth. All aquatic organisms have a preferred temperature in which they can survive and reproduce optimally. Temperature is also an important influence on water chemistry, as rates of chemical reaction increase with increasing temperature. Temperature regulates the solubility of gases and minerals (solids)—warm water contains less dissolved oxygen and more solids than cold water. Thermal stratification refers to the layering that occurs, particularly in the warm months. Typically, a warmer, less dense layer called the epilimnion overlies a colder, denser layer called the hypolimnion. In between these two layers is a third layer called the metalimnion where strong differences in temperature and density exist. Seasonal changes cause mixing of the layers. Usually, a thermometer is used to determine temperature, although when taking measurement below the surface, methods such as thermocouples and thermistors can be used. A thermocouple measures the current generated by two different metals at different temperatures. A thermistor measures voltage produced by a semi-conducting material that decreases in resistance with increasing temperature.

- **Conductivity:** Electrical conductivity is a measure of water's ability to conduct electricity, and is therefore a measure of the water's ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the conductivity. Wide variations in water temperatures affect conductivity, making it difficult to make comparisons of this feature across different waters, or changes in this parameter for a particular body of water. The use of specific conductance, which is the conductivity normalized to 25°C, eliminates this problem and allows comparisons to be made. Specific conductance is a reliable measure of the concentration of total dissolved solids (TDS) and salinity. It also is a valuable tracer of water movement. By definition, specific conductivity is the reciprocal of the specific resistance of a solution measured between two electrodes (opposite electrical charges) placed in the water. For a known electrical current, the voltage drop across the electrodes reveals the water's resistance. Since the resistance of aqueous solution changes with temperature (resistance drops with increasing temperature), the resistance is corrected to the resistance of the solution at 25°C.

- **Dissolved Oxygen:** The concentration of dissolved oxygen (DO) is probably the single most important feature of water quality, as it is an important regulator of chemical processes and biological activity. Plant photosynthesis produces oxygen within the region below the water surface with adequate light. Microbial respiration and organic decay consume oxygen. At the surface, oxygen can move between the water and air, and the rate of exchange is dependent on wind speed and the surface water DO saturation. The saturation concentration of DO is regulated by temperature. Concentrations above the saturation value (supersaturation) indicate high photosynthetic activity, for example, during an algal bloom. Undersaturated conditions occur when oxygen-demanding processes exceed the sources of DO. DO is measured using a probe that consists of electrodes of opposing charges, which are separated from the surrounding water by a Teflon membrane. DO diffuses across the membrane and is reduced to hydroxide at the cathode and silver chloride is formed at the anode. The current associated with this process is proportional to the DO in the surrounding water.

- **pH:** pH is defined as - log [H+], where [H+] = concentration of hydrogen ions. The pH scale ranges from 0 to 14, corresponding to various degrees of acidity or alkalinity. A value of 7 is neutral; values below 7 and approaching 0 indicate increasing acidity (higher H+ concentrations), while values above 7 approaching 14 indicate increasing alkalinity. A wide range of pH values is encountered in different water bodies, associated primarily with the different ionic chemistries of the respective watersheds/tributaries. Inorganic carbon constituents are the major pH buffering system in most fresh waters. pH is an important regulator of chemical reactions and an important influence on aquatic biota (including composition). Photosynthetic uptake of CO2 tends to increase pH (e.g., during phytoplankton blooms) while decomposition/respiration tends to decrease pH. Values of pH are generally highest in the epilimnion and decline with increasing depth. Measuring pH involves taking an electrode consisting of a proton selective glass reservoir filled with a pH 7 reference solution. Protons interact with the glass, setting up a voltage potential across the glass. Since the H+ concentration of the reference solution does change, the difference between the voltage potentials is proportional to the observed pH.

5.2 The Tools

5.2.1 Boulder Area Sustainability Information Network (BASIN) (Boulder, Colorado)

Introduction

The Boulder Area Sustainability Information Network (BASIN) project is an EMPACT-funded project designed to help deliver a variety of environmental information about the Boulder area to its residents. BASIN's initial focus is on water in the region, including watershed and consumption issues. The objectives of the project include the following:

- To improve existing environmental monitoring to provide credible, timely, and usable information about the Boulder Creek Watershed to the public.
- To create a state-of-the-art information management and public access infrastructure using advanced, Web-based computer technologies.
- To build strong partnerships and an ongoing alliance of governmental, educational, nonprofit, and private entities involved in watershed monitoring, management, and education.
- To 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.

Lessons, Tools, and Activities

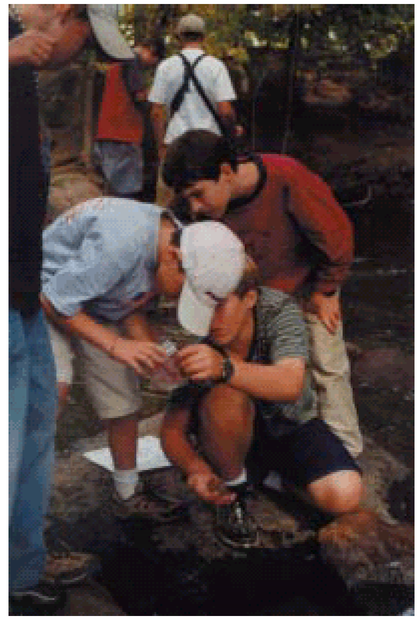
As part of the project, organizers adapted an existing online learning tool called the WatershED program, to the BASIN project Web site. Geared toward grades 4 through 12, WatershED aims to help teachers, students, and citizens in the Boulder area learn more about their local creeks and wetlands. It provides users with suggestions for what schools or neighborhood groups can do to preserve and protect local waterways and how they can become stewards of water resources.

The WatershED curriculum was developed by the Boulder Creek Initiative and the City of Boulder's Stormwater Quality Office with the help of teachers in the Boulder area. It was modified for students, teachers, and the general public for the BASIN Web site. The tool consists of a series of learning activities in addition to a Teacher's Guide.

The WatershED project can help participants:

- Get to know their watershed address as defined by creeks, wetlands, and lakes.
- Discover the plants, animals, and birds they might see in or around the creek or wetland in their neighborhood.
- Organize a StreamTeam to protect and enhance a local waterway.

The online resource includes background information on ecology and ecosystems and water quality. The activities cover the following topics, which are broken out by level of complexity as follows:



Introductory Level Activities:

- Water, Colorado's Precious Resource
- The Water Cycle
- The Boulder Water Story
- Water Law and Supply
- Water Conservation

Intermediate Level Activities:

- Stream Teams—An Introduction
- Mapping Your Watershed
- Watershed Walk
- Watershed Cleanup: A Treasure Hunt
- Storm Drain Stenciling
- Raise and Release: Aquarium Setup

Advanced Level Activities

- Water Quality (Introduction)
- Phytoplankton—Trends & Diversity
- Nutrients: Building Ecosystems in a Bottle
- Macroinvertebrates—Long-term Ecosystem Health
- Stream Gauging: A Study of Flow
- Water Quality (Intermediate and Advanced)

Resources

For additional information on the WatershED online learning tool affiliated with the BASIN EMPACT Project, contact Curry Rosato at 303 413-7365 or Donna Scott at 303 413-7364. In addition, all the activities listed above are available online at http://bcn.boulder.co.us/basin/learning/introduction.html.

5.2.2 Burlington Eco Info (Burlington, Vermont)

The goal of the Burlington Eco Info EMPACT project is to provide the public with clearly communicated, real-time, useful, accurate environmental monitoring data in an ongoing and sustainable manner. The project is a 2-year pilot project that will enable residents and policymakers alike to have expanded access to important environmental information, providing for improved decision-making. The project's partners include the City of Burlington Community and Economic Development Office, the University of Vermont (UVM) School of Natural Resources, the Green Mountain Institute for Environmental Democracy, the Center for Lake Champlain (formerly called the Lake Champlain Basin Science Center), and the U.S. Environmental Protection Agency. The project's Web site provides information on the air, water, land, and energy in Burlington and the surrounding area. Visitors can learn about city beaches, view the daily air quality forecast, see a live image of the waterfront, or get data from a dust monitoring station.

Lessons, Tools, and Activities

Although the Burlington Eco Info project is multi-media in nature, the curriculum portion of the project focuses on water quality issues in the Lake Champlain Basin. Through its partnership with the Center for Lake Champlain, the project has incorporated an environmental monitoring program for grades 7 through 12. The program utilizes the UVM's Ecosystem Science Lab (Rubenstein Lab) to perform analyses. The purposes of the environmental monitoring program are the following:

- For students and teachers to participate in and perform authentic scientific research techniques in a university lab setting.
- To promote watershed awareness and action focusing on water quality issues in the Lake Champlain Basin.
- To collect data and allow teachers and students to become involved with local watershed resources with the goal of contributing data that meets EPA's standards for water quality testing.
- To build stronger connections between students and teachers and their local watersheds.

The Center for Lake Champlain markets the program to middle and high school science educators in Vermont and New York schools and organizations located in the Lake Champlain watershed. Interested educators sign up for a teacher training led by the Center staff. After the training, teachers begin the program by teaching water quality related scientific activities at their schools. Following these activities, the class collects local water samples and visits the Rubenstein Ecosystems Lab at UVM to process them. Teachers and students then return to their schools for completion of the processing of their data and other followup activities.

Pre-visit Activities at School

Prior to taking the water samples, students use activities provided by the program and/or found in existing curricula (This Lake Alive!, Project Wild, Project WET, Aquatic WILD, etc.) to get necessary lab skills and knowledge of ecological principles. Trained UVM Resource Assistants visit classrooms to go over safety procedures and understanding of watershed issues. An interactive watershed model is used to help students visualize watershed concepts. In addition, students explore the geography of the Lake Champlain Basin and study the properties of water (pH, water cycle, etc.) to build a stronger connection between the field, lab work, and environmental health. Finally, students generate a focus question for their study.

Field Work Component

Students and teachers collect water samples and other information from a local site of their choice according to established protocols. Teachers also have the option to add a waterfront field component to their class time spent with the Center staff. The 1-hour waterfront option explores “in the field” sampling techniques and includes parameters such as temperature, pH, dissolved oxygen, conductivity, and turbidity.

Rubenstein Lab Activities

In the lab, students perform high-level tests on the water samples they collect in the field. The data generated by the tests are sent to local, state, and federal databases. The first part of the lab activity begins with students practicing lab techniques using glass and plastic pipettes and droppers. Through simple activities, such as color mixing and water drops on a penny, students immediately become actively engaged in the learning process. More sophisticated water sample analysis follows, which includes phosphorous and bacteria testing and a slide presentation designed for the program.

To date, 28 educators from 16 different schools and organizations in the Champlain Basin have participated in the teacher workshop in preparation for bringing their classes to the Rubenstein Lab to conduct water testing, and 267 middle and high school students from 13 schools have participated in the environmental monitoring program. Through three postcard and flyer mailings sent during fall 2000, fall 2001, and spring 2002, the Center reached more than 750 Vermont and New York middle and high school educators.

The Center for Lake Champlain offers a Watershed Investigation Kit for interested teachers, which was not funded through EMPACT, but rather a different EPA grant. The Kit contains everything needed for a thorough water quality study, including books, articles, maps, posters, videos and CD-ROMs, flashcards, and sampling test kits and materials. The Kit is recommended for middle and high school students and for community groups to use in asking questions and discovering more about their place in the Lake Champlain watershed.

Resources

For additional information on the environmental monitoring curriculum offered by the Center for Lake Champlain in association with the Burlington Eco Info EMPACT project, contact Julie Silverman at 802 864-1848 or juliesilverman@yahoo.com, or Kara Lenorovitz at klenorovitz@hotmail.com.

5.2.3 ECOPLEX (Dallas-Ft. Worth, Texas)

Introduction

Through the use of both innovative and proven environmental monitoring technologies, the ECOPLEX project collects real-time and time-relevant environmental data that informs citizens of the Dallas-Ft. Worth metropolitan area of current, historical, and near real-time forecasts of environmental conditions. The project involves a multi-media approach, collecting data related to air, water, soil, and weather. The data, as well as instructions on how to use it, are posted on the project's Web site at http://www.ecoplex.unt.edu.

Lessons, Tools, and Activities

As part of the ECOPLEX project, curricula were developed covering the topics of ultraviolet (UV) radiation, water quality, and water quantity. (See Section 4.2.6 for information on the UV curriculum.) The curricula are geared towards kindergarten through 8th grade and were completed in August 2001. Approximately 120 teachers in 37 schools have utilized the lesson plans included in the curricula. Each lesson plan includes follow-on curriculum extensions, which explore the disciplines of math, language arts, technology, art and music, science, and social studies.

For kindergartners through 3rd grade, the ECOPLEX curriculum teaches students the quality, importance, and availability of water to life on earth. Students are introduced to the term "water quality" and learn the difference between drinking, fresh, and salt water. They learn how much of people's bodies and certain foods, such as fruit, consist of water. While visiting the ECOPLEX Web site to study water monitoring tests, students brainstorm ways to create good water quality. Students explore the dehydration process in foods, and they learn about precipitation, evaporation, and condensation, and how water can be a solid, liquid, or gas. Introduced to the concept of water conservation, children realize that the amount of water on earth is finite and that most of it is not available for public consumption. They discover how all the water we use is piped to a wastewater treatment system, so that it can be reused. They learn the differences between point and nonpoint source pollution and the physical and chemical aspects of water. And finally, they study the formation of reservoirs and lakes and discover the importance of wetlands as natural filters.

Intermediate students in 4th through 6th grades are introduced to the concepts of food webs and chains. Students learn how pollutants can enter water, affect aquatic organisms, and disrupt food chains. The curriculum covers topics such as groundwater and aquifer recharge, allowing students to discuss from where they get their water and chemical pollutants that cause serious concern, such as DDT, polychlorinated biphenyls (PCBs), and mercury. They discuss bioaccumulation and describe how DDT entered the eagle food chain. Water conservation is reemphasized, as students discuss ways that families can conserve. Students learn how aquatic organisms get oxygen, define photosynthesis and its reliance upon sunlight, and determine the effect of temperature on dissolved oxygen.

Older students in 7th and 8th grade further examine water quality by analyzing macroinvertibrates in the water. They learn that an ecosystem is a community of living and non-living components and that photosynthesis is important to both plants and animals. Students then conduct an experiment to see how fertilizers affect algae growth in bodies of water. Through collecting water samples from a local source, students record the numbers of macroinvertibrates and determine water quality. The

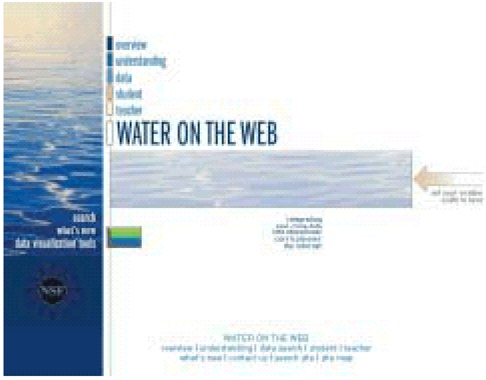
WOW is highlighted in this handbook because of its affiliation with the Lake Access EMPACT project http://www.nrri.umn.edu/empact—in 2000, EMPACT funded the deployment of two additional RUSS units in Lake Minnetonka, a large, heavily used complex in

ECOPLEX curriculum enables students to determine where their water comes from and the quantity of water used by individuals, families, and cities. Students learn about alternative solutions for future fresh water supplies, building upon previous lessons on the watercycle, watersheds, surface water, and fresh water conservation. Using world maps or globes, students discuss how water is redistributed around the globe via the watercycle, and they discuss the effects of population on water supplies and alternative solutions to collect and store water.

the suburban Minneapolis area.

5.2.4 Lake Access (Water on the Web) (Minneapolis, Minnesota)

Introduction



Water on the Web (WOW) is a National Science Foundation-funded, award-winning, Internet-based science curriculum for high school and college level students. The project, operated by the University of Minnesota-Duluth’s Natural Resources Research Institute, uses real-time, environmental lake data with the goal of equipping students with real world skills they can use in college and beyond. The program employs several remote underwater sampling stations, or RUSS units, in four Minnesota lakes and bays that represent a wide range in terms of size, depth, seasonal dynamics, and other characteristics. The RUSS units collect vertical profiles of temperature, dissolved oxygen, pH, conductivity, and turbidity every few hours and upload their data onto the WOW and Lake Access Web sites each morning.

WOW is based on real, scientific data, monitored and maintained by quality control protocols. Unlike canned data sets created to support a curriculum, the WOW data reflect the realities and complexities of real ecosystems, which means they do not often fit students’ or teachers’ preconceived ideas of how a lake behaves. WOW data are provided in several different formats in the data section of the WOW Web site. Raw data for a lake can be viewed in an archived data set. Weekly data sets can also be downloaded and reviewed in Excel spreadsheets, which also include graphing templates that assist students in plotting and understanding selected data. For many students, however, it is difficult to see and interpret patterns in numerical data, so WOW offers interactive data visualization tools. Some teachers use these tools to illustrate trends or relationships among the data, and other teachers have students explore the data using the tools. To provide students with the background information and context for understanding scientific data, the WOW Web site includes a variety of aids, including the following:

- Background information on each lake, its watershed, and its behavior during the period of sampling.
- A Lake Ecology Primer, which provides a context for understanding water quality parameters and how they relate to each other.
- A Geographic Information Systems (GIS) resource that describes the fundamentals of the technology.
- A section called “The RUSS,” which provides students with an introduction to RUSS

technology, WOW water quality measurements, reporting limits, and instrument accuracy.

- A glossary providing definitions of complex scientific terms.

Lessons, Tools, and Activities

The WOW curriculum provides a collection of individual, yet integrated, lessons designed to enrich and enhance student learning in general science courses. Most lessons appear in two different formats—a “Studying” lesson and an “Investigating” lesson. “Studying” lessons allow students to apply and learn concepts through direct, guided experiences. “Investigating” lessons provide students with opportunities to discover the same concepts and involve more solving. Each lesson is organized into a thinking framework of six sequential parts that are critical for improving scientific and technological literacy—knowledge base, experimental design, data collection, data management and analysis, interpretation of results, and reporting results. Using this format for scientific inquiry, teachers guide students through directed study or inquiry lessons depending on the students’ abilities and the science curriculum.

Since the program’s inception in 1998, several thousand students have used WOW and its materials. Students have learned the fundamentals of science based on real-time data, and teachers have been trained in advanced technology, including computerized mapping and modeling systems, remote sensing, instrumentation, and the use of the Internet.

A project is currently underway to create an online curriculum geared toward college students in 2- to 4-year institutions. This curriculum will serve as a capstone experience for students who are completing a technician program, or a gateway for students who are stimulated by the issues and interested in pursuing water science, water resource management, or environmental resource management degrees at four-year institutions. Students will learn and apply their knowledge and skills through inquirybased problems derived from real-world, real-time data collected by state-of-the-art water quality monitoring technology. The curriculum will be designed as a two semester lab sequence, consisting of six key units that cover the range of knowledge and skills needed by future water science technicians. Each unit will consist of a series of 3 to 8 interactive modules that cover specific topics (e.g., the Data Analysis Unit will include Web-based modules on Exploratory Data Analysis, Trend Analysis, Spatial Analysis, and Modeling). The curriculum will receive extensive pilot and beta testing by a group of over 100 community college teachers and will be designed to be disseminated through a commercial publisher.

Messages from teachers indicate the WOW lessons and Web site are being used in a variety of ways. One teacher used a tutorial and lessons to help students learn how to work with spreadsheets. Another adapted a lesson on fish stocking to illustrate that organisms are limited by environmental factors. Still other teachers have chosen ideas from the lessons and Web site and created their own lessons based on WOW data and resources.

“I found the Water on the Web site to be of great value and interest to the students...It was a wonderful source of detailed information and provided the students with access to nearly real-time water quality data. I was able to use the information to devise very realistic problems for the students to work through and discuss.”

—George W. Kipphut,
Murray State University, Kentucky

“Thank you for the wonderful data and project...This project puts symmetry on the year for us...The focus and quiet as they delve into the data and resources are great.”

—Ilona Rouda, The Blake School,
Minneapolis, Minnesota

Resources

For more information on the WOW project and curricula, contact:

George E. Host, Ph.D.
Senior Research Associate
Biostatistics-Forest Ecology
University of Minnesota-Duluth Campus
Center for Water and the Environment
Natural Resources Research Institute
Phone: 218 720-4264
Fax: 218 720-4328
E-mail: ghost@nrri.umn.edu

or

Bruce Munson
University of Minnesota-Duluth Campus
Phone: 218 726-6324
E-mail: bmunson@d.umn.edu

WOW information and lessons are all downloadable from the project's Web site at http://wow.nrri.umn.edu/wow/.

5.2.5 Monitoring Your Sound (MY Sound) (Long Island Sound, New York)

Introduction

The MY Sound project provides real-time water quality monitoring data from Long Island Sound to a broad spectrum of users, including government, academia, industry, organizations, and the general public. The project recognizes that water quality in Long Island Sound is an issue that affects everyone, not just those who live along the coast. If water quality is poor, the value of the Sound as an economic, recreational, and natural resource decreases; if water quality is good, people use it and it is a vital resource. A major goal of the project is to enhance and broaden the user's appreciation, knowledge, and use of Long Island Sound. The project, which was coordinated by a stakeholder committee comprised of project partners and stakeholder representatives, uses the Internet, local media, information kiosks, orientation briefings, and printed material.

The project has established five water quality monitoring stations near New London and Bridgeport Harbors. The EMPACT focus areas include Bridgeport Harbor and the greater CT-NY-Long Island metropolitan area. The monitoring stations collect data for the following parameters:

- Water temperature
- Conductivity/salinity
- Transmissivity
- Dissolved oxygen

- Nutrients/nitrate
- Chlorophyll
- Surface hydrocarbons
- Current speed and direction
- Selected meteorological parameters

Lessons, Tools, and Activities

At the time of publishing this handbook, the MY Sound project was developing curriculum support tools that can be used by teachers of environmental science, physics, and math courses. The materials will be geared toward students in grades 8 through 12. Specific components under development include:

- Fact sheets on topics related to the environmental health of Long Island Sound.
- Student exercises that use time series and statistical data on Long Island Sound phenomena to illustrate science and math principles and enhance knowledge of the Sound.
- Guided Internet explorations that lead teachers and students through key Web sites to investigate marine science topics.

Examples of future student exercises include:

- A Long Island Sound lobster mortality exercise that illustrates the use of statistics in investigating lobster population decline in recent years (will involve both manual calculations and spreadsheet development).
- A sunken oil barge salvage exercise that illustrates hydrodynamic principals important in re-floating a sunken oil barge in eastern Long Island Sound.
- A small boat drift exercise using MY Sound wind and current data that illustrates the use of vector addition in conducting a search and rescue operation.
- An ocean data analysis exercise using wind and dissolved oxygen time series data that illustrate the concepts of hypoxia, temperature stratification, and vertical mixing on a Summer 2000 event in western Long Island Sound.

Examples of guided Internet investigations include:

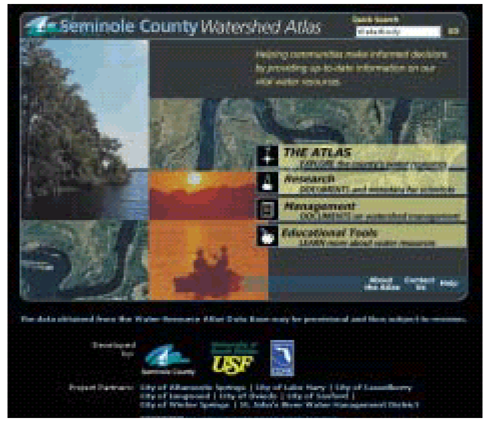
- Waste water pollution (municipal and industrial)
- Oil and hazardous chemical spills
- Non-point source pollution
- Invasive species
- Marine debris
- Habitat modification and restoration

Resources

For additional information on the MY Sound project and status of the curriculum component, contact Pete Tebeau at 860 446-0193 or visit the MY Sound Web site at http://www.MYSound.uconn.edu.

5.2.6 Online Dynamic Watershed Atlas (Seminole County, Florida)

Introduction



The Seminole County Watershed Atlas is designed to provide citizens, scientists, and planners of the Seminole County region with comprehensive and current water quality, hydrologic, and ecological data, as well as a library of scientific and educational resources on ecology and management. The Atlas was created to provide a “one stop information shop” for concerned citizens and scientists who live and work on water bodies and have found it difficult to gather the information they need from the many agencies that collect the related data. The Atlas functions as a warehouse for a variety of water resources information, including documents and educational links. The Atlas also is a rich resource that educates citizens about the data presented and gives scientists easy access to the specialized information they need.

Lessons, Tools, and Activities

As part of the Atlas project, Seminole County initiated a water quality and hydrology curriculum component in September 2001. The curriculum, which is being developed in conjunction with the University of South Florida and the Seminole County School Board, along with several other minor partners, is expected to be completed by January 2004. Designed for grades 5 through 12, the curriculum will be provided to county schools, a local environmental studies center, and other interested environmental education groups. The curriculum will cross several disciplines, including math, science, and social studies. Project organizers are expecting that in the future, other counties will develop their own watershed databases and could adapt the Seminole County curriculum to meet their needs.

Teachers will work with county staff to design the curriculum and will then train other teachers how to use it. Curriculum staff will develop both teacher and student guides. Teachers and students will need Internet access to use the curriculum, and optional field activities are under consideration, which might require environmental monitoring equipment.

Resources

For additional information on the Seminole County Watershed Atlas project or curriculum, contact Kim Ornberg at 407 665-5738 or visit the project Web site at http://www.seminole.wateratlas.usf.edu.

5.2.7 Onondaga Lake/Seneca River (Syracuse, New York)

Introduction

The Onondaga Lake/Seneca River EMPACT project provides environmental information on the health of the Onondaga Lake/Seneca River ecosystems to students, researchers, and the local Syracuse community. Onondaga Lake is one of the most polluted lakes in the United States, with fishing and swimming prohibited and several water quality standards routinely violated. The lake pollution affects adjoining waterways, including the Seneca River. In 1998, local, state, and federal authorities agreed on a 15-year staged program to address the impacts of sewage pollution on the lake and river, and in 1999, the project was awarded an EMPACT grant. The program, a partnership between the Syracuse City School District, the Upstate Freshwater Institute, State University of New York–School of Environmental Science and Forestry, Syracuse University, and local businesses, collects and delivers critical near real-time data from remote underwater sample stations, or RUSS units, in the lake and river. The goals of the project include:

- Applying and advancing innovative remote monitoring technology to meet the acute present and future monitoring needs for the lake and river.
- Addressing the community's lack of understanding concerning the degraded conditions of the ecosystems.
- Promoting excellence in teaching, learning, and research.

The lasting benefits of the projects will include:

- Addition of critical capabilities to the long-term monitoring program.
- Creation of vehicles to communicate important characteristics and findings to all stakeholders.
- A community that is more engaged in critical environmental decision-making.

Lessons, Tools, and Activities

Three educational resources have been developed to support classroom instruction and connect school curricula to the Onondaga Lake-Seneca River EMPACT Project. Grade-level course guides for early primary (K–3), elementary (4–6), intermediate (7–9), and commencement (10–12) students have been developed to supplement project efforts. The lessons in the guides were designed to be implemented as part of a regular science course. For example, students could learn weather principles by studying the RUSS meteorological data. There are some teachers who are using the materials in special Onondaga Lake Units. These types of units are taught in the spring and review all the concepts of a course.

Several essential understandings form the basis of the course guides. A committee of teachers representing all grade levels and content areas of the Syracuse City School District analyzed the issues and concepts impacting Onondaga Lake and its watershed. Through their analysis, they identified the following essential understandings:

- Several dynamic processes are constantly reshaping the Onondaga Lake Watershed, including:

    - Succession: The continuing process in which an ecosystem evolves to maximize the cycling and utilization of resources.
    - Seasonal changes: The processes involved with the motion of the earth and moon about the sun, and the processes that occur in response to their motion.
    - Human processes: The processes involved with human activity and the environmental impacts that result.

- The earth is a closed system.
    - Life is sustained by and is part of a set of cyclic processes.
    - All resources used by humans were developed through a series of cyclic processes.
    - All waste products, if not transformed, will remain in the global system.
- Humans make decisions. Human action is directed primarily by thought and decisionmaking in an effort to improve the quality of life.
- Efficient and effective communication skills are necessary for success at any task or performance.

In addition to the essential understandings that were developed under the project, teachers developed essential questions to drive classroom inquiry and research. The primary question to drive inquiry in all classrooms and content areas is “How do we make the decisions necessary to develop and maintain a healthy community?” The Onondaga Lake and Seneca River are two components of the watershed ecosystem. Because all components of the ecosystem are interconnected, monitoring changes in water quality provides insight into the overall health of the watershed and the communities it supports. As a result, students are challenged to assess their community and their impact upon it. The key questions for driving inquiry for each essential understanding of the project are:

- What are the processes that impact our community?
- How does material enter and leave our community?
- What happens to these materials when they interact with our community?
- How do these materials impact upon and/or affect our community?
- How do humans, individually and in groups, make decisions?
- How do people make the decisions necessary to communicate effectively with each other?

For each grade level, there are lessons covering each essential understanding and key question. For example, to address the key understanding of dynamic processes and the key question, “What are the processes that impact our community?” the Onondaga Lake curriculum includes the lesson “Shake, Rattle, and Role: Earth’s Dynamic Processes.” The theme, topics, and project work vary by grade level. As an example, for 10th grade, the theme of the lesson is cycles and cyclic processes; the curriculum topics include biological interactions with dynamic changes, lake biology, and Onondaga Creek Watershed ecology; students assume the role of research botanists, microbiologists, zoologists, entomologists, and environmental engineers and present a physical model as a project.

Resources

For more information on the Onondaga Lake/Seneca River project, contact Richard List at 315 435-5842 or at rlist@freeside.scsd.k12.ny.us and visit the project Web site at http://www.ourlake.org.

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6.0 Land-Use and Soil-Based Projects

6.1 Teacher Tips

Soil is a dynamic resource that supports plant life. It is comprised of a number of different materials, including sand, silt, clay, organic matter, and many species of living organisms. Therefore, soil has biological, chemical, and physical properties, some of which can change depending on how the soil is managed. The Soil Science Society of America defines soil quality as "the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation." Management that enhances soil quality benefits cropland, rangeland, and woodland productivity. In addition, enhanced soil quality benefits water quality, air quality, and wildlife habitat. Soil provides several essential services or functions:

EPA's Office of Research and Development (ORD) conducts research in innovative monitoring and measurement technologies, as well as in tools to interpret data streams and to increase the quality and the number of environmental parameters that can be monitored and reported in EMPACT communities. Although there are currently no research grants researching soil monitoring technologies, teaching students about soil quality is important, so this handbook provides background information as a resource for the teacher.

- Soil supports the growth and diversity of plants and animals by providing a physical, chemical, and biological environment for the exchange of water, nutrients, energy, and air.
- Soil regulates the distribution of rain or irrigation water between infiltration and runoff, and it regulates the flow and storage of water and the materials found in it, such as nitrogen, phosphorus, pesticides, and nutrients.
- Soil stores, moderates the release of, and cycles plant nutrients and other elements.
- Soil acts as a filter to protect the quality of water, air, and other resources.

Soil quality is evaluated using indicators that reflect changes in the capacity of the soil to function. Useful indicators are those that are sensitive to change and that change in response to management. Some examples include soil erosion, sediment deposition, soil biodiversity, water capacity, and pesticides. Monitoring of soil quality indicators over time identifies changes or trends in the functionality or quality of the soil. Monitoring can be used to determine the success of management practices or the need for changes or adjustments.

Most soil-related EMPACT projects focus either on lead exposure from residential soils or the status of brownfield properties. (See http://www.epa.gov/empact/soil.htm for more information on these projects, which do not currently have curriculum components.)

Another topic associated with soil is land use and urban sprawl. Urban sprawl can be defined as the unplanned, unlimited extension of neighborhoods outside of a city's limits, usually associated with low density residential and commercial settlements, dominance of transportation by automobiles, and widespread strip commercial development. Over the past 50 years, American cities have been experiencing an accelerated urbanization and suburbanization process resulting from rapid technological advancement and relatively steady economic growth. Some argue that urban sprawl leads to inefficient land use patterns. Communities can implement a number of growth management programs to encourage more efficient and environmentally sound development patterns.

6.2 The Tools

6.2.1 Northeast Ohio Urban Growth Simulator

Introduction

The Northeast Ohio (NEO) EMPACT project compiled urban sprawl data to create a land-use computer modeling tool. Developed by Kent State University, Cleveland State University, and the University of Akron, it provides citizens with local urban sprawl information and development scenarios for Northeast-Ohio. This information helps decision-making on how the region should grow and provides possible land use consequences that might arise from different kinds of growth (i.e., farmland loss, wetland destruction).

Lessons, Tools, and Activities

As part of the NEO EMPACT project, a handbook was developed to introduce teachers and students to the importance of understanding urban sprawl in their communities. Urban Sprawl in Northeast Ohio is arranged in thematic and developmental order to provide students with a comprehensive understanding of urban sprawl and its effects on the environment.

The handbook for educators and students includes detailed background information, lessons, and activities focused on urban sprawl. It progresses from developing an understanding of urban sprawl to discussing concrete actions students and teachers can take to raise awareness of urban sprawl. The major sections of the handbook include:

- The introductory section, *All About Urban Sprawl—Notes for Educators*, provides detailed background information on urban sprawl and how it relates to other environmental problems such as air and water pollution and acid rain.

- The *10 Experiments and Exercises* on urban sprawl provide hands-on lessons in urban sprawl. Geared towards specific grades, the experiments and exercises cover land use planning, various types of air pollution (e.g., particulates, carbon dioxide), soil buffering, air quality as it relates to combustion byproducts, habitat destruction, water pollution, and city planning.

- The *Students, Urban Sprawl, and the Internet* section is complemented by the online *Urban Growth Simulator* and its *Self-Guided Workbook*, which allow students to simulate how their community would change with future development. The workbook describes the Urban Growth Simulator Web site, and includes four guided simulation exercises.

- The *Urban Sprawl Activities for Younger Students* focus on developing students' oral, visual, and writing skills. Activities include conducting a mock interview with a famous environmentalist, a word search and crossword puzzle, writing an urban sprawl bill, determining the authority of various levels of government (i.e., federal, state, local) to pass land use laws, and designing urban sprawl posters for display in the community.

- *Urban Sprawl—What Students Can Do* offers teachers and students suggestions for reducing sprawl and its side effects in the local community and at school.

- *Urban Sprawl World Wide Web Resources for Educators* lists sources of additional information on urban sprawl for educators and students.

Resources

For additional information on the NEO Urban Sprawl curriculum handbook, contact Adam Zeller of the Earth Day Coalition at 216 281-6468 or azeller@earthdaycoalition.org and visit the NEO EMPACT Web site at http://empact.nhlink.net.

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Appendix A: Additional Resources

U.S. Environmental Protection Agency (EPA) Office of Solid Waste

http://www.epa.gov/epaoswer/osw/teacher.htm

This Web site provides educational tools and a list of related publications, including:

- *Let's Reduce and Recycle: Curriculum for Solid Waste Awareness*
- *School Recycling Programs: A Handbook for Educators*
- *Adventures of the Garbage Gremlin*

EPA also lists a wealth of activities including the "Planet Protectors Coloring Book."

The Globe Program: Global Learning and Observations To Benefit the Environment

http://www.globe.gov

This Web site provides science and education resources including teacher guides, workshops, and tools, such as a geography quiz and cloud identification quiz.

Natural Resource Conservation Service

http://www.nrcs.usda.gov/feature/education

This Web site includes ideas and educational tools for teachers.

U.S. Department of Agriculture (USDA) for Kids

http://www.usda.gov/news/usdakids/index.html

"USDA for Kids" Web site is a great resource for educational tools, including a food pyramid guide, Smokey the Bear, and "Food for Thought."

National Soil Survey Center

http://soils.usda.gov

This Web site provides information on soil science education.

National Geographic Society

http://www.nationalgeographic.com

This Web site provides extensive teacher resources related to geography and science.

North American Association of Environmental Education (NAAEE)

1255 23rd Street NW., Suite 400
Washington, DC 20037-1199
202 884-8912
Fax: 202 884-8701

http://www.naaee.org

NAAEE was established in 1971 as a network of professionals and students working in environmental education. NAAEE's members are located throughout North America and in more than 40 countries around the world; they believe that education is the key to ensuring a healthy, sustainable environment and improving the quality of life on earth. Members can join various sections: Elementary and Secondary Education, College and University Environmental Programs, and Non-formal Education.

Association for Supervision and Curriculum Development (ASCD)

1250 North Pitt Street
Alexandria, VA 22314
703 549-9110

http://www.ascd.org

ASCD, an education association, serves its members through publications, professional development opportunities, research and information searches, the Curriculum and Technology Resource Center, and affiliates in each state and several foreign countries. Resources include information on staff development practices, cooperative learning, peer coaching, and science and social studies content for schools.

National Science Teachers Association (NSTA)

1840 Wilson Boulevard
Arlington, VA 22201-3000
703 243-7100
Fax: 703 243-7177

http://www.nsta.org

The National Science Teachers Association (NSTA) is committed to improving science education at all levels, preschool through college. NSTA produces several publications, conducts national and regional conventions, and provides scholarships, teacher-training workshops, educational tours, and an employment registry. The Web site provides an extensive range of resources for teachers of students of all levels; journals and books on science education and instruction are also available.

National School Boards Association (NSBA)

1680 Duke Street
Alexandria, VA 22314
703 838-6722

http://www.nsba.org

The National School Boards Association is a national federation of state school boards. NSBA produces "Electronic School," a free online technology publication for K-12 educators. NSBA houses the Institute for the Transfer of Technology to Education (ITTE), a program to help advance the wise use of technology in public education.

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Appendix B: Glossary of Terms

Air Terms

Acid rain: Air pollution produced when acid compounds formed in the atmosphere are incorporated into rain, snow, fog, or mist. The acid compounds come from sulfur oxides and nitrogen oxides, products of burning coal and other fuels and from certain industrial processes. Acid rain can impact the environment and human health and damage property.

Atmosphere: A thin layer of gases surrounding the Earth, composed of 78 percent nitrogen, 21 percent oxygen, 0.9 percent argon, 0.03 percent carbon dioxide, and trace amounts of other gases. There is no exact place where the atmosphere ends; it just gets thinner and thinner, until it merges with outer space.

Basal cell carcinoma: Skin cancer tumors that might appear as slow-growing, translucent, pearly nodules, which might crust, discharge pus, or even bleed. These tumors typically develop where you are most exposed to the sun—on the face, lips, tops of ears, and hands.

Carbon monoxide (CO): A colorless, odorless, poisonous gas produced by the incomplete burning of solid, liquid, and gaseous fuels. Appliances fueled with natural gas, liquified petroleum (LP gas), oil, kerosene, coal, or wood may produce CO. Burning charcoal produces CO and car exhaust contains CO.

Chlorofluorocarbons (CFCs): Stable, low toxic, and inexpensive chemicals that were most commonly used as refrigerants, solvents, and aerosol propellants. CFCs and their relatives, when released into the air, rise into the stratosphere and take part in chemical reactions that result in reduction or depletion of the stratospheric ozone layer. The 1990 Clean Air Act includes provisions for reducing releases (emissions) and eliminating production and use of these ozone-destroying chemicals.

Clean Air Act: The original Clean Air Act was passed in 1963, but our national air pollution control program is actually based on the 1970 version of the law. The 1990 Clean Air Act Amendments are the most far-reaching revisions of the 1970 law.

Criteria air pollutants: A group of very common air pollutants regulated by EPA on the basis of criteria (information on health and/or environmental effects of pollution).

Emission: Release of pollutants into the air from a source. Continuous emission monitoring systems (CEMS) are machines that some large sources are required to install, to make continuous measurements of pollutant release.

EMPACT: Environmental Monitoring for Public Access and Community Tracking, a program begun by EPA in 1997, helps communities collect, manage, and distribute environmental information, providing residents with up-to-date and easy-to-understand information they can use to make informed, day-to-day decisions.

Greenhouse effect: A natural phenomenon whereby clouds and greenhouse gases, such as water vapor and carbon dioxide, trap some of the Sun's heat in the atmosphere. The greenhouse effect helps regulate the temperature of the Earth. Human activities are adding greenhouse gases to the natural mix.

Greenhouse gases: Human activities, such as fuel burning, are adding greenhouse gases to the atmosphere. Because these gases remain in the atmosphere for decades to centuries (depending on the gas) global temperatures will rise.

Melanoma: The most fatal form of skin cancer. Malignant melanomas may appear suddenly without warning as a dark mole or other dark spot on the skin and can spread quickly.

Monitoring (monitor): Measurement of air pollution is referred to as monitoring. Continuous emission monitoring systems (CEMS) will measure, on a continuous basis, how much pollution is being released into the air. The 1990 Clean Air Act requires states to monitor community air in polluted areas to check on whether the areas are being cleaned up according to schedules set out in the law.

Nitrogen oxides (NOx): A criteria air pollutant. Nitrogen oxides are produced from burning fuels, including gasoline and coal, and react with volatile organic compounds to form smog. Nitrogen oxides are also major components of acid rain.

Ozone (O3): An ozone molecule consists of three oxygen atoms. Stratospheric ozone shields the Earth against harmful rays from the sun, particularly ultraviolet B. Ground-level ozone contributes to smog.

Ozone depletion: The ozone layer is damaged when substances such as chlorofluorocarbons accelerate the natural process of destroying and regenerating stratospheric ozone. As the ozone layer breaks down, it absorbs smaller amounts of UV radiation, allowing more of it to reach the earth.

Particulates, particulate matter: A criteria air pollutant. Particulate matter includes dust, soot, and other tiny bits of solid materials that are released into and move around in the air.

Pollutants (pollution): Unwanted chemicals or other materials found in the air.

Smog: A mixture of pollutants, principally ground-level ozone, produced by chemical reactions in the air involving smog-forming chemicals. A major portion of smog-formers come from burning of petroleum-based fuels such as gasoline. Major smog occurrences are often linked to heavy motor vehicle traffic, sunshine, high temperatures, and calm winds or temperature inversion (weather condition in which warm air is trapped close to the ground instead of rising).

Source: Any place or object from which pollutants are released.

Spectrophotometer: An instrument for measuring the relative intensities of light in different parts of the spectrum used to measure the amount of UV radiation reaching the earth.

Squamous cell carcinoma: Skin cancer tumors that might appear as nodules or red, scaly patches, which can develop into large masses and spread to other parts of the body.

Stratosphere: The stratosphere starts just above the troposphere and extends to 50 kilometers (31 miles) high. The temperature in this region increases gradually to -3 degrees Celsius, due to the absorption of ultraviolet radiation. The ozone layer, which absorbs and scatters the solar ultraviolet radiation, is in this layer. Ninety-nine percent of air is located in the troposphere and stratosphere.

Stratospheric ozone: A bluish gas composed of three oxygen atoms. Natural processes destroy and regenerate ozone in the atmosphere. When ozone-depleting substances such as chlorofluorocarbons accelerate the destruction of ozone, there is less ozone to block UV radiation from the sun, allowing more UV radiation to reach the earth.

Sulfur dioxide: A criteria air pollutant. Sulfur dioxide is a gas produced by burning coal, most notably in power plants. Sulfur dioxide plays an important role in the production of acid rain.

Sunscreen: A substance, usually a lotion, that you can apply to protect your skin from UV radiation. It works by reflecting UV radiation away from your skin in addition to absorbing UV radiation before it can penetrate your skin.

SunWise School Program: EMPACT program that aims to teach grades K-8 school children and their caregivers how to protect themselves from overexposure to the sun. The program raises children's awareness of stratospheric ozone depletion and ultraviolet radiation and encourages simple sun safety practices.

Troposphere: The troposphere is the lowest region in the Earth's (or any planet's) atmosphere, starting at ground (or water) level up and reaching up to about 11 miles (17 kilometers) high. The weather and clouds occur in the troposphere.

Ultraviolet B (UVB): A type of sunlight. Ultraviolet B exposure has been associated with skin cancer, eye cataracts, and damage to the environment. The ozone in the stratosphere, high above the Earth, filters out ultraviolet B rays and keeps them from reaching the Earth. Thinning of the ozone layer in the stratosphere results in increased amounts of ultraviolet B reaching the Earth.

UV Index: A tool developed by the National Weather Service that predicts the next day's UV intensity on a scale from 0 to 10+, helping people determine appropriate sun-protective behaviors.

UV radiation: A portion of the electromagnetic spectrum with wavelengths shorter than visible light. UV radiation produced by the sun is responsible for sunburn and other adverse health effects. Scientists classify UV radiation into three types: UVA, UVB, and UVC.

Volatile organic compounds (VOCs): Chemicals that produce vapors readily at room temperature and normal atmospheric pressure, so that vapors escape easily from volatile liquid chemicals. Organic chemicals all contain the element carbon and are the basic chemicals found both in living things and in products derived from living things, such as coal, petroleum and refined petroleum products. Many volatile organic chemicals are also hazardous air pollutants.

Water Terms

Abiotic: Not alive; non-biological. For example, temperature and mixing are abiotic factors that influence the oxygen content of lake water, whereas photosynthesis and respiration are biotic factors that affect oxygen solubility.

Acid: A solution that is a proton (H+) donor and has a pH less than 7 on a scale of 0-14. The lower the pH the greater the acidity of the solution.

Acidity: A measure of how acidic a solution may be. A solution with a pH of less than 7.0 is considered acidic. Solutions with a pH of less than 4.5 contain mineral acidity (due to strong inorganic acids), while a solution having a pH greater than 8.3 contains no acidity.

Acid rain: Precipitation having a pH lower than the natural range of ~5.2 - 5.6; caused by sulfur and nitrogen acids derived from human-produced emissions.

Acidification: The process by which acids are added to a water body, causing a decrease in its buffering capacity (also referred to as alkalinity or acid neutralizing capacity), and ultimately a significant decrease in pH that may lead to the water body becoming acidic (pH < 7).

Algae: Simple single-celled, colonial, or multi-celled aquatic plants. Aquatic algae are (mostly) microscopic plants that contain chlorophyll and grow by photosynthesis and lack roots, stems (non-vascular), and leaves.

Alkalinity: Acid neutralizing or buffering capacity of water; a measure of the ability of water to resist changes in pH caused by the addition of acids or bases. Therefore, it is the main indicator of susceptibility to acid rain. A solution having a pH below about 5 contains no alkalinity.

Anoxia: Condition of being without dissolved oxygen.

Anthropogenic: A condition resulting from human activities.

Aquatic respiration: Refers to the use of oxygen in an aquatic system, including the decomposition of organic matter and the use of oxygen by fish, algae, zooplankton, aquatic macrophytes, and microorganisms for metabolism.

Base: A substance which accepts protons (H+) and has a pH greater than 7 on a scale of 0-14; also referred to as an alkaline substance.

Basin: Geographic land area draining into a lake or river; also referred to as drainage basin or watershed.

Benthic: Refers to being on the bottom of a lake.

Bioaccumulation: The increase of a chemical's concentration in organisms that reside in environments contaminated with low concentrations of various organic compounds. Also used to describe the progressive increase in the amount of a chemical in an organism resulting from rates of absorption of a substance in excess of its metabolism and excretion. Certain chemicals, such as PCBs, mercury, and some pesticides, can be concentrated from very low levels in the water to toxic levels in animals through this process.

Biochemical oxygen demand (BOD): Sometimes referred to as Biological Oxygen Demand (BOD). A measure of the amount of oxygen removed (respired) from aquatic environments by aerobic microorganisms either in the water column or in the sediments. Primarily of concern in wastewater "streams" or systems impacted by organic pollution.

Biomass: The weight of a living organism or group of organisms.

Biotic: Referring to a live organism; see abiotic.

Buffer: A substance that tends to keep pH levels fairly constant when acids or bases are added.

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

Clarity: Transparency; routinely estimated by the depth at which you can no longer see a Secchi disk. The Secchi disk, an 8-inch diameter, weighted metal plate, is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi depth.

Conductivity (electrical conductivity and specific conductance): Measures water's ability to conduct an electric current and is directly related to the total dissolved salts (ions) in the water. Called EC for electrical conductivity, it is temperature-sensitive and increases with higher temperature.

Dissolved oxygen (DO or O2): The concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter, parts per million, or percent of saturation. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms.

Dissolved solids concentration: The total mass of dissolved mineral constituents or chemical compounds in water; they form the residue that remains after evaporation and drying.

Ecosystem: All of the interacting organisms in a defined space in association with their interrelated physical and chemical environment.

Epilimnion: The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed at some point during the day, and, because of its exposure, can freely exchange dissolved gases (such as O2 and CO2) with the atmosphere.

Eutrophication: Unhealthy increases in the growth of phytoplankton. Symptoms of eutrophication include algal blooms, reduced water clarity, periods of hypoxia, and a shift toward species adapted toward these conditions.

Evaporation: The process of converting liquid to vapor.

Food chain: The transfer of food energy from plants through herbivores to carnivores. For example, algae are eaten by zooplankton, which in turn are eaten by small fish, which are then eaten by larger fish, and eventually by people or other predators.

Food web: Food chains connected into a complex web.

Hydrogen: Colorless, odorless, and tasteless gas; combines with oxygen to form water.

Hydrology: The study of water's properties, distribution, and circulation on Earth.

Hypolimnion: The bottom and most dense layer of a stratified lake. It is typically the coldest layer in the summer and warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur.

Hypoxia: A deficiency of oxygen reaching the tissues of the body.

Isothermal: Constant in temperature.

Leach: To remove soluble or other constituents from a medium by the action of a percolating liquid, as in leaching salts from the soil by the application of water.

Metalimnion: The middle or transitional zone between the well-mixed epilimnion and the colder hypolimnion layers in a stratified lake.

Nonpoint source: Diffuse source of pollutant(s); not discharged from a pipe; associated with land use such as agriculture, contaminated groundwater flow, or onsite septic systems.

Nutrient loading: Discharging of nutrients from the watershed (basin) into a receiving water body (lake, stream, wetland).

Oxygen: An odorless, colorless gas; combines with hydrogen to form water; essential for aerobic respiration. See respiration.

Oxygen solubility: The ability of oxygen gas to dissolve into water.

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

pH: A measure of the concentration of hydrogen ions.

Phosphorus: Key nutrient influencing plant growth in lakes.

Photosynthesis: The process by which green plants convert carbon dioxide (CO2) dissolved in water to sugars and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base and is an important source of oxygen for many lakes.

Phytoplankton: Microscopic floating plants, mainly algae, that live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current.

Respiration: The metabolic process by which organic carbon molecules are oxidized to carbon dioxide and water with a net release of energy.

Solubility: The ability of a substance to dissolve into another.

Solution: A homogenous mixture of two substances.

Solvent: A substance that has the ability to dissolve another.

Stormwater discharge: Precipitation and snowmelt runoff (e.g., from roadways, parking lots, roof drains) that is collected in gutters and drains; a major source of nonpoint source pollution to water bodies.

Temperature: A measure of whether a substance is hot or cold.

Total Dissolved Solids (TDS): The amount of dissolved substances, such as salts or minerals, in water remaining after evaporating the water and weighing the residue.

Turbidity: Degree to which light is blocked because water is muddy or cloudy.

Turnover: Fall cooling and spring warming of surface water make density uniform throughout the water column, allowing wind and wave action to mix the entire lake. As a result, bottom waters contact the atmosphere, raising the water's oxygen content.

Water Column: A conceptual column of water from lake surface to bottom sediments.

Watershed: All land and water areas that drain toward a river or lake; also called a drainage basin or water basin.

Soil Terms

Bedrock: Consolidated rock.

Brownfields: Abandoned, idled, or underused industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.

Clay: Soil composed mainly of fine particles of hydrous aluminum silicates and other minerals. Soil composed chiefly of this material has particles less than a specified size.

Erosion: The wearing away of the land surface by running water, wind, ice, other geological agents, or human activity.

Infiltration: The downward entry of water through the soil surface.

Limestone: A white to gray, fine-grained rock made of calcium carbonate.

Percolation: Water that moves through the soil at a depth below the root zone.

Sand: A loose granular material that results from the disintegration of rocks. It consists of particles smaller than gravel but coarser than silt.

Sandstone: A very grainy rock that comes in many colors, including gray, red, or tan.

Sedimentary rock: Rock that has formed from compressed sediment, like sand, mud, and small pieces of rocks.

Shale: Dark-colored rock that is usually black, deep red, or gray-green. It has a fine grain and is usually found below sandstone, not on the surface. Shale was formed from fine silt and clay.

Silt: Predominantly quartz mineral particles that are between the size of sand and clay in diameter. Silt, like clay and sand, is a product of the weathering and decomposition of preexisting rock.

Soil: Soil is made up of minerals (rock, sand, clay, silt), air, water, and organic (plant and animal) material. There are many different types of soils, and each one has unique characteristics, like color, texture, structure, and mineral content.

Soil contamination: Pollution caused by a number of activities, including the dumping of hazardous substances, pesticide and fertilizer use, and industrial or chemical processes. Pollutants in soils can also be transported to groundwater sources and into the air. Contaminated soils are often a major concern at brownfield and Superfund sites. Common soil contaminants include arsenic, benzene, cyanide, lead, and mercury.

Soil formation: Soil is formed slowly as rock erodes into tiny pieces near the Earth’s surface. Organic matter decays and mixes with rock particles, minerals, and water to form soil.

Soil texture: Distribution of individual particles of soil. Soil washing: A technology that uses liquids (usually water, sometimes combined with chemical additives) and a mechanical process to scrub soils of contaminants.

Superfund: The Federal government’s program to clean up the nation’s uncontrolled hazardous waste sites.

Topsoil: Soil consisting of a mixture of sand, silt, clay, and organic matter. Topsoil is rich in nutrients and supports plant growth.

Urban sprawl: The unplanned, unlimited extension of neighborhoods outside of a city’s limits, usually associated with low density residential and commercial settlements, dominance of transportation by automobiles, and widespread strip commercial development.

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Appendix C: Activities by Grade Level

Curriculum	K	1	2	3	4	5	6	7	8	9	10	11	12	12+
Airbeat					X	X	X	X	X	X	X	X	X	
Air Currents							X	X	X	X	X	X	X	
Air Info Now: Environmental Monitoring for Public Access and Community Tracking					X	X	X	X	X	X	X	X	X	
AIRNow			X	X	X	X								
Boulder Area Sustainability Information Network					X	X	X	X	X	X	X	X	X	
Burlington Eco-Info								X	X	X	X	X	X	
Community Accessible Air Quality Monitoring Assessment (Northeast Ohio)					X	X	X	X	X					
ECOPLEX	X	X	X	X	X	X	X	X	X					
Lake Access (WOW)												X	X	X
Monitoring Your Sound									X	X	X	X	X	
Online Dynamic Watershed Atlas (Seminole County, FL)						X	X	X	X	X	X	X	X	
Onondaga Lake/Seneca River	X	X	X	X	X	X	X	X	X	X	X	X	X	
Northeast Ohio Urban Growth Simulator					X	X	X	X	X					

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Appendix D: Activities by Subject

Curriculum	Subject				
	Math	Language Arts	Science	Social Studies	Art
Airbeat	X	X	X		
Air CURRENTS	X	X	X	X	X
Air Info Now: Environmental Monitoring for Public Access and Community Tracking		X	X		
AIRNow	X		X		X
Boulder Area Sustainability Information Network			X	X	
Burlington Eco-Info			X		
Community Accessible Air Quality Monitoring Assessment (Northeast Ohio)		X	X		X
ECOPLEX	X		X		X
Lake Access	X		X		
Monitoring Your Sound	X		X		
Online Dynamic Watershed Atlas (Seminole County, FL)	X		X	X	
Onondaga Lake/Seneca River			X		
Northeast Ohio Urban Growth Simulator			X	X	

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Appendix E: Selected Lesson Plans and Activities

AirInfo Now

- Group Details – Blue Group: Weather (PDF)
  Data Sheet – Blue Group: Weather (Excel)
- Group Details – Brown Group: Visibility (PDF)
  Data Sheet – Brown Group: Visibility (Excel)
- A Guide to CO-City (PDF)
- So What's Making it Look Brown Outside? Collecting and Measuring Particulate Matter (PDF)
- What's the Connection Between Convection and Inversion? Convection Currents and Temperature Inversion (PDF)
- Getting a Handle on Greenhouse Gases: Your Family's Impact on the Greenhouse Effect (PDF)
- Helping to Find a Solution to Air Pollution! (PDF)
- Green Group: Location (PDF)
  Green Group: Location (Excel)
- Real-Time Air Quality Activity: Groups (PDF)
- Practice Data Sheet (Excel)
- Group Details – Red Group: Time (PDF)
  Data Sheet – Red Group: Time (Excel)
- Real-Time Air Quality Activity: Student Sheets(PDF)
  Real-Time Air Quality Activity: Teacher Sheets(PDF)
- Group Details – Yellow Group: Health (PDF)
  Data Sheet – Yellow Group: Health (Excel)

Airnow

- Air Quality Index Poster: Are you breathing clean air? (PDF)
- Air Quality Index: A Guide to Air Quality and Your Health (PDF)
- Air Quality Index Kids Website: Teacher's Reference (PDF)
- Green Day Poster (PDF)
- Orange Day Poster (PDF)
- Air Quality Index Posters (PDF)
- Purple Day Poster (PDF)
- Red Day Poster (PDF)
- Yellow Day Poster (PDF)

ECOPLEX

- **UV**
  - UV/7-2: Spotlight the Sun Data Table (PDF)
  - Ozone Chemistry: Formation & Depletion(PDF)
  - 8th Grade Lesson Plan – UV: Chemistry of Ozone Depletion(PDF)
  - 5th Grade Lesson Plan – UV: Check It Out! (PDF)
  - First Grade UV: Catching and Counting UV Rays! (PDF)
  - 4th Grade UV Lesson: What Depletes Our Ozone? Me and My Zone! (PDF)
  - Kindergarten UV: UV and Me! (PDF)
  - Second Grade UV: The Air Out There – UV and Ozone (PDF)
  - UV/7-1: Distribution of the Sun's Rays (PDF)

  - 6th Grade UV: Friend or Foe (PDF)
  - 3rd Grade UV Lesson: When Good Ozone Goes Bad (PDF)

- **Water Quality**
  - Third Grade Water Quality: Test, Test, Is This Water Safe? (PDF)
  - Fourth Grade Water Quality: Chain, Chain, Chain, Chain of Food (PDF)
  - Fifth Grade Water Quality: Tick Tock Toxins (PDF)
  - 6th Grade Water Quality Lesson: Water O2 and You! (PDF)
  - 7th Grade Water Quality Lesson: Taxa-Rich and Taxa-Poor! (PDF)
  - Water Quality 1-1 Record Sheet (PDF)
  - Water Quality 2-1 Record Sheet (PDF)
  - Water Quality 4-1 Datasheet (PDF)
  - Water Quality 5-1 Datasheet (PDF)
  - First Grade Water Quality: Water – It's a Gas…Sometimes! (PDF)
  - Kindergarten Water Quality: Water in Me (PDF)
  - Second Grade Water Quality: Amazing Water (PDF)

- **Water Quantity**
  - 7th Grade Water Quantity: Water Use and Abuse (PDF)
  - 3rd Grade Water Quantity: Name That Surface Water (PDF)
  - 4th Grade Water Quantity: H2O is Underground Too! (PDF)
  - 5th Grade Water Quantity: What-A-Shed (PDF)
  - WQT/6-1: Water vs. Land and Sea (PDF)
  - WQT/6-2: Diagram for Stream Table (PDF)
  - 6th Grade Water Quantity: The Ups and Downs of Your Watershed (PDF)
  - 8th Grade Water Quantity: Water to Supply an Ever-growing Population (PDF)
  - First Grade Water Quantity Lesson: Here I Go 'Round My Watershed! (PDF)
  - Water Quantity Letter (PDF)
  - Kindergarten Water Quantity Lesson: Drip! Drop! Water Does Not Stop! (PDF)
  - Second Grade Water Quantity Lesson: Now You See It – Now You Don't! (PDF)
  - Water Quantity: What to Do and How to Do It (PDF)
  - WQT/7-1: Water Use Chart (PDF)

MY Sound

- The Impact of Atmospheric Nitrogen Deposition on Long Island Sound (PDF)
- Alternative Strategies for Hypoxia Management: Creative Ideas to Complement Advanced Treatment (PDF)
- Fact Sheet #1: Hypoxia in Long Island Sound (PDF)
- Toxic Contamination in Long Island Sound (PDF)
- Nutrient Reduction: New Solutions to Old Problems (PDF)
- Pathogens (PDF)
- The Impact of Septic Systems on the Environment (PDF)
- Water Conservation and Marine Water Quality (PDF)
- Wastewater Treatment (PDF)
- Supporting the Sound (PDF)
- Floatable Debris (PDF)
- How Low Dissolved Oxygen Conditions Affect Marine Life in Long Island Sound(PDF)
- Puttting the Plan in Motion (PDF)

SunWise

- SunWise Monitor, November 1999 (PDF)

SunWise Monitor, April 2000 (PDF)
SunWise Monitor, April 2001 (PDF)

- Mission: SunWise – Activity Book (PDF)
  Mission: SunWise – Activity Book (Spanish) (PDF)
- Sun Safety for Kids: The SunWise School Program (PDF)|
  The SunWise School Program Guide (PDF)
- Mission: SunWise (PDF)
  Mission: SunWise (Spanish) (PDF)
- Summertime Safety: Keeping Kids Safe from Sun and Smog (PDF)
- Action Steps for Sun Protection (PDF)
- Sunscreen: The Burning Facts (PDF)
- The Sun, UV, and You: A Guide to SunWise Behavior (PDF)
- What Is the UV Index? (PDF)
- UV Radiation (PDF)
- Ozone Depletion (PDF)

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Group Details

Blue Group: Weather

Group Summary:	Roles:	Assignment Summary:
This group will track the wind speed and direction, humidity, rainfall, and temperature in the city via the Internet.	Assign roles. Each person tracks one weather feature or pollutant. 1. Wind Tracker 2. Ozone Tracker 3. Humidity Tracker 4. Particulate Tracker (PM_{10} & $PM_{2.5}$) 5. Rain Tracker 6. Carbon Monoxide Tracker **7.** Temperature Tracker	Each student will enter the data into a spreadsheet for his/her pollutant or weather feature.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).
2. Decide on the location your group will monitor – 22nd & Craycroft or Rose Elementary. (*Note: PM tracker will use Geronimo for PM_{10} & Rose Elementary for PM $_{2.5}$*)
3. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel Spreadsheet for the "Blue Group: Weather."
4. Save the spread sheet onto your disk or computer.

Blue Group Instructions, pg. 2

COLLECT DATA: Everytime

1. Open your previously saved Excel spread sheet for “Blue Group: Weather”

2. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and click on the “Your Data” in the “Blue Group: Weather” column to obtain current weather data.

3. Select either the 22nd & Craycroft location or Rose Elementary Location.

4. Enter the date you need into the From: and To: boxes.

5. Make sure the time boxes (hh:mm) read 00:00 and 23:59. (*Note: If you are looking at today’s data, the second box will automatically read the current time. To get a full day of data you need to enter yesterday’s date – or Friday’s date if it is currently Monday*).

6. Click on “Show Report.”

The abbreviations for the weather data are:
- OTP – outside temperature in degrees farenheight - VWD – variable wind direction in degrees - VWS – variable wind speed in miles per hour - RH – relative humidity in percent

7. Enter the date into the “Blue Group: Weather” spreadsheet.

8. Enter the data for your pollutant or weather feature into your spreadsheet.

9. Be sure to save your worksheet.

Blue Group Instructions, pg. 3

PRESENTATION PREP: Graphing 1st Presentation

Plot the data on a graph (weather vs. time or pollutant level vs. time).

1. Go to your spreadsheet and hold down the control button on the keyboard. With your mouse highlight the data for 8:00 and 17:00 for each day. (Continue to hold down control button.)

2. Click on the bar graph icon OR go to the “Insert” menu and select “Chart.”

3. Select “Column” for chart type then select “Next.”

4. Leave the data range alone and select “Series In: Columns.”

5. Select “Next.”

6. Enter a “Chart Title” such as “Wind Speed: Location” (or whatever your pollutant).

7. Enter a “Category (X) Axis” such as “Time.”

8. Enter a “Value (Y) Axis” such as “MPH” ” (or whatever units go with what you track)then select “Next.”

9. Select “Place Chart: As New Sheet” and enter a label such as “Wind Graph 1.”

10. Select “Finish.”

11. Now refine your graph: (See Example)

    A. Delete the series box (right side of graph).

    B. Change the background color:
    - Double click in the open part of the graph.
    - In the “Area” section click on the white square.

    C. Create Text Boxes for each day:
    - Type the date in the black space at the top of the Excel window (following the =).
    - Hit enter.
    - Drag the text box to the appropriate location on the graph.

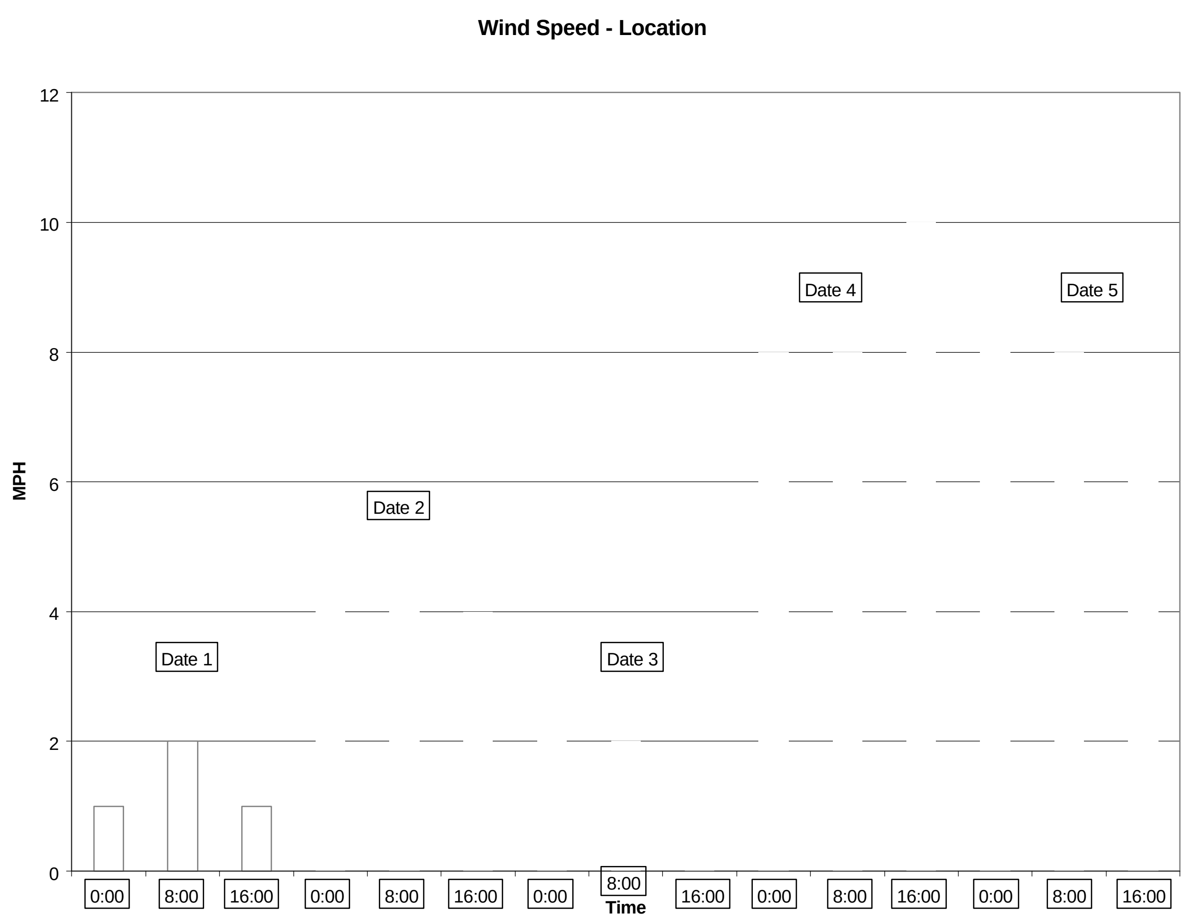
Blue Group Instructions, Pg. 4

C. Change the X-Axis labels:

- Double click at the bottom of the graph and select the tab labeled “Patterns” then under “Tick Mark Labels” select “None.”
- Create your own tick mark labels (0:00, 8:00, 16:00) for the x-axis by creating text boxes and dragging the boxes down to the appropriate location at the bottom of the graph. Repeat for each day.

D. Color code the days:

- Double click on the inside of a single bar (only that bar should highlight – not with squares in all the bars).
- The “Format Plot Area” window should come up.
- Select “Fill Effects.” Use the same color code for each day – SEE BELOW (for each 0:00, 8:00, 16:00 period).



PRESENTATION PREP: Find Averages

DO THIS AFTER EACH FULL MONTH OF DATA IS ENTERED (20 DAYS).

1. Find the average and standard deviation for each time at the end of each month.

2. You will notice there are some squares with the words "#DIV/0!". These squares already have the formula to find the average of your data. (Note: The average changes as you enter the data.)

3. You will need to enter the formula for the average for the remaining squares.

4. Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells for which you want to take the average (*Note: 16:00 will be one cell number higher than 8:00 a.m. – e.g. B104 instead of B103)*.

5. You will need to find the Standard Deviation (which tells you how variable your data is or how much of a change in the weather there is on different days at the same time). Do this by copying and pasting the formula from one Standard Deviation cell into the cell you want.

PRESENTATION PREP: Graphing #2

DO THIS AFTER EACH FULL MONTH OF DATA IS ENTERED (20 DAYS).

1. Graph the month's averages for your pollutant using a bar graph.

CHALLENGE: Try to make a scatter plot combining 2 of your variables (e.g. temperature & ozone).

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in air quality based on different weather events.

Consider the following (use your graphs to help you):
- Does ozone, carbon monoxide, PM_{10}, or $PM_{2.5}$ increase, decrease, or not change as a function of temperature, wind, humidity, or other weather feature?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Group Details

Brown Group: Visibility

Group Summary:	Roles:	Assignment Summary:
This group will monitor the visibility by monitoring the webcam. They will compare the visibility and pollution color with respect to concentration and type of pollutant.	Assign roles. 1. Webcam tracker 2. Weather tracker Pollution Trackers: 3. Ozone tracker 4. Carbon Monoxide (CO) tracker 5. Particulate tracker (PM_{10} & $PM_{2.5}$)	Each student will enter the data into the spread sheet for whatever s/he is tracking.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. If you are a "Weather Tracker" or "Pollution Tracker," go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and click on "Get Your Spreadsheet."

3. Save the spreadsheet onto your disk or computer.

4. Your monitoring location will be Rose Elementary. *Note: The PM tracker has to obtain data from Rose Elementary & Geronimo (together).*

5. As a group, decide what time of day you will monitor (e.g. 8 a.m.). It is recommended that you monitor sometime between 7-10 a.m. and/or 4-6 p.m.

Brown Group, Pg. 2

COLLECT DATA: Everytime

Webcam Tracker	Weather Trackers	Pollution Trackers
1. Go to the activity website and click on the "Visibility Page" 2. View and save image to your disk. a. If a dialogue box appears with a warning, CLICK "CONTINUE." This may happen 2 or more times. b. Look at the photos. Go to the **digital panorama**. CLICK on the image to bring up the full sized image. c. To save this image: - RIGHT CLICK on the image. In the box that pops up CLICK "save image/picture as." A box will appear. - Pick your FOLDER: In the box you can navigate to the folder where you are storing your images. - NAME your file. Use a standard format for each file. For example, a file saved on December 3, 2002 at 8am might be "02.12.03.8am." This format also makes it easy to sort through large number of images from many years. - CLICK "SAVE."	1. Open the Excel spread sheet for "Brown Group: Visibility." 2. Go to the activity web site http://www.airinfonow.com/html/airexercise/materials.html, click "Get Your Data" in the "Brown Group: Visibility" column to obtain current weather data. 3. Enter the date you need into the From: and To: boxes. 4. Enter the time you are monitoring into the boxes e.g 8:00 and 9:00. (*Note: If you are looking at the afternoon data remember to use military time – 13:00 for 1:00 p.m.*). 5. Select "Rose Elementary", scroll down, and then click on "**show report"**. 6. The abbreviations for the data you will collect are: - RH – relative humidity in percent 7. Enter the date into the "Brown Group: Visibility" spreadsheet. 8. Enter the data into the spreadsheet (you will do this daily). - Be sure to save your worksheet.	1. Open your saved Excel spreadsheet. 1. Go to the activity web site and click on "your data" in the "Brown Group: Visibility." 2. Enter the date you need into the From: and To: boxes. 3. Enter the time you are monitoring into the boxes e.g 8:00 and 9:00. (*Note: If you are looking at the afternoon data remember to use military time – 13:00 for 1:00 p.m.*). 4. Select "Rose Elementary", scroll down, and then click on "**show report"**. 5. Enter the date & data for your pollutant into the spreadsheet. 6. Repeat until all the data is entered. 7. Be sure to save your worksheet!

Brown Group, Pg. 3

PRESENTATION PREP: Graphing & Photo Comparison

1. Your group needs to create graphs of your data and identify trends in the webcam photos

CREATE GRAPHS FOR POLLUTION & WEATHER DATA

2. In your spreadsheet, highlight the data for pollutant and the days you are investigating.

3. Click on the bar graph icon OR go to the “Insert” menu and select “Chart.”

4. Select “Column” for chart type then select “Next.”

5. Leave the data range alone and select “Series In: Columns.”

6. Now click on the “Series” tab (top of gray box).

7. Click in the box “Category (X) axis labels” and then go back to your spreadsheet and highlight the dates for your data. (This will change the x-axis labels to your dates).

8. Select “Next.”

9. Enter a “Chart Title” such as “Daily Carbon Monoxide Levels: Location” (or whatever your pollutant is).

10. Enter a “Category (X) Axis” such as “Date.”

11. Enter a “Value (Y) Axis” such as “PPM” (or whatever unit your pollutant or weather feature is measured in) then select “Next.”

12. Select “Place Chart: As New Sheet” and enter a label such as “CO Graph.”

13. Select “Finish.”

PHOTO COMPARISON

1. Place the photos in a format where you can look at the photos and the graphs at the same time.

Brown Group, Pg. 4

SUGGESTIONS: You may need to have:

a) A photo of each day that corresponds with the high & low for a specific pollutant or weather event; OR
b) A week's worth of photos per page with one graph; OR
c) A week's worth of photos per page with several graphs, or, (or some other configuration).

This is up to you – just make sure your audience can see your data and understand it!

PRESENTATION PREP: Find Trends

8. As a group, analyze trends in visibity and individual air pollutants (ozone, carbon monoxide, PM_{10}, and $PM_{2.5}$) and weather.

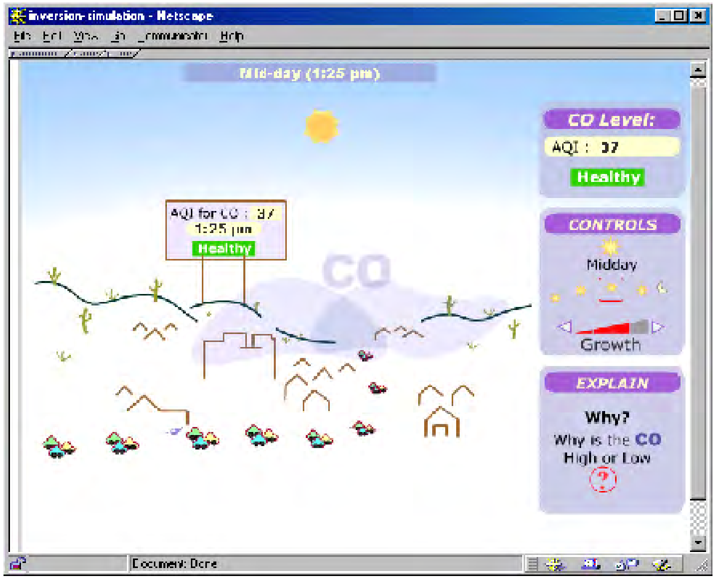
Consider the following:

- How does weather affect visibility?
- Are there color's associated with different pollutants (e.g. brown, gray, white)?
- Does the pollution or weather affect only one section or level on the horizon? (Use a landmark)
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypotheses to describe the trends. Be careful not to overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

A Guide to CO-City



The main Animation

CONTROLS

Change the time of day.

Change the size of the city.

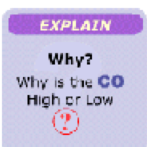
These can affect the number of cars, the number of buildings, and the amount of CO in the air.

Three ways to know how much pollution is in the air.

The CO Level readout.

The BILLBOARD.

The CO CLOUD will get bigger and darker when there is more



Use the "WHY" button to find out why the CO is high or low.

Here's why the CO is high or low ...

It could be the size of the city, it could be the time of day.

Those are important factors.

Other factors are:

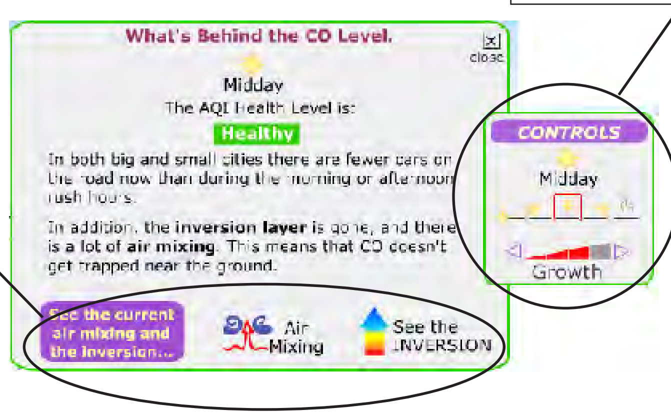
1. There are more cars on the road at some times of the day.
2. The CO is trapped during some times of the day.
3. The air isn't mixing.

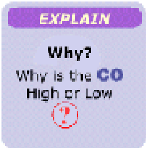
You can change the TIME or GROWTH in the city and the CO LEVEL and the explanation will be updated.

Use the Mixing and Inversion buttons to get details about:

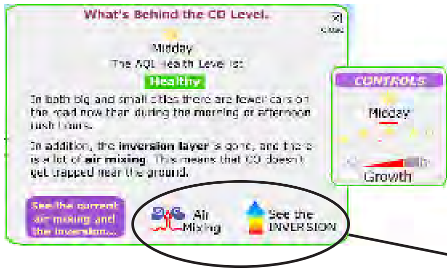
1. What processes lead to mixing of air masses.

2. How the inversion lay forms or disappears.





The WHY button



The window with the answers.

Once you know about the inversion layer and the air mixing. You might want to know:

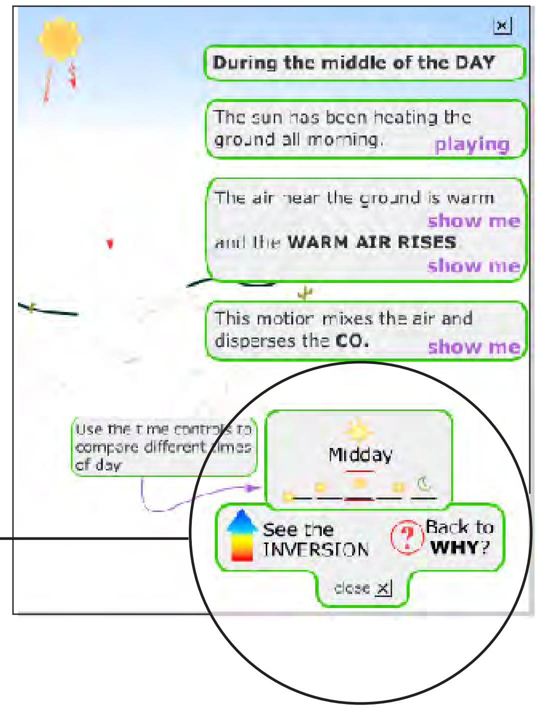
How did the inversion layer get there?
How did it disappear?
What makes the air mix?

The "Air Mixing" button and the "See the Inversion" button can illuminate these questions.

Air Mixing The Air Mixing screens

The bubbles explain the steps that lead to mixing or stagnant air.

Move your mouse over the words "**show me**" to see how things happen.



Use the "TIME" controls to see how things look at different times of day.

Or use the "INVERSION" button to see how the air mixing relates to the state of the inversion layer.

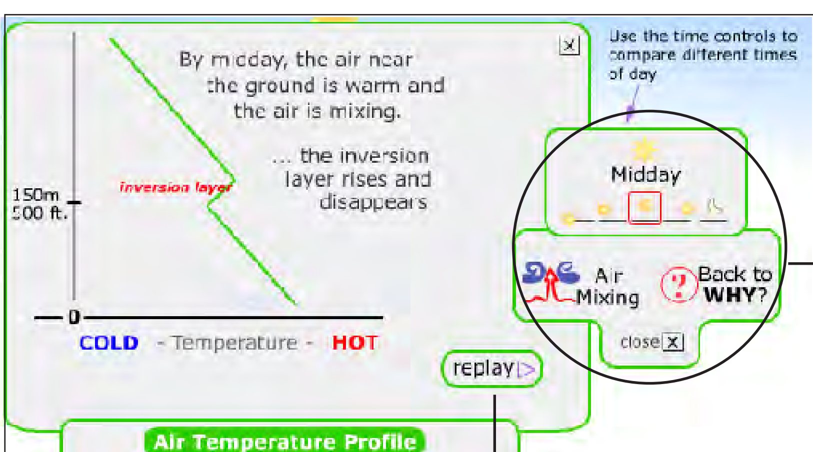
Or go back to the "WHY" screen to get the big picture.

Or "CLOSE" this screen to go back to the main CO-City animation.

See the INVERSION The Inversion screens

This window explains how the inversion layer changes.

The graph shows that the air temperature changes as you go higher above the ground.



REPLAY parts of the animation as needed.

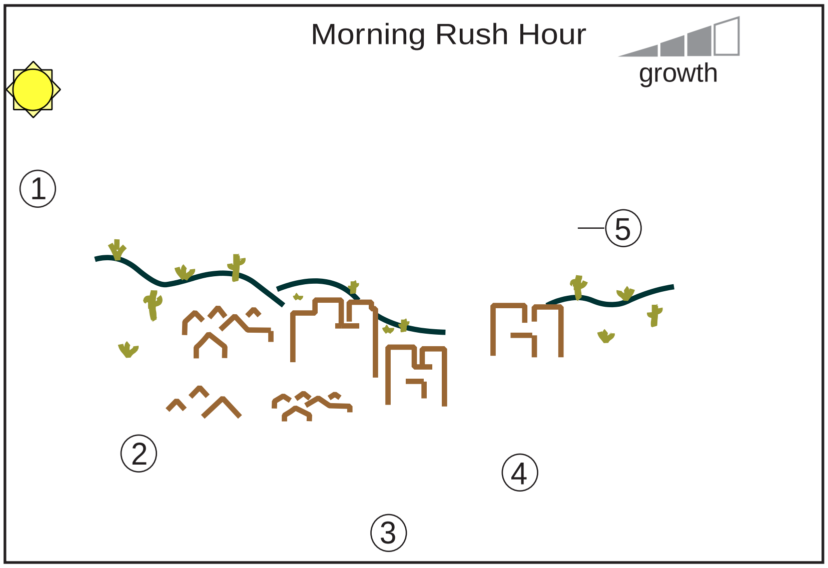
Use the "TIME" controls to see how things look at different times of day.

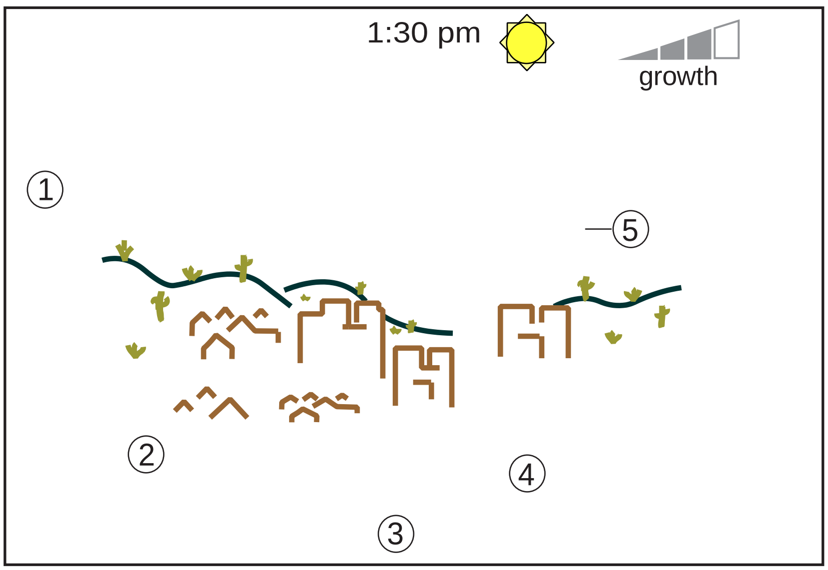
Or use the "INVERSION" button to see how the air mixing relates to the state of the inversion layer.

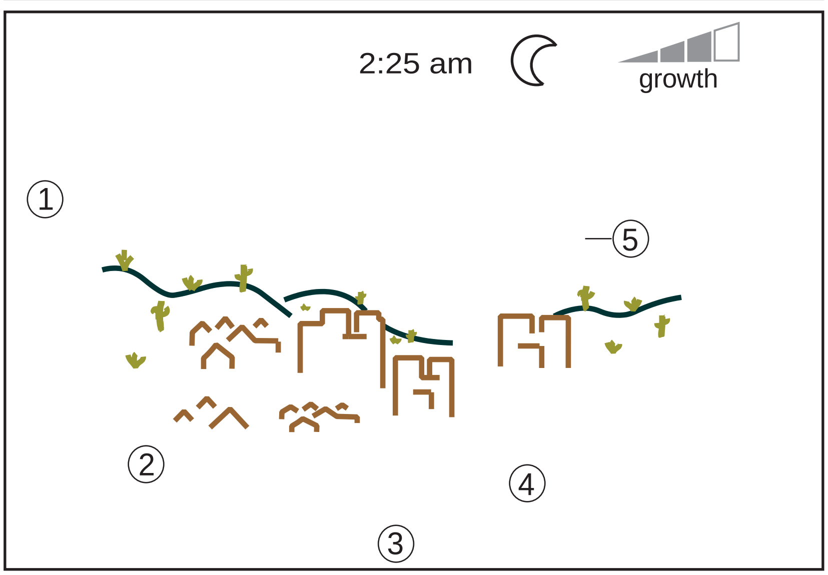
Or go back to the "WHY" screen to get the big picture.

Or "CLOSE" this screen to go back to the main CO-City animation.

Inversion Layer and Pollution Worksheet







Instructions: Fill out the following information for each of the scenes on the left. The example picture at the bottom shows how to fill in the picture.

1 If an inversion layer is present, write "**Inversion**" next to 1 and draw a horizontal line (as in the example). If there is no inversion layer write "**NONE**".

2 Next to 2 write the AQI value for the time of day and city growth level indicated in the drawing.

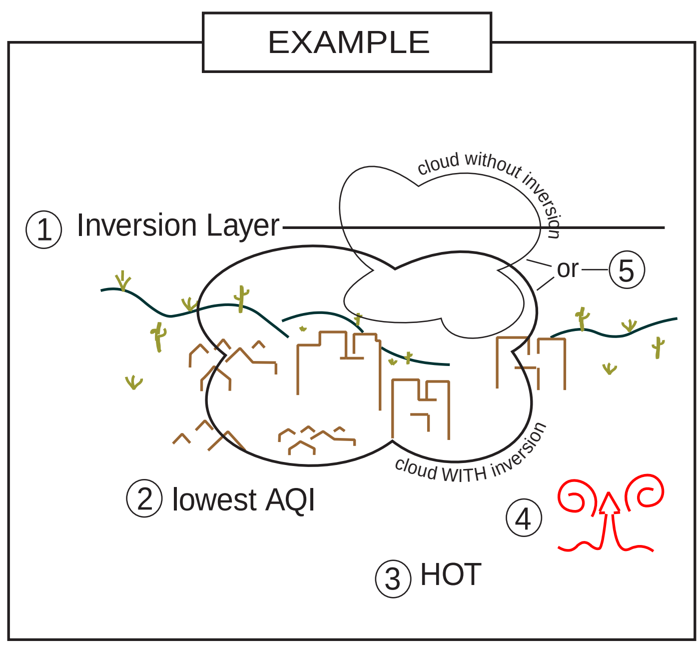
3 The ground is ... WARM or COLD (write WARM or COLD next to 3)

4 Indicate whether the air is circulating or not - if the air is circulating DRAW the circulating air (as in the example), if not then write "NO MIX" next to 4 .

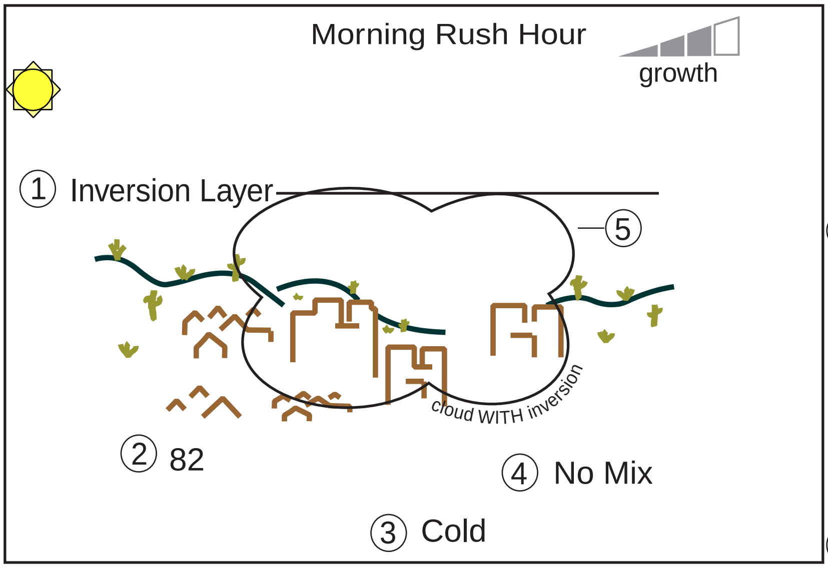
5 Draw a cloud according the the following guidelines.

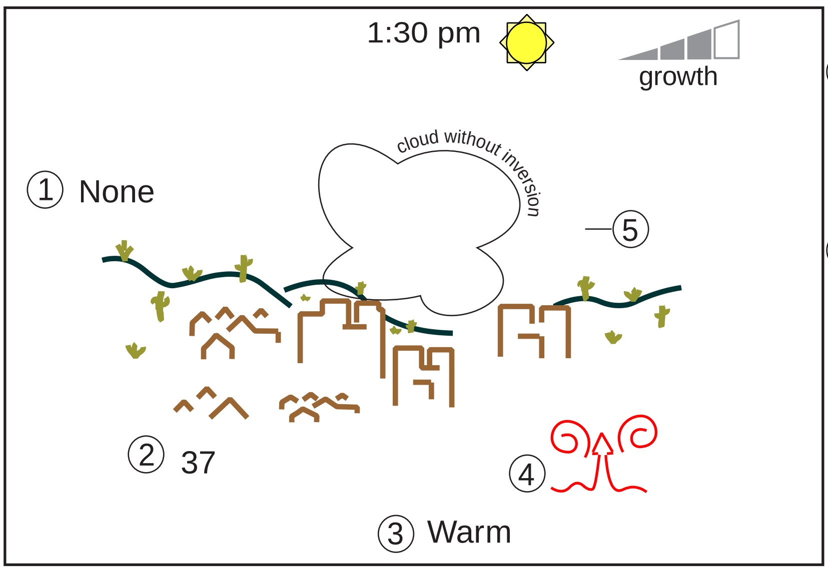
1-Scale the cloud to represent how much pollution there is (use your AQI value from question #2 - the scene with the most pollution should have the biggest cloud ...).

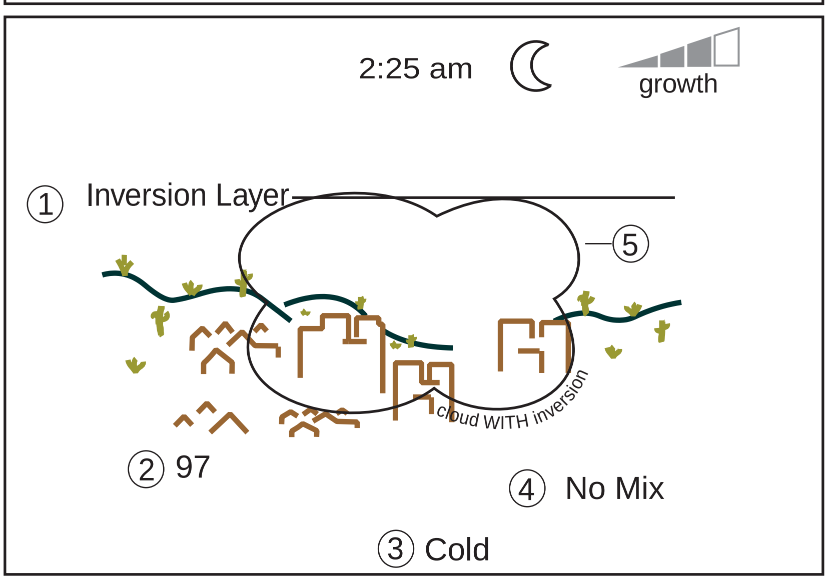
2-If an inversion layer is present the cloud should be trapped beneath it.



GRADING GUIDE:
Inversion Layer and Pollution Worksheet







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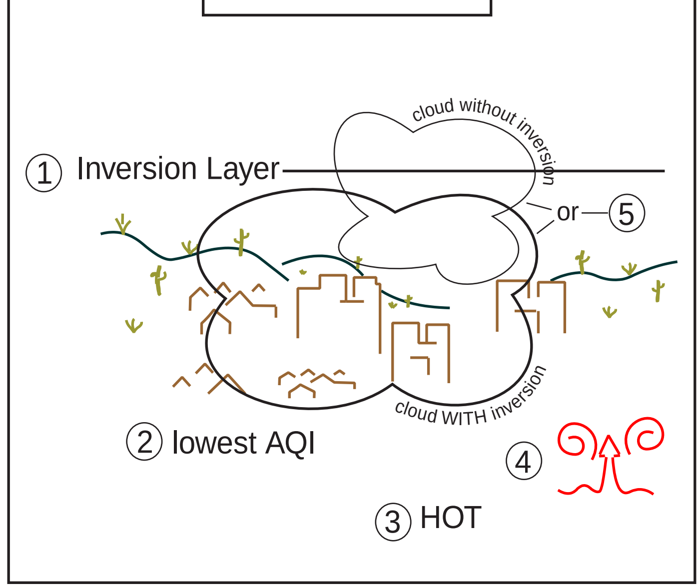
5 Draw a cloud according the the following guidelines.

1-Scale the cloud to represent how much pollution there is (use your AQI value from question #2 - the scene with the most pollution should have the biggest cloud ...).

2-If an inversion layer is present the cloud should be trapped beneath it.

EXAMPLE



So What's Making it Look Brown Outside?

Collecting and Measuring Particulate Matter

Time Needed: Several Days

NOTE: Rainy weather will interfere with the results of this experiment.

Student Outcomes:
Students will:

1. Identify gaseous and solid pollutants in the atmosphere.
2. Observe an experiment that illustrates how to capture particulate pollutants and identify which vehicle gives off more particulates.
3. Conduct an experiment capturing particulate pollutants and determine which locations appear to have more pollution.

Materials Needed:
__Scissors
__Six coffee filters
__Six 3" x 5" index cards
__Microscope or magnifying glass
__Access to six motor vehicles
__The chart provided

Background Information:
Pollutants are generally considered gaseous or solid. There are five major gaseous pollutants in the atmosphere: Sulfur dioxide, carbon monoxide, carbon dioxide, nitrogen oxides and ozone. The solid form of air pollution consists of particulate matter, lead and others. Only small amounts of these gases and solids need be present to pollute the air.

Sulphur dioxide (SO_2) is given off by power plants and factories that burn coal for fuel. SO_2 rises in a cloud from volcanoes and from industrial combustion of fuels containing sulphur. It reacts with oxygen and water in the air to become sulfuric acid, or acid rain. Acid rain can harm animal populations in lakes and rivers as well as trees and other plants by damaging leaves and root systems. It can deteriorate metal and stone on buildings and statues. Acid rain occurs not only at the source of the pollutant, but also many hundreds of miles away due to the movement of air masses.
Carbon dioxide (CO_2) is a normal component of the atmosphere. CO_2 is not really thought of as a major pollutant, but CO_2 levels are increasing. Because of the increased combustion of fossil fuels in the last hundred years (due primarily to increases in population and industrialization) many fear that this CO_2 increase is upsetting the temperature balance within the Earth's atmosphere. This is called global warming.
Carbon monoxide (CO) is a colorless, odorless and tasteless gas that enters the atmosphere when incomplete combustion occurs. The effects of CO are headaches, reduced mental alertness, and heart damage. It may even cause death by reducing the oxygen-carrying capacity of red blood cells.
Nitrogen oxides (NO_2) are mainly composed of nitric oxide (NO) and nitrogen dioxide (NO_2). These are the main components of smog, which is a dangerous vapor that covers cities during a temperature inversion. These nitrogen oxides combine with oxygen and, in the presence of sunlight, form ozone. They can combine with water to make acid rain, react in the air to produce ozone and other pollutants, or are harmful by themselves as a gas in the air.
Ozone (O_3) is a form of oxygen, produced during the interaction of nitrogen oxides, gaseous hydrocarbons, and

sunlight. If the air over a city does not move, pollutants become trapped close to the Earth's surface, reacting and producing smog and ozone. Ozone can cause breathing problems, harm trees and plants, and cause a rapid deterioration of materials such as rubber and fabrics.

Lead (Pb) was more of a problem a few years back when more motor vehicles used gasoline with lead additives. Strict limitations of the level of lead in gasoline has reduced lead emissions by 94 percent and lead in the air by 87 percent. Today, most cars in the USA use unleaded gasoline, but there is still much leaded gas being sold throughout the world. When leaded gasoline is burned, lead is released into the air. When people or animals breathe lead, over a period of time it accumulates in their bodies and can cause brain and kidney damage.

Particulate Matter (PM) consists of soot, dust, tiny droplets of liquid, and other materials. It is sent up into the air primarily by the burning of coal, diesel fuel, and wood. Particulates gradually settle back to the ground and can cause people to cough, get sore throats, or develop other more serious breathing problems. Pollution from particulate matter also causes discoloration of buildings and other structures. Many particulate pollutants are not generated by people, but by nature. Pollen, dust, volcanic ash and desert soils blown by the wind are all forms of particulate pollution.

Problem:

If cars put particulate matter in the atmosphere, how can this particulate matter can be captured and measured?

Hypothesis:

Older vehicles, and those using leaded fuel or diesel fuel, will produce more particulate matter emissions.

Procedure:

1. *Prior to performing this experiment,* find six people who are willing to be interviewed by students and have their automobiles tested (if possible, include a diesel school bus and an older leaded gas vehicle).

2. Divide the class into six groups. Cut the coffee filter into 2"x4" rectangular pieces. Have each group glue one piece of coffee filter to their index card.

3. Allow your students to see the six vehicles you are going to test. Ask them to guess which vehicles will produce the most and least particulate pollution and have them write down why they chose as they did.

4. Assign one vehicle to each student group.

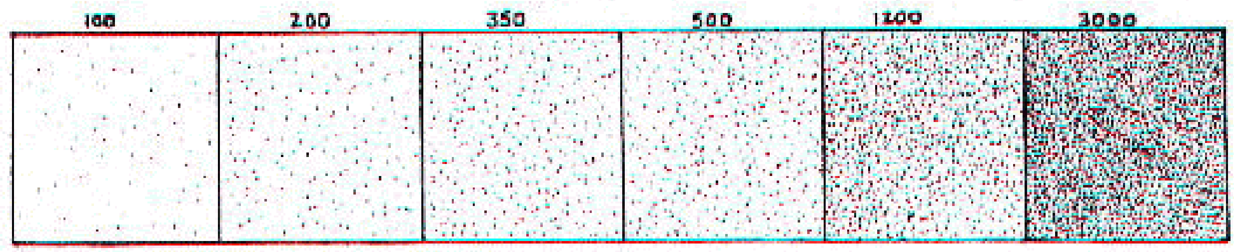
5. Assign one student from each group to interview the vehicle's owner to determine how old the vehicle is, when it was last tuned, what type of fuel it uses, etc. Have another student write the car owner's name, vehicle year and make on the back of the card. When the interviews are complete, have owners start their cars. Have another student from each group hold the index card approximately 6 inches from the automobile exhaust pipe for one minutes.

CAUTION: Do not allow the students to touch the tailpipe and have everyone avoid breathing the fumes. Do this experiment in a well-ventilated area.

6. After each group has tested their vehicle, bring the index cards back to the classroom and look at the cards under a microscope, or with a magnifying glass. Using the particulate scale, have the students estimate the number of particulates per square inch on their card. Have the students write the approximate number of particles per square inch on their card.

7. Have one student from each group bring their card to the board and relay their findings to the class. As a class, display the cards from least amount to greatest amount of particulates.

Conclusion:



Based on your observations, do the results of the experiment support or reject your hypothesis? Why or why not?

1. Have the students discuss which cars gave off more particulate pollution; was it older cars, larger cars, diesel-fueled cars, cars that hadn't been tuned in a long time?

2. What conclusion do the students draw from this investigation?

3. Would it matter if the car is regularly tuned up?

4. What other car maintenance factors could influence its emissions?

5. Have the students describe any relationship they see between the answers to the interview questions and the level of particulates on the scale.

6. Have the students graph the age of the automobile versus the number of particulates per square inch.

7. What other ways do vehicles contribute to particulate pollution?

8. Do you think the type of fuel used is also responsible for the amount of particulate emissions?

9. Would you expect solar-, electric-, or compressed natural gas-powered vehicles to have more or less emissions?

What's The Connection Between Convection And Inversion?

Convection Currents and Temperature Inversion

Time Needed: 20 - 30 minutes

Student Will:

1. Observe a demonstration that illustrates convection currents and temperature inversions.
2. Conduct an investigation that demonstrates how warm air rises.
3. Make a jar of smog to demonstrate how contained smoke will not disperse.

Materials Needed:

__A large shoe box
__Plastic wrap
__Two cardboard tubes
__Candle
__A long match
__Paper towels
__Scissors
__Tape
__Clay
__Ice cubes
__Paper
__A heat lamp

Background Information:

Once you have lived in Tucson/Pima County for a while, you become familiar with the haze that sometimes forms over our city. A drive to larger cities reveals persistent smog with the whole city sitting in a brown haze. What causes this brown haze or smog that can cause burning, itching eyes and shortness of breath? And why does it appear in greater amounts in regions surrounded by mountains?

Sources of smog may include motorized vehicles, industries, airplanes, trains, wood stoves, wildfires and blowing dust. In Tucson/Pima County, approximately 70 % of the air pollution is caused by motor vehicle use.

To begin to understand where smog is more likely to linger, we must understand convection currents and temperature inversions. Warm air is lighter (less dense) than cold air. As warm air rises, cold air moves to take its place. This cyclic nature of moving air is called a convection current. Convection causes currents of air to move around outdoors (and inside buildings as well.) Birds float upward on rising currents of warm air and gliders stay up in the air in the same way.

Convection currents help disperse air, including any pollutants in the air. This natural force moves polluted air rising from urban centers and dilutes it in less-polluted air above. Due to convection, air pollution does not remain isolated or localized. But a temperature inversion can obstruct normal convection currents.

A temperature inversion occurs when a mass of warm air moves over stagnant, cooler, surface air. This warm air mass forms a lid over the area, trapping all the polluted surface air left from the city's transportation systems, industries, and homes. If a temperature inversion traps pollutants, then a visible layer of smog will result. Because our sparse vegetation allows the ground to cool off nightly and our city is surrounded by mountains, smog is very likely to linger until the morning sun warms the air enough to begin the mixing (convection) cycle.

The following experiment demonstrates convection currents and a temperature inversion.

Problem:
How do convection currents and temperature inversions influence air pollution?

Hypothesis:
Polluted air will be moved and diluted by convection currents, but will remain stagnant during a temperature inversion.

Procedure:

1. Divide your students into small groups and see if they can suggest methods to show how convection currents and temperature inversions influence air pollution. Perhaps their ideas will illustrate this point just as clearly as the following experiments, and the lesson will stick with them longer if they do the brainstorming. In case there are few reasonable suggestions, here's an activity to help you out!

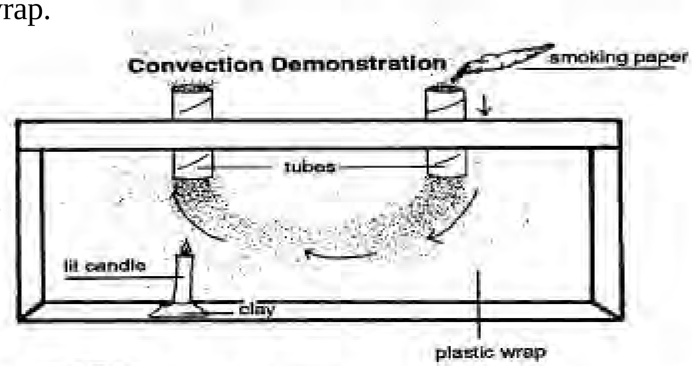
2. Take the top off the shoe box and lay the box on its side. Cut two holes in the top side of the box (one at each end), just large enough for two paper towel tubes. Push the tubes into the holes and seal the openings with tape in order to ensure an airtight seal. You have just made two paper towel tube chimneys.

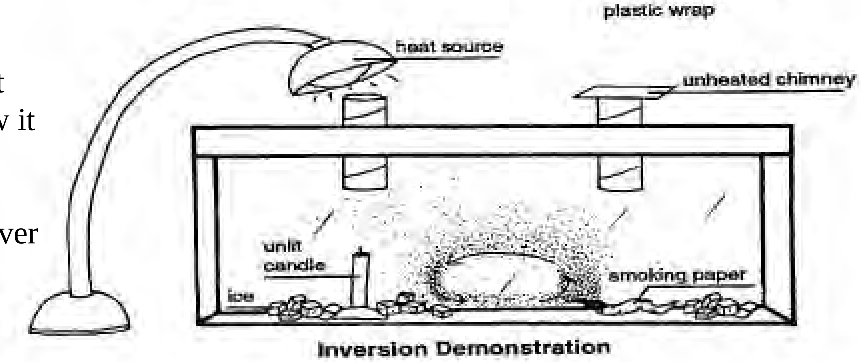
3. Set a candle in a clay base under one of the paper towel tube chimneys, pressing the clay firmly into place to hold it tight. The candle should be at least 2 inches lower than the chimney. (Make sure the wick is exposed and upright.)

4. Cover the open side of the box with clear plastic wrap. Tape the plastic wrap to the front of the box, forming an airtight seal.

5. Very **CAREFULLY**, using a long match, (or a match taped to a pencil) light the candle by putting it down the chimney. Once the candle is lit, allow the box to warm up for approximately five minutes.

6. Take a tightly wadded up paper towel and light it with a match. Let it burn for a few seconds, and then blow it out. It should be smoking profusely. Note that the smoke rises (warm air). Now hold the smoking paper down over the second chimney (without the candle). Record your observations:





The cold (heavier) air above the smoking paper will push the smoke down through the chimney. The smoke will then warm, rise toward the candle, and exit the convection box via the opposite chimney. This demonstrates the cyclic nature of convection and how warm air rises and cold air sinks.

7. Now, to simulate a temperature inversion, blow out the candle, place the ice cubes down both chimneys and let the box cool down for five minutes.

8. While the box is cooling down, put the heat lamp directly over one chimney, not blocking it, but making sure the heat is funneled down into the box.

9. Drop a smoking wad of paper down the other chimney, then place a piece of paper over this chimney. A temperature inversion prevents normal convection. The warmer air mass moves over the cooler ground air and traps it. Compare the heated chimney with the unheated one, after 30 seconds of viewing the trapped smoke, by lifting the unheated chimney's cover and watching the smoke escape. Record your observations:

Conclusion:
Based on your observations, does this experiment support or reject your hypothesis?
Why or why not?

Follow-up:
1. What, in nature, warms the air like the candle did in the experiment?

2. How does Tucson's geography and weather make it a prime candidate for temperature inversions?

3. What human activity is most responsible for air pollution in our community?

4. Recall that pollution lingers during a temperature inversion, when cool polluted air is trapped under a lid of warm air. At what time of day or night are these conditions most likely to occur?

5. What human activity occurs at this time of day or night and contributes to air pollution?

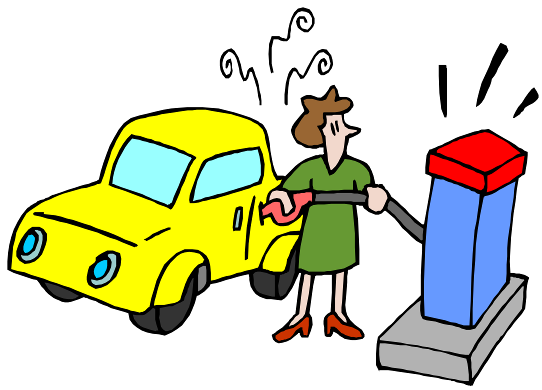
6. What would cause cold, polluted air to rise and be diluted? At what time of day or night would you expect this to happen?

7. If the sun rose later in the day, what effect would this have on lingering air pollution?

8. At what time of the year would you expect this to happen?

Getting a Handle on Greenhouse Gases

Your Family's Impact on the Greenhouse Effect



Materials Needed:

__A calculator
__Your family
__Gasoline receipts or gasoline credit card bill
__Household utility bills (electric and natural gas)
__Household receipts for propane or other fuels

Background:
The burning of fossil fuels such as gasoline, coal, oil, natural gas, and wood usually produces CO_2. However, some electric utility companies utilize electricity from non-fossil fuel sources of energy such as nuclear, solar, hydroelectric, and wind. Because of this, your determinations in this experiment are only estimates of CO_2 production.
You can determine how much CO_2 your family releases into the atmosphere by calculating the amount of gasoline your family buys and the amount of fossil fuel your family uses to heat or cool your house.

Problem:
The burning of fossil fuels releases CO_2 into the atmosphere.

Hypothesis:
By using utility and gasoline receipts, an estimation of CO_2 production can be calculated.

Procedure:
To determine how much energy your family used in one month:

1. Look at the gasoline credit card bill or gasoline receipts to find out how many gallons of gas were bought. If your family uses propane gas, you can use that receipt to estimate how many gallons of propane are used in a month. Record this figure.

2. Check the utility bill to find out how many "kilowatt hours" (kph) your family used. If you have a natural gas bill, find out how many "therms" you used last month. (Kilowatt hours and therms are the units your utility company uses to measure your energy use).

3. Use this chart to estimate the amount of CO_2 released.

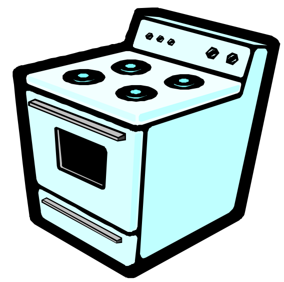
Electricity ________ (kwh) X 1.8 = ___________ lbs. of CO_2.

Natural gas ________ (therms) X 12 = ________ lbs. of CO_2.

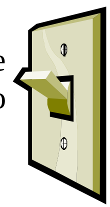
Gasoline ___________ (gallons) X 19 = __________ lbs. of CO_2.

Propane __________ (gallons) X 12 = __________ lbs. of CO_2

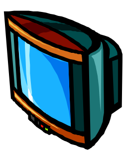
Total per month = ___________ lbs. of CO_2



Work with your family to try to conserve energy for one month. There are many efforts your family can make to reduce energy consumption including:



Turning off lights when leaving the room.
Turning down the temperature of the hot water heater.
Buying a water heater "blanket."
Turning off the TV when no one is watching it.
Only using the washing machine or dishwasher when they are full.
Using the dryer less, using a clothes line more.
Replacing light bulbs with lower wattage bulbs (try 75 watts instead of 100).



Mention to your family that for every gallon of gas a car burns, 18 - 20 pounds of CO_2 are put into the atmosphere! The average car pumps its own weight (3,500 lbs.) Of CO_2 into the atmosphere every year.

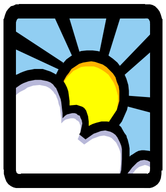
Suggest to your family to try a "No Car Day" once a week to see if you can figure out other ways of getting to school and work. Perhaps members of your family can carpool with co-workers or school mates or take the bus once a week. Are you close enough to your destination to ride a bike or walk? After one month of these activities to reduce energy use, recalculate your gas and utility bills.

Conclusions:
Do your conclusions support or reject your hypothesis?

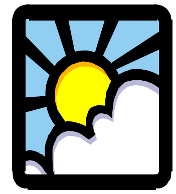
Follow-up:
Perhaps understanding the money saved would encourage your family to reduce their use of fossil fuels. Is there a way to determine how much money was saved when your family reduced their utility and gasoline bills (if there was a reduction)?

How can your family reduce (or continue to reduce) the amount of CO_2 released into the air?

Do you think different societies contribute different amounts of CO_2 into the air?



Helping to Find a Solution to Air Pollution!



Background:
Many times, when you study a subject or investigate an issue, you form an opinion about that issue and consider steps you would be willing to take to make a difference. However, over time it is easy to forget how important the issue seemed as you learn about other issues and subjects.

In this activity you will write a letter ... to YOURSELF! Your teacher will keep the letter and return it to you at the end of the school year. The letter will be a reminder to you about the air pollution unit you studied and how you considered what YOU could do to help this problem.

Include in your letter:

1. One paragraph concerning information about what you have learned about air pollution in our community.

2. One paragraph about what others are doing to help solve this problem.

3. A final paragraph about what YOU are willing to do about air pollution. Some examples would be: Walk or ride your bike more often, take the bus more often, carpool more with your friends, or encourage your family to keep your car well-tuned. Be honest with what you will be able to commit to and keep your commitment in mind over the next few months.

4. Turn your letter in with a self-addressed envelope to your teacher. Try to remember and live by the commitment you made regarding air pollution.

Closing Thoughts ...
A fun idea to share with others on what you have learned about air pollution would be to write and produce an air pollution video or skit. Plan on showing this skit or video to others in your school during Earth Day or as part of a Science Fair.

Another idea would be to contact the existing bicycle club at your school or, if there isn't one, start one! Bicycle shops or other businesses may sponsor you so you can have "fun rides" to raise money and build awareness to help stop air pollution.

Green Group: Location

Group Summary:	Roles:	Assignment Summary:
This group will compare the pollution levels for ozone (O_3), carbon monoxide (CO), and particulate matter (PM_{10} and $PM_{2.5}$) at different locations within the city using the 8 hour Air Quality Index reports.	Assign roles. Each person tracks one pollutant. 1. Ozone Tracker 2. Carbon Monoxide Tracker 3. Particulate Tracker If there are more than 3 people in this group, then there will be several ozone and carbon monoxide trackers (divide the locations to track)	Each student will enter the data into a spreadsheet for his/her pollutant for each location where it is monitored.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel spreadsheet for the "Green Group: Location."

3. Save the spreadsheet onto your disk or computer.

Green Group Instructions, pg. 2

COLLECT DATA: Everytime

1. Open your saved Excel spreadsheet.

2. Go to the bottom of the spreadsheet and select your pollutant (carbon monoxide, ozone, or particulates). This will open the correct sheet.

3. Go to the activity web site and click on “Get Your Data” in the Green Group: Location Column.

4. Choose the date you need.

Note: In order to get a full day’s worth of data, you will need to view the data for the previous week day (i.e. yesterday, or if it is currently a Monday you will view Friday’s data).

5. Click on “**view” PSI Report text/html**. You see the locations listed.

6. Enter the date you have chosen into the “Green Group: Location” spreadsheet.

7. Enter the data for your pollutant into the spreadsheet.

8. Repeat until all the data is entered.

9. Be sure to save your worksheet!

Green Group Instructions, pg. 3

PRESENTATION PREP: Find Averages

1. Find the average and standard deviation for each location for your pollutant at the end of each week.

2. You will notice there are some squares with the words “#DIV/0!”. These squares already have the formula to find the average of your data. (Note: The average changes as you enter the data.)

3. You will need to enter the formula for the average for the remaining squares. There are several ways to do this – try one of each of the ways:

a. *Go to INSERT Þ FUNCTION Þ select AVERAGE Þ enter the first and last cell numbers you want to average separated by a colon. In the third average box that would be (E3:E7).*

OR

b. *Type =average(E3:E7) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells for which you want the average.*

4. You will need to find the Standard Deviation (which tells you how variable your data is or how much change there is between weekdays at the same location). There are several ways to do this – try one of each of the ways:

a. *go to INSERT Þ FUNCTION Þ select STDEV Þ enter the first and last cell numbers you want to average separated by a colon. In the third Standard Deviation box that would be (E3:E7).*

OR

b. *Type =stdev (E3:E7) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains a Standard Deviation calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the Standard Deviation of.*

Green Group Instructions, pg. 4

PRESENTATION PREP: Graphing

1. Each student will plot the averages on a graph (pollutant vs. location)

2. In your spreadsheet, highlight the averages for each location. If you are plotting multiple week averages, hold down the "Control" button and click on the squares you want to graph.

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Rows."

6. Now click on the "Series" tab (top of gray box).

7. Click in the box "Category (X) axis labels" and then highlight your locations. (You should see the X axis labels change from 1, 2, 3… to Alvernon & 22nd, Cherry & Glenn, or whatever your locations are.)

8. Select "Next."

9. Enter a "Chart Title" such as "Average Weekly Carbon Monoxide By Location: Dates" (or whatever your pollutant is for whatever time period.

10. Enter a "Category (X) Axis" such as "Location."

11. Enter a "Value (Y) Axis" such as "AQI" the select "Next."

12. Select "Place Chart: As New Sheet" and enter a label such as "CO Graph."

13. Select "Finish." Be sure to save your work!

14. Now we are going to add error bars.

15. Double click on one of the bars. You should see squares show up in the middle of all of the bars.

16. A window titled "Format Data Series" should come up.

17. Click on the tab titled "Y Error Bars."

18. Select "Display Both."

Green Group Instructions, pg. 5

19. Under “Error Amount” select “Custom” and click in the “+” field.

20. Now go back to the spread sheet by clicking on the lower left tab.

21. Highlight the cells standard deviation cells that correspond with the averages you plotted.

22. Go back to the chart. Under “Error Amount” select “Custom” and click in the “-” field.

23. Again, go back to the spread sheet and highlight the same standard deviation cells. You should see the error bars on the columns.

PRESENTATION PREP: Mapping

DO THIS AFTER AT LEAST 1 MONTH’S DATA HAS BEEN COLLECTED.

As a group, plot the average AQI on a map of Tucson using the AQI color code. (AQI color code is found at the bottom of a data page on the website)

1. Draw 3 maps of Tucson on a large sheet of butcher paper (~ 4’ x 4’) and label “Ozone Map”, “Carbon Monoxide Map”, and “Particulate Map”. Decide ahead of time what your map scale will be (e.g. how many inches = how many miles or kilometers). Be sure to include major intersections and landmarks.

2. Mark the locations of the monitoring stations on your maps.

3. On a scratch sheet of paper decide what your boundary distances will be from each station on the map. These boundaries will be your “best guess” regions where the air quality is similar to that registered at the nearest monitoring station.

4. Using the AQI colors, decide on a color scale to indicate pollutant concentrations.

    For example: The AQI may be “good” and the region would be colored green, but you may want to have light green to represent an average concentration range of 0 to 25, and dark green to represent and AQI range of 25 to 50. You can create a scale for all of the AQI colors (green, yellow, orange, red, purple).

Green Group Instructions, pg. 6

5. On the map, color in the average pollutant concentrations according to the AQI color scale you created.

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in air quality based on location in the city.

Consider the following (Use your graphs and maps to help you):

- Are there certain locations in the city that have higher ozone, carbon monoxide, PM_{10}, or $PM_{2.5}$?
- Do you have any ideas why there may be differences?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Groups

Green Group: Location

- This group will see if they can identify pollution trends according to location.

Red Group: Time

- This group will see if they can identify trends in pollution concentrations by time of day.

Yellow Group: Health Effects

- This group will monitor the occurrences of asthma attacks at several schools throughout the district and see if there are any correlations with air pollution levels.

Blue Group: Weather

- This group will see if they can identify trends in pollutant concentrations with changes in weather.

Brown Group: Visibility

- They will try to identify trends in visibility with respect to weather, type of pollution and concentration.

Timeline

Data Collection

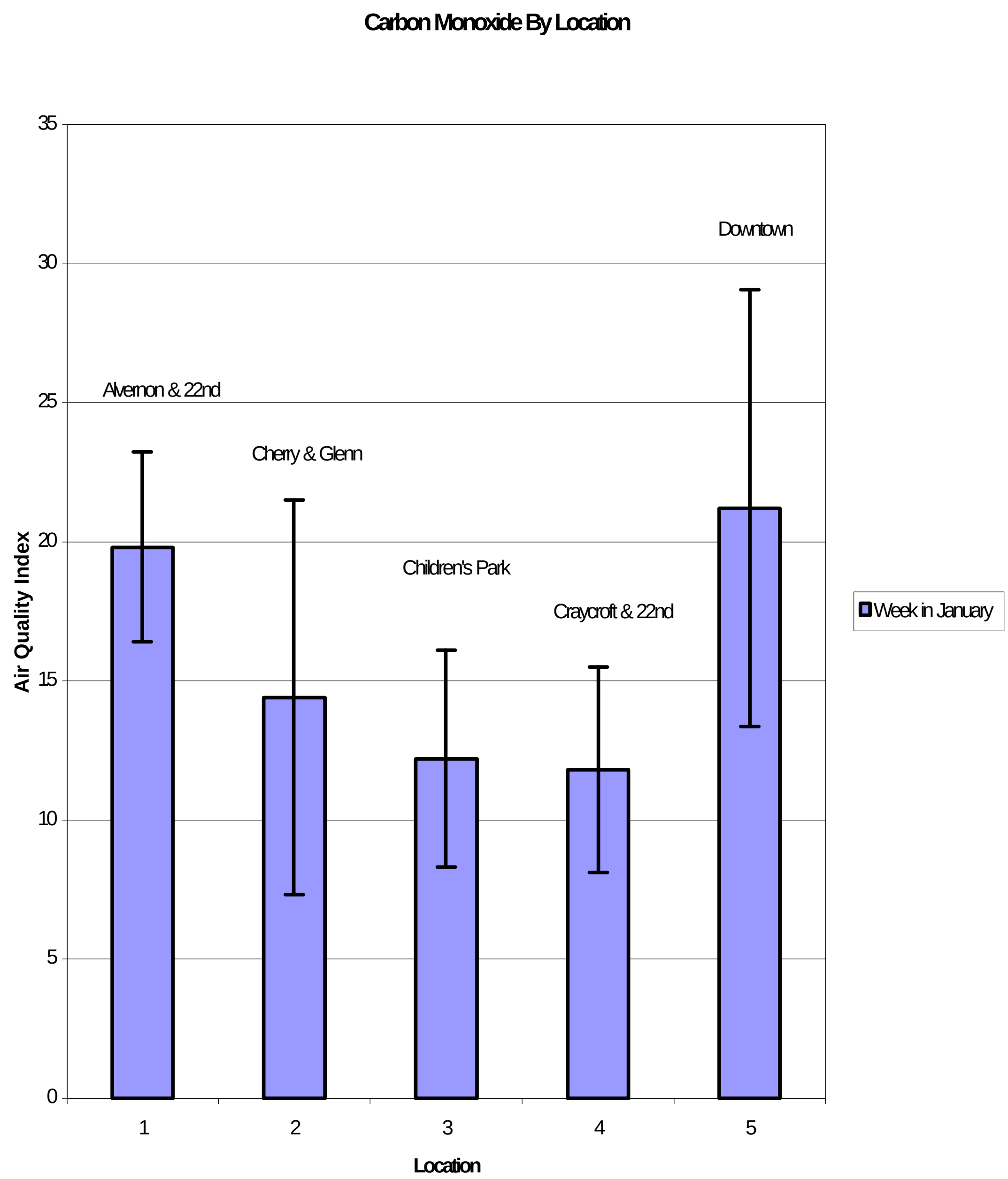
1st Week	
(data entry)	30 minutes
2nd Week	
(data entry)	30 minutes
3rd Week	
(data entry)	30 minutes
(data compilation/report prep)	1 – 1.5 hours
(report to class)	30-45 minutes
Monthly (through a cold & warm season)	
(data entry, compilation, & report)	2-3 hours per month

Air Quality Index

Air Quality Index Color	Air Quality Index Values	Air Quality Descriptor	Health Effects
	0-50	Good	No health effects are expected.
	51-100	Moderate	Unusually sensitive individuals may experience respiratory effects from prolonged outdoor exertion if you are unusually sensitive to ozone.
	101-150	Unhealthy for sensitive groups	Member of sensitive group may experience respiratory symptoms (coughing, pains when taking a deep breath).
	151-200	Unhealthy	Member of sensitive group have higher chance of experiencing respiratory symptoms (aggravated cough or pain), and reduces lung function.
	201-300	Very Unhealthy	Members of sensitive groups experience increasingly severe respiratory symptoms and impaired breathing.

Introduction to Excel: Data Samples

Day	Date	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
1	1/27/01	22	15	16	15	20
2	1/28/01	15	3	6	6	8
3	1/29/01	19	14	12	11	26
4	1/30/01	19	22	15	12	25
5	1/31/01	24	18	12	15	27


Carbon Monoxide By Location
Air Quality Index
35
30
25
20
15
10
5
0
Alvernon & 22nd
Cherry & Glenn
Children's Park
Craycroft & 22nd
Downtown
1
2
3
4
5
Location
Week in January

Height Statistics

19													
18													
17													
16													
15													
14													
13													
12													
11													
10													
9													
8													
7													
6													
5													
4													
3													
2													
1													
60”	61”	62”	63”	64”	65”	66”	67”	68”	69”	70”	71”	72”	73”

Height

VOCABULARY

Air Quality Index (AQI) – A scale developed by the EPA (Environmental Protection Agency) to report the levels of certain air pollutants, and their effects on human health.

Parts Per Million – A unit of measurement that describes the number of parts of something within a million parts of something else.

Carbon Monoxide – A toxic gas made from incomplete combustion (burning) of carbon-based materials like gasoline, coal, and methane (natural gas). The abbreviation for carbon monoxide is CO, which shows its chemical composition of one carbon atom attached to one oxygen atom.

PM 2.5 – Particulate matter that is very small, less than 2.5 microns in size. These particles are created by combustion, mostly from vehicles. Because they are so small, they can go deep inside the lungs.

PM 10 – Particulate matter that is "larger", approximately 10 microns in size. These particles can include dust, pollen, and ash. They can irritate the upper respiratory system like the nose and upper lungs.

Micrograms – A unit of measurement that depicts very, very small quantities of a substance - 1/1,000,000 or 0.000001 of a gram.

Military Time – Time units that sequentially number the hours in a day from 0:00 (midnight) to 23:00(11 p.m.).

Ozone – A gas made up of three molecules of oxygen (O_3). In the upper atmosphere ozone protects the earth from ultra violet rays, but if ozone is created in the lower atmosphere (what we breathe) it can negatively affect plant and animal life.

DATA COLLECTION

STEP 1: Go to the Real-Time Air Quality Activity website.

STEP 2: Find your group on the webpage.

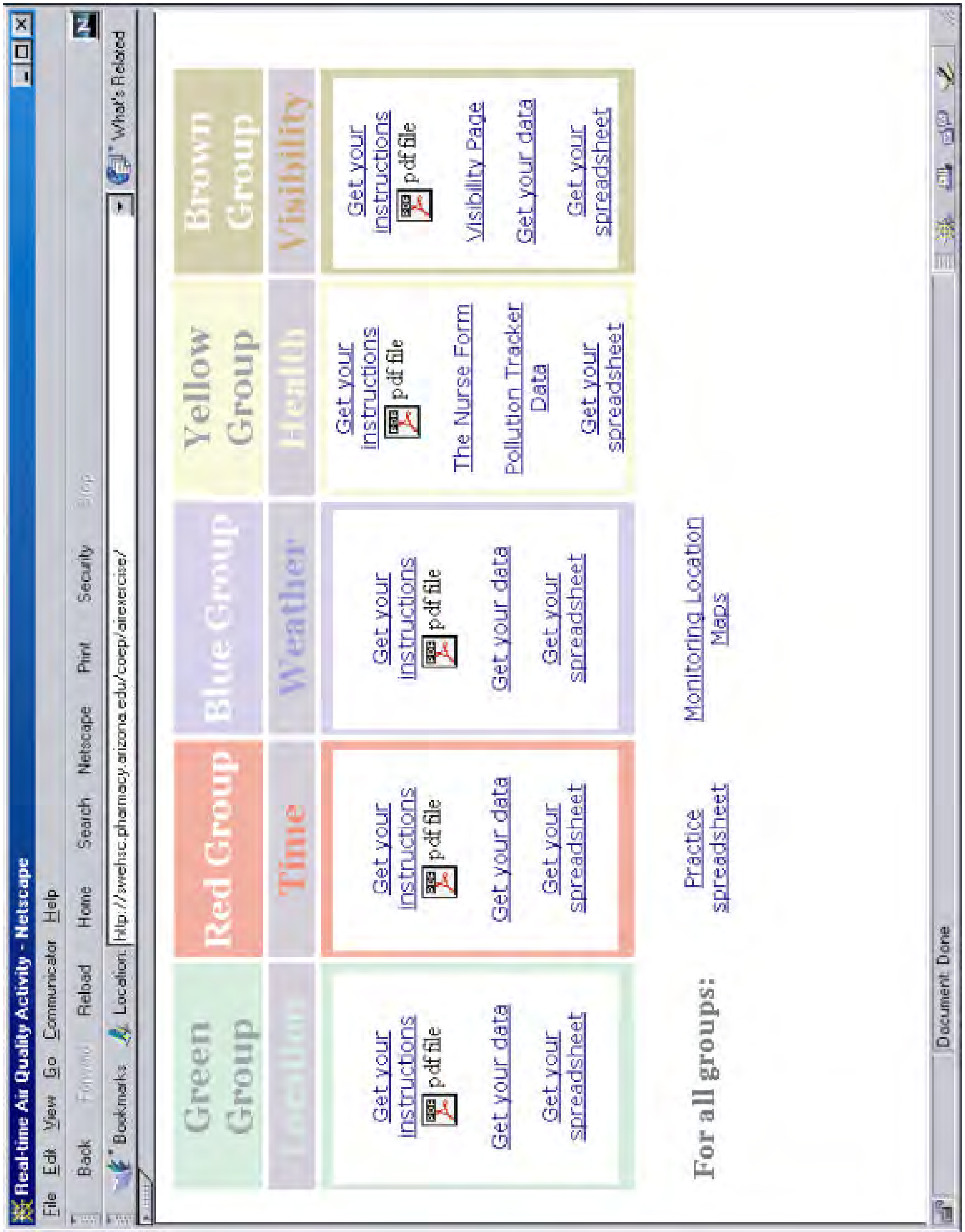
STEP 3: Click on Your Spreadsheet.

STEP 4: Save the spreadsheet in your file folder. Keep the Excel window open.

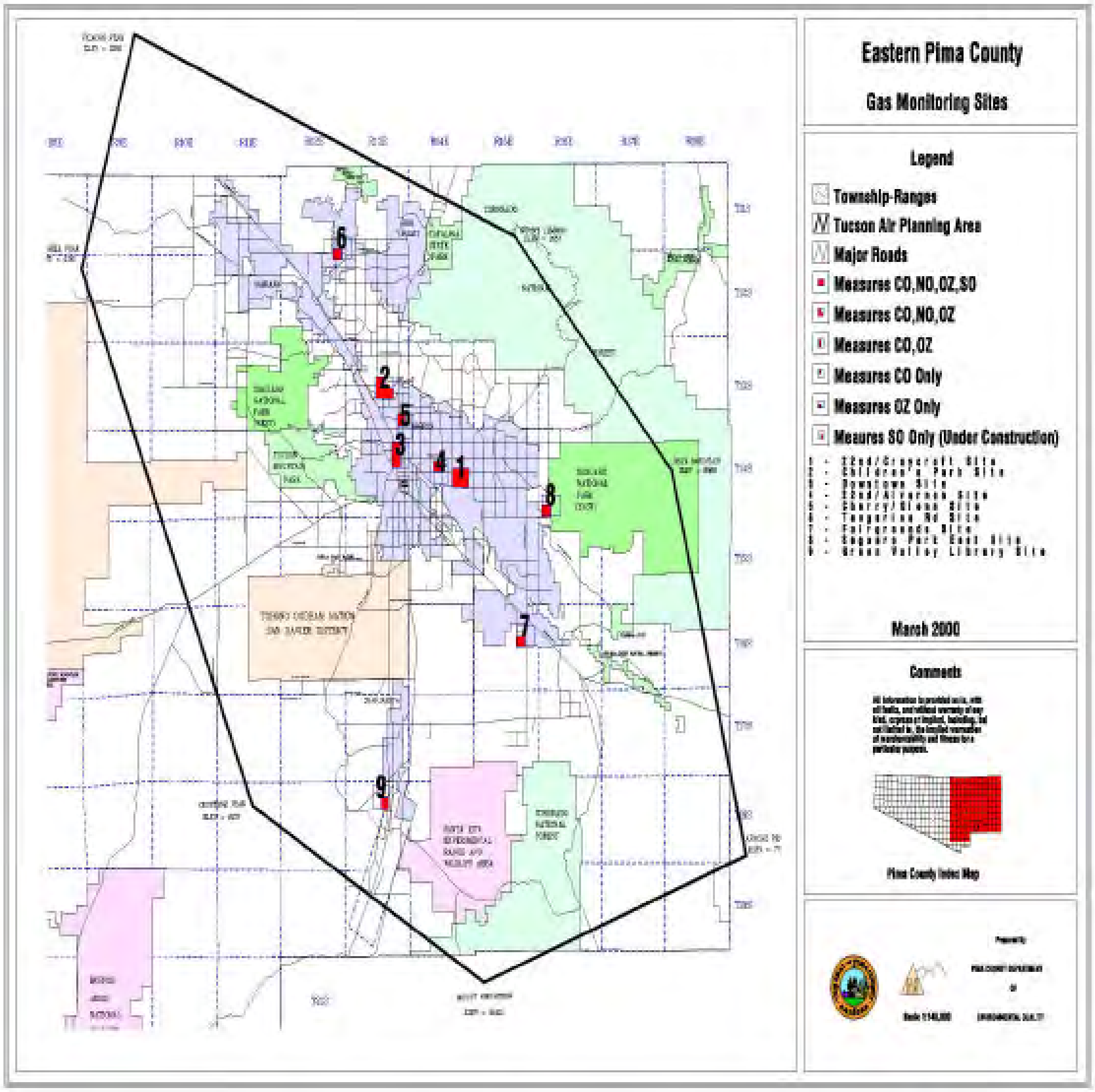
STEP 5: Open a new browser and go back to the Real-Time Air Quality Activity website.

STEP 6: Click on Your Data.

STEP 7: Follow the instructions in your folder to enter the data in your spreadsheet.


Real-time Air Quality Activity - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Stop
Bookmarks Location: http://swehsc.pharmacy.arizona.edu/coep/airexercise/
What's Related
Green Group
Location
Get your instructions
pdf file
Get your data
Get your spreadsheet
Red Group
Time
Get your instructions
pdf file
Get your data
Get your spreadsheet
Blue Group
Weather
Get your instructions
pdf file
Get your data
Get your spreadsheet
Yellow Group
Health
Get your instructions
pdf file
The Nurse Form
Pollution Tracker Data
Get your spreadsheet
Brown Group
Visibility
Get your instructions
pdf file
Visibility Page
Get your data
Get your spreadsheet
For all groups:
Practice spreadsheet
Monitoring Location Maps
Document: Done

Monitoring Sites



Group Details

Red Group: Time

Group Summary:	Roles:	Assignment Summary:
This group will compare the pollution levels for ozone (O_3), carbon monoxide (CO), and particulate matter (PM_{10} and $PM_{2.5}$) by time of day.	Assign roles. Each person tracks one pollutant. 1. Ozone Tracker 2. Carbon Monoxide Tracker 3. PM_{10} Tracker 4. $PM_{2.5}$ Tracker If there are more than 4 students, split each day into 2 sections (e.g. 0:00 – 12:00 & 13:00 – 23:00.)	Each student will enter the data for his/her pollutant into a spreadsheet.

Detailed Instructions:

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Decide on the location your group will monitor. *Note: PM_{10} and $PM_{2.5}$ are limited to Green Valley, OR Rose Elementary & Geronimo together)*

3. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel Spreadsheet for the "Red Group: Time."

4. Save the spread sheet onto your disk or computer.

Red Group Instructions, pg. 2

COLLECT DATA: Everytime

1. Open your saved Excel spreadsheet.

2. Go to the bottom of the spreadsheet and select your pollutant (carbon monoxide, ozone, or particulates). This will open the correct sheet.

3. Go to the activity web site and click on "your data" in the "Red Group: Time."

4. Enter the date you need into the From: and To: boxes.

5. Make sure the time boxes (hh:mm) read 00:00 and 23:59. (*Note: If you are looking at today's data, the second box will automatically read the current time*. *To get a full day of data you need to enter yesterday's date – or Friday's date if it is currently Monday*).

6. Select the location you are monitoring, scroll down, and then click on "**show report**".

(Particulate matter is monitored at the following sites: Green Valley PM_{10} and $PM_{2.5}$, Geronimo PM_{10}, Rose Elementary $PM_{2.5}$.)

7. Write down the data for your pollutant.

8. Enter the date and location you have chosen into the "Red Group: Time" spreadsheet.

9. Enter the data for your pollutant into the spreadsheet.

10. Repeat until all the data is entered.

11. Be sure to save your worksheet!

Red Group Instructions, pg. 3

PRESENTATION PREP: Find Averages

1. Find the average and standard deviation for each time at the end of each week or month.

2. You will notice there are some squares with the words “#DIV/0!”. These squares already have the formula to find the average of your data. (Note: The average changes as you enter the data.)

3. You will need to enter the formula for the average for the remaining squares. There are several ways to do this – try one of each of the ways.

a. *Go to INSERT Þ FUNCTION Þ select AVERAGE Þ enter the first and last cell numbers you want to average separated by a colon. In the next empty average box that would be (B12:F12).*

OR

b. *Type =average(B12:F12) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the average of.*

4. You will need to find the Standard Deviation (which tells you how variable your data is or how much of a change there is at the same time on different weekdays). There are several ways to do this – try one of each of the ways.

a. *go to INSERT Þ FUNCTION Þ select STDEV Þ enter the first and last cell numbers you want to average separated by a colon. In the next empty Standard Deviation box that would be (B12:F12).*

OR

b. *Type =stdev(B12:F12) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains a Standard Deviation calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells for which you want the Standard Deviation.*

Red Group Instructions, pg. 4

PRESENTATION PREP: Graphing

1. Each student will plot the averages on a graph (pollutant level vs. time).

2. In your spreadsheet, highlight the numbers under “Average” from Midnight (00:00) down to 23:00 hours.

3. Click on the bar graph icon OR go to the “Insert” menu and select “Chart.”

4. Select “Column” for chart type then select “Next.”

5. Leave the data range alone and select “Series In: Columns” then select “Next.”

6. Now click on the “Series” tab (top of gray box).

7. Click in the box “Category (X) axis labels” and then highlight “Midnight, 1:00, 2:00…down to 23:00.” (You should see the X axis labels change to Midnight, 1:00, etc. instead of 1, 2, 3…)

8. Select “Next.”

9. Enter a “Chart Title” such as “Daily Carbon Monoxide Levels: Dates” (or whatever your pollutant is for whatever time period).

10. Enter a “Category (X) Axis” such as “Hours.”

11. Enter a “Value (Y) Axis” such as “PPM” (or whatever units your pollutant is measured in) then select “Next.”

12. Select “Place Chart: As New Sheet” and enter a label such as “CO Graph.”

13. Select “Finish.” Be sure to save your work!

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in air quality based on time. Consider the following (use your graphs to help you):

- Are there certain times of day with more ozone, carbon monoxide, PM_{10}, or $PM_{2.5}$?
- Do you have any ideas why certain pollutants may be higher at certain times of day?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Real-Time Air Quality Activity

Student Sheets

Group Sign-up Sheet
Real-time Air Quality Activity

Green Group: Location (minimum 3 students)

1.____________________ 3. ______________________ ______________________

2.____________________ ______________________ ______________________

Red Group: Time (minimum 4 students)

1.____________________ 3. ______________________ ______________________

2.____________________ 4. ______________________ ______________________

Yellow Group: Health Effects (minimum 4 students)

1.__________________ 3.____________________ ______________________

2.________________ 4.____________________ ______________________

Blue Group: Weather (minimum 8 students)

1.____________________ 4.______________________ 7.______________________

2.____________________ 5.______________________ 8.______________________

3.____________________ 6.______________________

Brown Group: Visibility (minimum 4 students)

1.__________________ 3.____________________ ______________________

2.__________________ 4. ____________________ ______________________

Notebook Cover Sheet

NAME:

GROUP:

MONITORING LOCATION:

ROLE:

NOTES

My Data is Saved at (recommend saving in 2 locations!):

I Have Entered Data for the Following Dates:

Dates for:			
Days 1-5:	Days 26-30:	Days 51-55:	Days 76-80:
Days 6-10:	Days 31-35:	Days 56-60:	Days 81-85:
Days 11-15:	Days 36-40:	Days 61-65:	Days 86-90:
Days 16-20:	Days 41-45:	Days 66-70:	Days 91-95:
Days 21-25:	Days 46-50:	Days 71-75:	Days 96-100:

Real-time Air Quality Notebooks Contents

1. Cover Sheet
   Must include: Name, Group, Monitoring Location, Role

2. Group Details Pages

3. Vocabulary

<u>Once Data has been Collected:</u>

4. Graph
   Must include: proper labeling

5. Sentence/paragraph describing your graph

6. Print out of group presentation (print several slides per page, include notes)

You will be graded on the completeness of the contents, the quality & accuracy of your graphs, & the quality & accuracy of your sentence describing the graphs.

Introduction to Excel – Student Instructions

1. Download the "Practice Spreadsheet" from the website

http://www.airinfonow.com/html/airexercise/materials.html

2. Enter the following data into the Carbon Monoxide spread sheet.

Day	Date	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
1	1/27/01	22	15	16	15	20
2	1/28/01	15	3	6	6	8
3	1/29/01	19	14	12	11	26
4	1/30/01	19	22	15	12	25
5	1/31/01	24	18	12	15	27

3. Calculate the average for E10, F10, and G10

To obtain the average click on the **f(x)** button at the top-center of the page ⇒ select AVERAGE ⇒ click OK ⇒ enter the first and last cell numbers you want to average separated by a colon. At the Children's Park location that would be (E5:E9)

4. Calculate the standard deviation for D11, E11, F11, and G11.

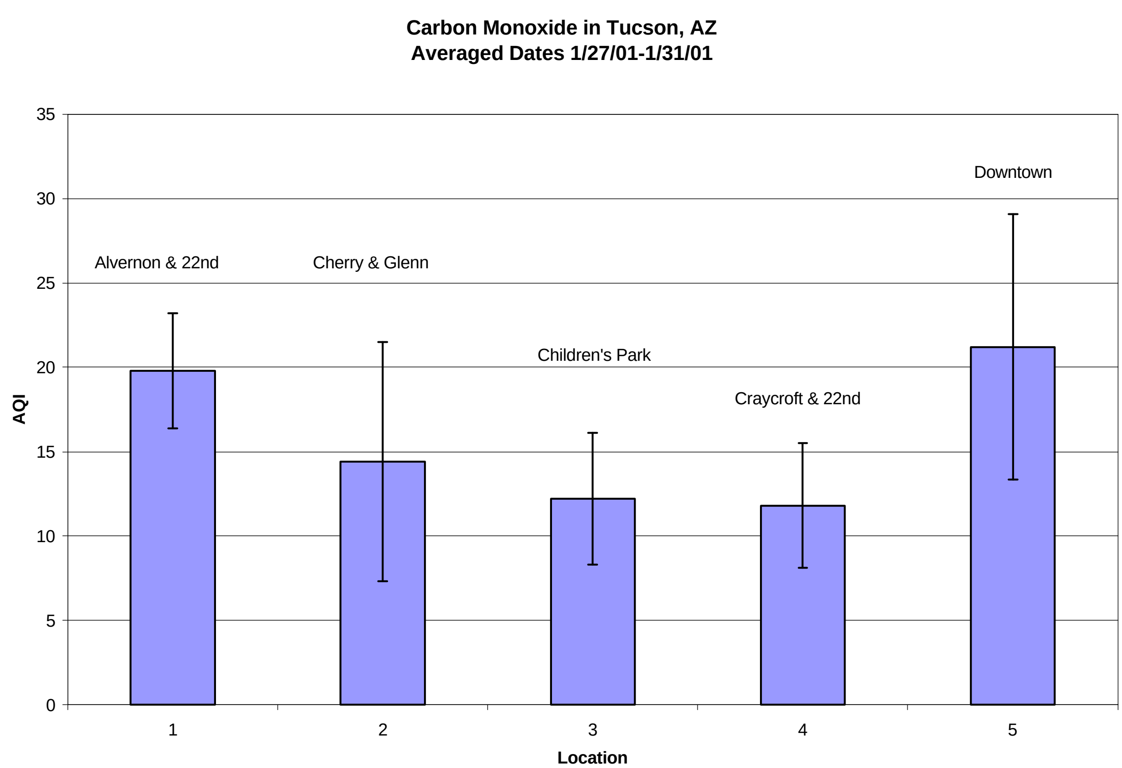
To obtain the standard deviation click on the **f(x)** ⇒ select STDEV ⇒ click OK ⇒ enter the first and last cell numbers you want to average separated by a colon. At the Cherry & Glenn location that would be (D5:D9) and at Children's Park that would be (E5:E9).

5. Create a graph of the data.

A. Highlight C10:G10 (averages)
B. Click on the Chart icon OR go to "Insert" ™ "Chart"
C. Under "Chart Type" highlight column, select "Next"
D. Check to make sure the "Data Range" has the correct squares (the ones you highlighted it will look like ='carbonmonoxide'!$C$10:$G$10). Leave "Series in rows" selected.
E. Go to the top of the window & click on the "Series" tab.
F. In the "Name" box type in "Week in January," select "Next."
G. In the "Chart Title" type in the title "Carbon Monoxide by Location."
H. In the "Category (X) Axis" type in "Location."
I. In the "Category (Y) Axis" type in "Air Quality Index."

J. Click “Next.”
K. Save chart “As New Sheet.” And label “Chart Example.”
L. Select “finish.”
M. Now we are going to add error bars.
N. Double click on one of the bars.
O. A window titled “Format Data Series” should come up.
P. Click on the tab titled “Y Error Bars.”
Q. Select “Display Both.”
R. Under “Error Amount” select “Custom” and click in the “+” field.
S. Now go back to the “Carbon Monoxide” spread sheet by clicking on the lower left tab.
T. Highlight the cells C11:G11 (standard deviation.).
U. Go back to the chart. Under “Error Amount” select “Custom” and click in the “-” field.
V. Again, go back to the “Carbon Monoxide” spread sheet and highlight the cells C11:G11 (standard deviation.). You should see the error bars on the columns.
W. Click “OK.”
X. Next we will label the columns.
Y. Click in the text box located just above the graph, remove any text, and type in the location for Bar 1, which is “Alvernon & 22nd.” Then hit “Enter.”
Z. Move the text box above the Bar 1.
AA. Repeat steps V & W until all the bars are labeled.

Graph should look like:



Introduction to Statistics Activity – Student Sheet

1. Measure your height in inches and write it down (you will share this with the class).
2. Copy down the class height data below and calculate the average.

Average =

3. Hand calculate the standard deviation of three of the above heights. Use the chart below to guide you:

Sample #	Height (Inches or meters)	Deviation (measured value – average) OR (column 2 – average)	Deviation Squared (deviation X deviation) OR (column 3)^2
1			
2			
3			
	Sum = Average =		Sum of deviations =

Standard Deviation (sum of deviations/n-1) =

4. Enter all of the class heights into an Excel spreadsheet.

5. Find the average and the standard deviation using Excel. Write down your answer:

Class Average =

Standard Deviation =

Guess & Know – Student Sheet

If you are *guessing* or *think* you know the answer, but are uncertain, then write it in the GUESS section. If you are certain about your answer, write it in the KNOW section. **Keep this sheet in your notebook, you will need it again later.**

1. What are some common air pollutants?

GUESS:

KNOW:

2. Fill out the table.

	Carbon Monoxide		**Ozone**		**Particulates**	
	GUESS	**KNOW**	**GUESS**	**KNOW**	**GUESS**	**KNOW**
Source(s)						
Health Effects (refer to specific body parts or functions)						
Visibility (color, more/less opaque)						

Guess & Know, page 2

3. Write a hypothesis about:

   a. How the weather affects a particular pollutant (such as temperature, wind, humidity)

   b. How pollution levels vary throughout the day.

   c. How pollution levels vary at different locations within the city (such as downtown, freeway, North, South, East, West)

Group Details

Green Group: Location

Group Summary:	Roles:	Assignment Summary:
This group will compare the pollution levels for ozone (O_3), carbon monoxide (CO), and particulate matter (PM_{10} and $PM_{2.5}$) at different locations within the city using the 8 hour Air Quality Index reports.	Assign roles. Each person tracks one pollutant. 1. Ozone Tracker 2. Carbon Monoxide Tracker 3. Particulate Tracker If there are more than 3 people in this group, then there will be several ozone and carbon monoxide trackers (divide the locations to track)	Each student will enter the data into a spreadsheet for his/her pollutant for each location where it is monitored.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel spreadsheet for the "Green Group: Location."

3. Save the spreadsheet onto your disk or computer.

Green Group Instructions, pg. 2

COLLECT DATA: Everytime

1. Open your saved Excel spreadsheet.

2. Go to the bottom of the spreadsheet and select your pollutant (carbon monoxide, ozone, or particulates). This will open the correct sheet.

3. Go to the activity web site and click on "Get Your Data" in the Green Group: Location Column.

4. Choose the date you need.

Note: In order to get a full day's worth of data, you will need to view the data for the previous week day (i.e. yesterday, or if it is currently a Monday you will view Friday's data).

5. Click on "**view" PSI Report text/html**. You see the locations listed.

6. Enter the date you have chosen into the "Green Group: Location" spreadsheet.

7. Enter the data for your pollutant into the spreadsheet.

8. Repeat until all the data is entered.

9. Be sure to save your worksheet!

Green Group Instructions, pg. 3

PRESENTATION PREP: Find Averages

1. Find the average and standard deviation for each location for your pollutant at the end of each week.

2. You will notice there are some squares with the words “#DIV/0!”. These squares already have the formula to find the average of your data. (Note: The average changes as you enter the data.)

3. You will need to enter the formula for the average for the remaining squares. There are several ways to do this – try one of each of the ways:

   a. *Go to INSERT Þ FUNCTION Þ select AVERAGE Þ enter the first and last cell numbers you want to average separated by a colon. In the third average box that would be (E3:E7).*

      OR

   b. *Type =average(E3:E7) then hit enter. You can also highlight/select the cells you want to include.*

      OR

   c. *Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells for which you want the average.*

4. You will need to find the Standard Deviation (which tells you how variable your data is or how much change there is between weekdays at the same location). There are several ways to do this – try one of each of the ways:

   a. *go to INSERT Þ FUNCTION Þ select STDEV Þ enter the first and last cell numbers you want to average separated by a colon. In the third Standard Deviation box that would be (E3:E7).*

      OR

   b. *Type =stdev (E3:E7) then hit enter. You can also highlight/select the cells you want to include.*

      OR

   c. *Select a cell that already contains a Standard Deviation calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the Standard Deviation of.*

Green Group Instructions, pg. 4

PRESENTATION PREP: Graphing

1. Each student will plot the averages on a graph (pollutant vs. location)

2. In your spreadsheet, highlight the averages for each location. If you are plotting multiple week averages, hold down the "Control" button and click on the squares you want to graph.

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Rows."

6. Now click on the "Series" tab (top of gray box).

7. Click in the box "Category (X) axis labels" and then highlight your locations. (You should see the X axis labels change from 1, 2, 3… to Alvernon & 22^{nd}, Cherry & Glenn, or whatever your locations are.)

8. Select "Next."

9. Enter a "Chart Title" such as "Average Weekly Carbon Monoxide By Location: Dates" (or whatever your pollutant is for whatever time period.

10. Enter a "Category (X) Axis" such as "Location."

11. Enter a "Value (Y) Axis" such as "AQI" the select "Next."

12. Select "Place Chart: As New Sheet" and enter a label such as "CO Graph."

13. Select "Finish." Be sure to save your work!

14. Now we are going to add error bars.

15. Double click on one of the bars. You should see squares show up in the middle of all of the bars.

16. A window titled "Format Data Series" should come up.

17. Click on the tab titled "Y Error Bars."

18. Select "Display Both."

Green Group Instructions, pg. 5

19. Under “Error Amount” select “Custom” and click in the “+” field.

20. Now go back to the spread sheet by clicking on the lower left tab.

21. Highlight the cells standard deviation cells that correspond with the averages you plotted.

22. Go back to the chart. Under “Error Amount” select “Custom” and click in the “-” field.

23. Again, go back to the spread sheet and highlight the same standard deviation cells. You should see the error bars on the columns.

PRESENTATION PREP: Mapping

DO THIS AFTER AT LEAST 1 MONTH’S DATA HAS BEEN COLLECTED.

As a group, plot the average AQI on a map of Tucson using the AQI color code. (AQI color code is found at the bottom of a data page on the website)

1. Draw 3 maps of Tucson on a large sheet of butcher paper (~ 4’ x 4’) and label “Ozone Map”, “Carbon Monoxide Map”, and “Particulate Map”. Decide ahead of time what your map scale will be (e.g. how many inches = how many miles or kilometers). Be sure to include major intersections and landmarks.

2. Mark the locations of the monitoring stations on your maps.

3. On a scratch sheet of paper decide what your boundary distances will be from each station on the map. These boundaries will be your “best guess” regions where the air quality is similar to that registered at the nearest monitoring station.

4. Using the AQI colors, decide on a color scale to indicate pollutant concentrations.

   For example: The AQI may be “good” and the region would be colored green, but you may want to have light green to represent an average concentration range of 0 to 25, and dark green to represent and AQI range of 25 to 50. You can create a scale for all of the AQI colors (green, yellow, orange, red, purple).

Green Group Instructions, pg. 6

5. On the map, color in the average pollutant concentrations according to the AQI color scale you created.

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in air quality based on location in the city.

Consider the following (Use your graphs and maps to help you):

- Are there certain locations in the city that have higher ozone, carbon monoxide, PM_{10}, or $PM_{2.5}$?
- Do you have any ideas why there may be differences?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Group Details

Red Group: Time

Group Summary:	Roles:	Assignment Summary:
This group will compare the pollution levels for ozone (O_3), carbon monoxide (CO), and particulate matter (PM_{10} and $PM_{2.5}$) by time of day.	Assign roles. Each person tracks one pollutant. 1. Ozone Tracker 2. Carbon Monoxide Tracker 3. PM_{10} Tracker 4. $PM_{2.5}$ Tracker If there are more than 4 students, split each day into 2 sections (e.g. 0:00 – 12:00 & 13:00 – 23:00.)	Each student will enter the data for his/her pollutant into a spreadsheet.

Detailed Instructions:

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Decide on the location your group will monitor. *Note: PM_{10} and $PM_{2.5}$ are limited to Green Valley, OR Rose Elementary & Geronimo together)*

3. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel Spreadsheet for the "Red Group: Time."

4. Save the spread sheet onto your disk or computer.

Red Group Instructions, pg. 2

COLLECT DATA: Everytime

1. Open your saved Excel spreadsheet.

2. Go to the bottom of the spreadsheet and select your pollutant (carbon monoxide, ozone, or particulates). This will open the correct sheet.

3. Go to the activity web site and click on "your data" in the "Red Group: Time."

4. Enter the date you need into the From: and To: boxes.

5. Make sure the time boxes (hh:mm) read 00:00 and 23:59. (*Note: If you are looking at today's data, the second box will automatically read the current time*. *To get a full day of data you need to enter yesterday's date – or Friday's date if it is currently Monday*).

6. Select the location you are monitoring, scroll down, and then click on "**show report**".

(Particulate matter is monitored at the following sites: Green Valley PM_{10} and $PM_{2.5}$, Geronimo PM_{10}, Rose Elementary $PM_{2.5}$.)

7. Write down the data for your pollutant.

8. Enter the date and location you have chosen into the "Red Group: Time" spreadsheet.

9. Enter the data for your pollutant into the spreadsheet.

10. Repeat until all the data is entered.

11. Be sure to save your worksheet!

Red Group Instructions, pg. 3

PRESENTATION PREP: Find Averages

1. Find the average and standard deviation for each time at the end of each week or month.

2. You will notice there are some squares with the words “#DIV/0!”. These squares already have the formula to find the average of your data. (Note: The average changes as you enter the data.)

3. You will need to enter the formula for the average for the remaining squares. There are several ways to do this – try one of each of the ways.

    a. *Go to INSERT Þ FUNCTION Þ select AVERAGE Þ enter the first and last cell numbers you want to average separated by a colon. In the next empty average box that would be (B12:F12).*

    OR

    b. *Type =average(B12:F12) then hit enter. You can also highlight/select the cells you want to include.*

    OR

    c. *Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the average of.*

4. You will need to find the Standard Deviation (which tells you how variable your data is or how much of a change there is at the same time on different weekdays). There are several ways to do this – try one of each of the ways.

    a. *go to INSERT Þ FUNCTION Þ select STDEV Þ enter the first and last cell numbers you want to average separated by a colon. In the next empty Standard Deviation box that would be (B12:F12).*

    OR

    b. *Type =stdev(B12:F12) then hit enter. You can also highlight/select the cells you want to include.*

    OR

    c. *Select a cell that already contains a Standard Deviation calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells for which you want the Standard Deviation.*

Red Group Instructions, pg. 4

PRESENTATION PREP: Graphing

1. Each student will plot the averages on a graph (pollutant level vs. time).

2. In your spreadsheet, highlight the numbers under “Average” from Midnight (00:00) down to 23:00 hours.

3. Click on the bar graph icon OR go to the “Insert” menu and select “Chart.”

4. Select “Column” for chart type then select “Next.”

5. Leave the data range alone and select “Series In: Columns” then select “Next.”

6. Now click on the “Series” tab (top of gray box).

7. Click in the box “Category (X) axis labels” and then highlight “Midnight, 1:00, 2:00…down to 23:00.” (You should see the X axis labels change to Midnight, 1:00, etc. instead of 1, 2, 3…)

8. Select “Next.”

9. Enter a “Chart Title” such as “Daily Carbon Monoxide Levels: Dates” (or whatever your pollutant is for whatever time period).

10. Enter a “Category (X) Axis” such as “Hours.”

11. Enter a “Value (Y) Axis” such as “PPM” (or whatever units your pollutant is measured in) then select “Next.”

12. Select “Place Chart: As New Sheet” and enter a label such as “CO Graph.”

13. Select “Finish.” Be sure to save your work!

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in air quality based on time. Consider the following (use your graphs to help you):
    - Are there certain times of day with more ozone, carbon monoxide, PM_{10}, or $PM_{2.5}$?
    - Do you have any ideas why certain pollutants may be higher at certain times of day?
    - Are these trends consistent over the month, 2 months, 5 months?
    - Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Group Details

Blue Group: Weather

Group Summary:	Roles:	Assignment Summary:
This group will track the wind speed and direction, humidity, rainfall, and temperature in the city via the Internet.	Assign roles. Each person tracks one weather feature or pollutant. 1. Wind Tracker 2. Ozone Tracker 3. Humidity Tracker 4. Particulate Tracker (PM_{10} & $PM_{2.5}$) 5. Rain Tracker 6. Carbon Monoxide Tracker **7.** Temperature Tracker	Each student will enter the data into a spreadsheet for his/her pollutant or weather feature.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Decide on the location your group will monitor – 22nd & Craycroft or Rose Elementary. (*Note: PM tracker will use Geronimo for PM_{10} & Rose Elementary for $PM_{2.5}$*)

3. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel Spreadsheet for the "Blue Group: Weather."

4. Save the spread sheet onto your disk or computer.

Blue Group Instructions, pg. 2

COLLECT DATA: Everytime

1. Open your previously saved Excel spread sheet for “Blue Group: Weather”

2. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and click on the “Your Data” in the “Blue Group: Weather” column to obtain current weather data.

3. Select either the 22nd & Craycroft location or Rose Elementary Location.

4. Enter the date you need into the From: and To: boxes.

5. Make sure the time boxes (hh:mm) read 00:00 and 23:59. (*Note: If you are looking at today’s data, the second box will automatically read the current time. To get a full day of data you need to enter yesterday’s date – or Friday’s date if it is currently Monday*).

6. Click on “Show Report.”

The abbreviations for the weather data are: - OTP – outside temperature in degrees farenheight - VWD – variable wind direction in degrees - VWS – variable wind speed in miles per hour - RH – relative humidity in percent

7. Enter the date into the “Blue Group: Weather” spreadsheet.

8. Enter the data for your pollutant or weather feature into your spreadsheet.

9. Be sure to save your worksheet.

Blue Group Instructions, pg. 3

PRESENTATION PREP: Graphing 1st Presentation

Plot the data on a graph (weather vs. time or pollutant level vs. time).

1. Go to your spreadsheet and hold down the control button on the keyboard. With your mouse highlight the data for 8:00 and 17:00 for each day. (Continue to hold down control button.)

2. Click on the bar graph icon OR go to the “Insert” menu and select “Chart.”

3. Select “Column” for chart type then select “Next.”

4. Leave the data range alone and select “Series In: Columns.”

5. Select “Next.”

6. Enter a “Chart Title” such as “Wind Speed: Location” (or whatever your pollutant).

7. Enter a “Category (X) Axis” such as “Time.”

8. Enter a “Value (Y) Axis” such as “MPH” ” (or whatever units go with what you track)then select “Next.”

9. Select “Place Chart: As New Sheet” and enter a label such as “Wind Graph 1.”

10. Select “Finish.”

11. Now refine your graph: (See Example)

    A. Delete the series box (right side of graph).

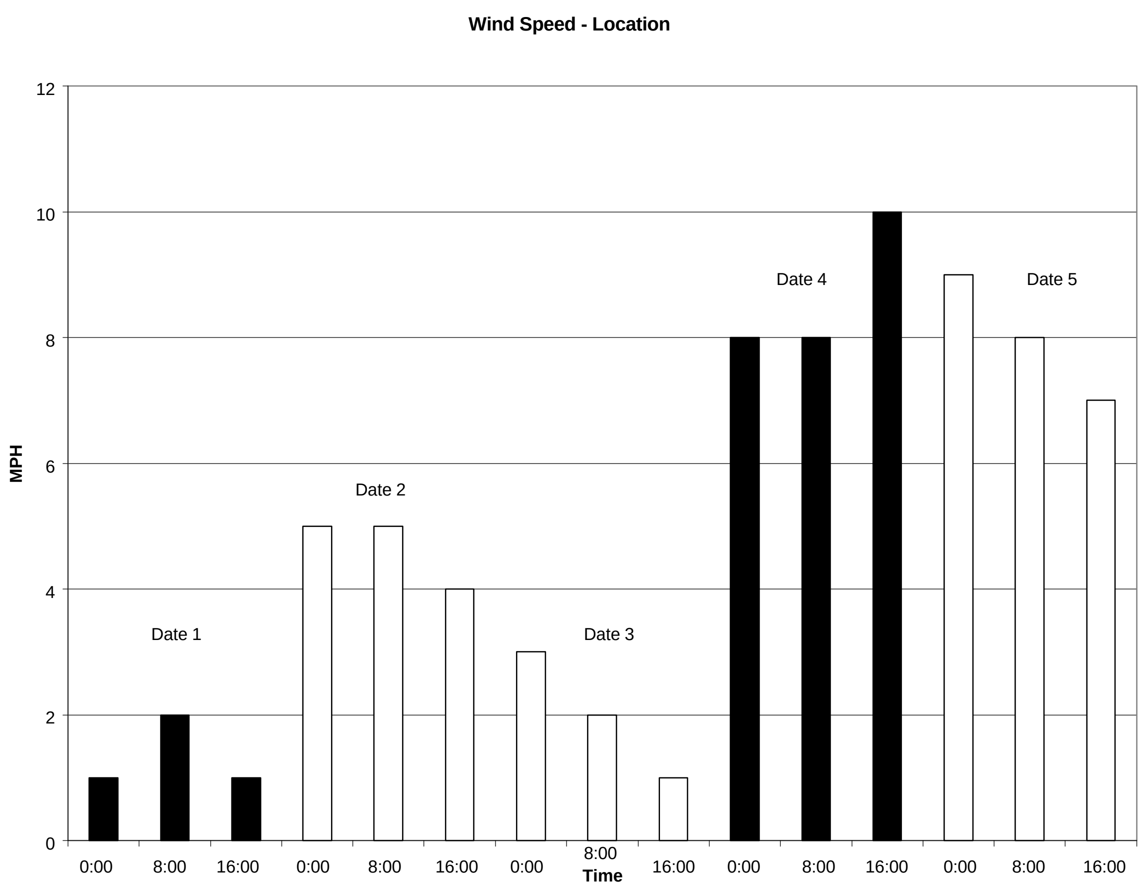
    B. Change the background color:
       - Double click in the open part of the graph.
       - In the “Area” section click on the white square.

    C. Create Text Boxes for each day:
       - Type the date in the black space at the top of the Excel window (following the =).
       - Hit enter.
       - Drag the text box to the appropriate location on the graph.

Blue Group Instructions, Pg. 4

C. Change the X-Axis labels:
- Double click at the bottom of the graph and select the tab labeled "Patterns" then under "Tick Mark Labels" select "None."
- Create your own tick mark labels (0:00, 8:00, 16:00) for the x-axis by creating text boxes and dragging the boxes down to the appropriate location at the bottom of the graph. Repeat for each day.

D. Color code the days:
- Double click on the inside of a single bar (only that bar should highlight – not with squares in all the bars).
- The "Format Plot Area" window should come up.
- Select "Fill Effects." Use the same color code for each day – SEE BELOW (for each 0:00, 8:00, 16:00 period).



PRESENTATION PREP: Find Averages

DO THIS AFTER EACH FULL MONTH OF DATA IS ENTERED (20 DAYS).

1. Find the average and standard deviation for each time at the end of each month.

2. You will notice there are some squares with the words "#DIV/0!". These squares already have the formula to find the average of your data. (Note: The average changes as you enter the data.)

3. You will need to enter the formula for the average for the remaining squares.

4. Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells for which you want to take the average (*Note: 16:00 will be one cell number higher than 8:00 a.m. – e.g. B104 instead of B103)*.

5. You will need to find the Standard Deviation (which tells you how variable your data is or how much of a change in the weather there is on different days at the same time). Do this by copying and pasting the formula from one Standard Deviation cell into the cell you want.

PRESENTATION PREP: Graphing #2

DO THIS AFTER EACH FULL MONTH OF DATA IS ENTERED (20 DAYS).

1. Graph the month's averages for your pollutant using a bar graph.

CHALLENGE: Try to make a scatter plot combining 2 of your variables (e.g. temperature & ozone).

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in air quality based on different weather events.

Consider the following (use your graphs to help you):

- Does ozone, carbon monoxide, PM_{10}, or $PM_{2.5}$ increase, decrease, or not change as a function of temperature, wind, humidity, or other weather feature?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Group Details

Yellow Group: Health

Group Summary:	Roles:	Assignment Summary:
This group will monitor the frequency of asthma attacks at several schools within the school district. They will compare asthma attack trends with Air Quality ratings at the nearest tracking locations.	Assign roles. 1. Health Tracker (number depends on how many schools participate) 2. Ozone Tracker 3. Carbon Monoxide Tracker 4. Particulate Tracker (PM_{10} & $PM_{2.5}$)	Each student will enter asthma or pollution data into a spreadsheet.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Decide on the location you are going to monitor (try to pick one close to your school)

   Note: The Particulate tracker will need to monitor at Rose Elementary & Geronimo (to get both PM types), or Green Valley.

3. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel Spreadsheet for the "Yellow Group: Health."

4. Save the spreadsheet onto your disk or computer.

Yellow Group Instructions, pg. 2

5. Go back to the website and look at “The Nurse Form.”

6. Compose a letter or phone call dialogue to contact nurses to invite their participation in your research. Be sure to mention that they can use the website form to enter their data, or you can make other arrangements to get the data from the nurses.

COLLECT DATA: Everytime

Open the Excel spread sheet for “Yellow Group: Health”

1. Go to the activity web site, click “Pollution Tracker Data” to obtain air quality/pollution data.

2. Choose the date you need.

3. Click on “**view” PSI Report text/html**. You see the locations listed.

4. Enter the date you have chosen into the “Yellow Group: Health” spreadsheet.

5. Enter the data for your pollutant into the spreadsheet.

Health Trackers: When you receive the data from the nurses, enter it into the spreadsheet for the correct date and location.

6. Repeat until all of the data is entered.

Be sure to save your worksheet!

PRESENTATION PREP: Research

1. Do some research to add to your background knowledge. (Do this during the first two weeks while you wait for the nurses to respond).

2. Each group member should try to select a different activity. The information you gather will be shared as your 1st report.

    a. Conduct research about asthma.

Yellow Group Instructions, pg. 3

b. Research the number of people admitted to local emergency rooms for asthma attacks.
c. Research the number of people with asthma nationally and locally.
d. Interview someone with asthma.
e. Pick a topic related to health and air pollution.

PRESENTATION PREP: Daily Data Graphs

1. Plot the data on a graph (pollutant level vs. time or asthma attacks vs. time).

2. Go to your spreadsheet and highlight the data for the first 2 weeks (or whatever time period you are reporting).

   Note: Health trackers will highlight the "Total" column.

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Columns."

6. Now click on the "Series" tab (top of gray box) "Category (x) axis labels", go back to your spreadsheet, and highlight the corresponding dates. (This will change the X-axis labels to the dates you want.)

7. Select "Next."

8. Enter a "Chart Title" such as "Asthma Incidence: Location" (or whatever your pollutant).

9. Enter a "Category (X) Axis" such as "Dates."

10. Enter a "Value (Y) Axis" such as "Asthma Incidents" " (or whatever units go with what you track) then select "Next."

11. Select "Place Chart: As New Sheet" and enter a label such as "Asthma Graph 1."

12. Select "Finish."

Yellow Group Instructions, pg. 4

PRESENTATION PREP: Find Averages (monthly)

DO THIS AFTER EACH FULL MONTH OF DATA IS ENTERED (20 DAYS).

1. Find the average and standard deviation for each time at the end of each reporting period.

2. **HEALTH TRACKERS**: Because you need to combine your asthma data before you can average it, calculate the total number of asthma incidents. Days 1 & 2 are calculated for you. To get the total highlight the row you want to add including the square for the answer (e.g. C7, D7, E7, F7) and then type **=sum(C7:E7)** in the square F7.

3. **POLLUTION & HEALTH TRACKERS:** You will notice there are some squares with the words "#DIV/0!". These squares already have the formula to find the average of your data. (Notice that the average changes as you enter the data.)

4. You will need to enter the formula for the average for the remaining squares. There are several ways to do this – try one of each of the ways.

a. *Go to INSERT Þ FUNCTION Þ select AVERAGE Þ enter the first and last cell numbers you want to average separated by a colon. In the next blank average box that would be (H5:H24).*

OR

b. *Type =average(H5:H24) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the average of.*

5. You will need to find the Standard Deviation (which tells you how variable your data is). There are several ways to do this – try one of each of the ways.

a. *go to INSERT Þ FUNCTION Þ select STDEV Þ enter the first and last cell numbers you want to average separated by a colon. In the third Standard Deviation box that would be (H5:H24)..*

OR

b. *Type =stdev(H5:H24) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains a Standard Deviation calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the Standard Deviation of.*

Yellow Group Instructions, pg. 5

PRESENTATION PREP: Monthly Data Graphs

1. Graph the average monthly data only after at least 2 months' worth of data has been collected. Otherwise, create a graph that contains all of the days (see above "Daily Data" graphing instructions).

2. Go to your spreadsheet, hold down the "Control" button and highlight the average for each month (you do not need to highlight the daily data).

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Columns" then select "Next."

6. Now click on the "Series" tab (top of gray box).

7. Click in the box "Category (X) axis labels" and then type in the date range for each month separated by commas (January 1-31, February 1-28).

8. Select "Next."

9. Enter a "Chart Title" such as "Monthly Asthma Attacks: Location" (or whatever your pollutant is for whatever location).

10. Enter a "Category (X) Axis" such as "Dates."

11. Enter a "Value (Y) Axis" such as "Number of Asthma Attacks" then select "Next."

12. Select "Place Chart: As New Sheet" and enter a label such as "Monthly Asthma Graph."

13. Select "Finish."

Yellow Group Instructions, pg. 6

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in asthma incidents and individual air pollutants (ozone, carbon monoxide, PM_{10}, and $PM_{2.5}$.)

Consider the following:

- Are there increases in asthma attacks with increases in any of the pollutants you are monitoring (ozone, carbon monoxide, PM_{10}, and $PM_{2.5}$.)?
- Are there other factors to consider with each asthma attack (e.g. was it induced by exercise)?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Group Details

Brown Group: Visibility

Group Summary:	Roles:	Assignment Summary:
This group will monitor the visibility by monitoring the webcam. They will compare the visibility and pollution color with respect to concentration and type of pollutant.	Assign roles. 1. Webcam tracker 2. Weather tracker Pollution Trackers: 3. Ozone tracker 4. Carbon Monoxide (CO) tracker 5. Particulate tracker (PM_{10} & $PM_{2.5}$)	Each student will enter the data into the spread sheet for whatever s/he is tracking.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. If you are a "Weather Tracker" or "Pollution Tracker," go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and click on "Get Your Spreadsheet."

3. Save the spreadsheet onto your disk or computer.

4. Your monitoring location will be Rose Elementary. *Note: The PM tracker has to obtain data from Rose Elementary & Geronimo (together).*

5. As a group, decide what time of day you will monitor (e.g. 8 a.m.). It is recommended that you monitor sometime between 7-10 a.m. and/or 4-6 p.m.

Brown Group, Pg. 2

COLLECT DATA: Everytime

Webcam Tracker	Weather Trackers	Pollution Trackers
1. Go to the activity website and click on the "Visibility Page" 2. View and save image to your disk. a. If a dialogue box appears with a warning, CLICK "CONTINUE." This may happen 2 or more times. b. Look at the photos. Go to the **digital panorama**. CLICK on the image to bring up the full sized image. c. To save this image: - RIGHT CLICK on the image. In the box that pops up CLICK "save image/picture as." A box will appear. - Pick your FOLDER: In the box you can navigate to the folder where you are storing your images. - NAME your file. Use a standard format for each file. For example, a file saved on December 3, 2002 at 8am might be "02.12.03.8am." This format also makes it easy to sort through large number of images from many years. - CLICK "SAVE."	1. Open the Excel spread sheet for "Brown Group: Visibility." 2. Go to the activity web site http://www.airinfonow.com/html/airexercise/materials.html, click "Get Your Data" in the "Brown Group: Visibility" column to obtain current weather data. 3. Enter the date you need into the From: and To: boxes. 4. Enter the time you are monitoring into the boxes e.g 8:00 and 9:00. (*Note: If you are looking at the afternoon data remember to use military time – 13:00 for 1:00 p.m.*). 5. Select "Rose Elementary", scroll down, and then click on "**show report**". 6. The abbreviations for the data you will collect are: - RH – relative humidity in percent 7. Enter the date into the "Brown Group: Visibility" spreadsheet. 8. Enter the data into the spreadsheet (you will do this daily). - Be sure to save your worksheet.	1. Open your saved Excel spreadsheet. 2. Go to the activity web site and click on "your data" in the "Brown Group: Visibility." 3. Enter the date you need into the From: and To: boxes. 4. Enter the time you are monitoring into the boxes e.g 8:00 and 9:00. (*Note: If you are looking at the afternoon data remember to use military time – 13:00 for 1:00 p.m.*). 5. Select "Rose Elementary", scroll down, and then click on "**show report**". 6. Enter the date & data for your pollutant into the spreadsheet. 7. Repeat until all the data is entered. 8. Be sure to save your worksheet!

Brown Group, Pg. 3

PRESENTATION PREP: Graphing & Photo Comparison

1. Your group needs to create graphs of your data and identify trends in the webcam photos

CREATE GRAPHS FOR POLLUTION & WEATHER DATA

2. In your spreadsheet, highlight the data for pollutant and the days you are investigating.

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Columns."

6. Now click on the "Series" tab (top of gray box).

7. Click in the box "Category (X) axis labels" and then go back to your spreadsheet and highlight the dates for your data. (This will change the x-axis labels to your dates).

8. Select "Next."

9. Enter a "Chart Title" such as "Daily Carbon Monoxide Levels: Location" (or whatever your pollutant is).

10. Enter a "Category (X) Axis" such as "Date."

11. Enter a "Value (Y) Axis" such as "PPM" (or whatever unit your pollutant or weather feature is measured in) then select "Next."

12. Select "Place Chart: As New Sheet" and enter a label such as "CO Graph."

13. Select "Finish."

PHOTO COMPARISON

1. Place the photos in a format where you can look at the photos and the graphs at the same time.

Brown Group, Pg. 4

SUGGESTIONS: You may need to have:

a) A photo of each day that corresponds with the high & low for a specific pollutant or weather event; OR
b) A week's worth of photos per page with one graph; OR
c) A week's worth of photos per page with several graphs, or, (or some other configuration).

This is up to you – just make sure your audience can see your data and understand it!

PRESENTATION PREP: Find Trends

9. As a group, analyze trends in visibity and individual air pollutants (ozone, carbon monoxide, PM_{10}, and $PM_{2.5}$) and weather.

Consider the following:

- How does weather affect visibility?
- Are there color's associated with different pollutants (e.g. brown, gray, white)?
- Does the pollution or weather affect only one section or level on the horizon? (Use a landmark)
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypotheses to describe the trends. Be careful not to overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

Real-Time Air Quality Activity

Developed by: Stefani D. Hines, M.A., M.S., University of Arizona, Southwest Environmental Health Sciences Center (SWEHSC), Community Outreach & Education Program.
In partnership with: John King, SWEHSC; Beth Gorman & Karen Wilhelmsen, Pima County Department of Environmental Quality; Lee Comrie & Natalie Barnes, Pima Association of Governments.

Materials: Internet access
Excel (or other spread sheet application)
Large sheets of blank paper
Color markers
Maps of Tucson
Color Folders (for groups to organize materials)
Tape measures or yard sticks (for Introduction to Statistics)
Computer Diskettes (to save group work)

Objectives: Familiarize students with data collection and analysis techniques.
Increase awareness among students of local air quality issues and corresponding health effects.

Time Commitment: Class 1 - Activity Introduction: 1 hour
Class 2 - Introduction to Excel: 1 hour
Class 3 – (OPTIONAL) Introduction to Statistics: 1 hour
Class 4 – Guess & Know & Data Collection Practice: 1 hour
Classes 5+ - Data Collection

<u>1st Week</u>
(data entry) 30 minutes

<u>2nd Week</u>
(data entry) 30 minutes

<u>3rd Week</u>
(data entry) 30 minutes
(data compilation/report prep) 1 – 1.5 hours
(report to class) 30-45 minutes

<u>Monthly</u> (through a cold & warm season)
(data entry, compilation, & report) 2-3 hours per month

Background Knowledge Needed: Introduction to common air pollutants (ozone, carbon monoxide, particulates 10 μ and 2.5μ);

Grades: It is recommended that the students receive two grades, an individual and a group grade. The individual grade will be their notebooks and the group grade will be their presentation.

Project Overview:

Preparation

1. Prior to or in conjunction with this activity, you may want to have the students learn about common air pollutants and their health effects, as well as, basic statistics (basic statistics activity is also included in this material). Interactive online air quality activities and other air quality activities can be found at http://swehsc.pharmacy.arizona.edu/coep/exercises.html or http://www.airinfonow.org

Class 1 – Activity Introduction (1 hour)

2. Introduce the students to the Real-Time Air Quality Activity (Activity Introduction guidelines page 4).

3. Divide the students into the following groups and hand out student instruction sheets (Student Sheets Section):

   Green Group: Location (minimum 3 students)
   Red Group: Time (minimum 4 students)
   Yellow Group: Health Effects (minimum 4 students)
   Blue Group: Weather (minimum 8 students)
   Brown Group: Visibility (minimum 4 students)

4. Have the students set up a color-coordinated notebook that includes the following:
   - Cover sheet
   - Vocabulary
   - "Introduction to Excel" instructions
   - "Statistics Activity" (if you do it with the class)
   - "Guess & Know" Sheet
   - "Group Details" for their assigned group

Class 2 –Introduction to Excel (1 hour)

5. Introduce students to Excel (guidelines page 7).

Class 3 – Introduction to Statistics (OPTIONAL) (1 Hour)

6. If your students are not already familiar with the basics of statistics (average, standard deviation), you may want to conduct this simple exercise.

Class 4 - Guess & Know (15 min) & Data Collection Practice (45 minutes)

7. Have the students do the Guess & Know activity (page 11 & Student Sheets Section). This serves as a pre-test, gets the students thinking about the issues, and gets them working together.

8. Have the students in the same groups work on near-by computers to do the "Data Collection Practice (page 12)" They need to get into the habit of helping each other out.

Subsequent Classes – Data Collection & Products

9. Begin data collection. In this activity a week is defined as Monday – Friday.

Products:

10. Students will give group summary presentations/reports at the end of weeks 2 and 4 and monthly thereafter.

Optional Products:

Students will provide "press releases" to their school or community to inform them of the current air quality and/or alert their audience when pollutant levels are high.

Students will present their final product (paper or brochure), summarizing their group results.

Optional Follow-up Activity

11. Follow up with an activity on how to take action and help control air pollution (www.airinfonow.org) .

Activity Introduction – Teacher Notes

1. Inform the students that they are going to have the opportunity to monitor air pollution in their city (Tucson) and near their school over the next several months.

   Points to include:

   a. (Optional) They can inform their community about current air quality levels, especially when pollution levels are high. This can help people who are sensitive to air pollution make decisions that could help save their life.
   b. They are doing real research using real data.
   c. The reason the monitoring time is so long is to see what happens to air pollution in hot and cold seasons.

2. They will be pulling real-time air quality data off the Internet and keeping track of that information so they can learn about air pollution in their community and the health effects of air pollution.

3. Tell the students that they will be divided into groups each tracking something different and you will share what you find with your classmates, and the community. (OVERHEAD)

   Green Group: Location
   - Different parts of the city have varying concentrations of pollutants. This is because traffic and weather patterns differ according to location. This group will see if they can identify pollution trends according to location.

   Red Group: Time
   - Pollutant concentrations vary by time of day. This group will see if they can identify trends in pollution concentrations by time of day.

   Yellow Group: Health Effects
   - One of the reasons we care about air pollution is because it can adversely affect our health. People who have asthma or lung disease may be particularly susceptible to the effects of air pollution. This group will monitor the occurrences of asthma attacks at several schools throughout the district and see if there is any correlation with air pollution levels.

   Blue Group: Weather-Internet
   - Pollutant concentrations vary with weather conditions like temperature, wind speed and direction, humidity, and rainfall. This group will see if they can identify trends in pollutant concentrations

with changes in weather. They will monitor the weather conditions via the internet at weather stations in other locations in the city.

Brown Group: Visibility

- Air pollution can obscure our views and add a colored tint to the sky. This group will monitor the visibility from the sky-cam Internet camera. They will try to identify trends in visibility with respect to weather, type of pollution and concentration.

4. Students will regularly share their data with their classmates. (Optional) They can alert their school or community when air pollution levels are high. And at the end of the activity, they will summarize their findings in a paper (or some other product) that can be shared with the community.

5. Review the timeline with the students (OVERHEAD)

6. Define the following terms for the students (OVERHEAD & STUDENT HANDOUT):

   Air Quality Index (AQI) – A scale developed by the EPA (Environmental Protection Agency) to report the levels of certain air pollutants, and their effects on human health.

   Parts Per Million – A unit of measurement that describes the number of parts of something within a million parts of something else.

   Carbon Monoxide – A toxic gas made from incomplete combustion (burning) of carbon-based materials like gasoline, coal, and methane (natural gas). The abbreviation for carbon monoxide is CO, which shows its chemical composition of one carbon atom attached to one oxygen atom.

   PM 2.5 – Particulate matter that is very small, less than 2.5 microns in size. These particles are created by combustion, mostly from vehicles. Because they are so small, they can go deep inside the lungs.

   PM 10 – Particulate matter that is “larger”, approximately 10 microns in size. These particles can include dust, pollen, and ash. They can irritate the upper respiratory system like the nose and upper lungs.

   Micrograms – A unit of measurement that depicts very, very small quantities of a substance - 1/1,000,000 or 0.000001 of a gram.

   Military Time – Time units that sequentially number the hours in a day from 0:00 (midnight) to 23:00(11 p.m.).

Ozone – A gas made up of three molecules of oxygen (O_3). In the upper atmosphere ozone protects the earth from ultra violet rays, but if ozone is created in the lower atmosphere (what we breathe) it can negatively affect plant and animal life.

7. Take the students through an virtual tour of the monitoring sites via the Internet http://www.airinfonow.org (or use the OVERHEAD).

8. Show the students the main website they will be working from (or use OVERHEAD of front page)

   http://www.airinfonow.com/html/airexercise/materials.html

   - "Your Data" links take the students to the real-time air quality data.

     Note: The "report main" page or "Index to Available Data Listings" shows the raw data in parts per million (ppm) and will be used by the Red Group.

     Note: The "Reports list" or "Saved Reports" page shows the Air Quality Index numbers (AQI) and will be used by the Green, Blue, Yellow, and Brown Groups.

   - "Your Spreadsheet" downloads the spreadsheet for each group.

9. Divide the students into groups, set up notebooks.

Notebook Contents:

- Cover sheet
- Vocabulary
- "Introduction to Excel" instructions
- "Statistics Activity" (if you do it w/the class)
- "Guess & Know" sheet
- "Group Details" for their assigned group

Introduction to Excel – Teacher Notes

It is recommended that the students have an opportunity to become familiar with Excel prior to starting their data collection. To do this, have the students download the Excel spreadsheet for the “Practice Spreadsheet”, insert one week’s worth of data, and then find the average, standard deviation, and create a graph. A student activity sheet is provided with instructions. (Student Sheets Section)

Step-by-Step Instructions:

a. Tell students they will download pre-labeled Excel spreadsheets from the website http://www.airinfonow.com/html/airexercise/materials.html

b. Explain that this is a practice exercise that gets them familiar with how to use Excel before they enter their “real data.”

c. Remind the students that they will be using different spread sheets for their color groups.

d. From the webpage, have them select the “Practice spreadsheet.” (More advanced students can set-up their spreadsheets from scratch.)

e. Have the students type the following **Carbon Monoxide** data into the spread sheet (OVERHEAD):

Day	Date	Alvernon & 22^{nd}	Cherry & Glenn	Children’s Park	Craycroft & 22^{nd}	Downtown
1	1/27/01	22	15	16	15	20
2	1/28/01	15	3	6	6	8
3	1/29/01	19	14	12	11	26
4	1/30/01	19	22	15	12	25
5	1/31/01	24	18	12	15	27

f. Point out that the average is calculated on the spreadsheet for a few examples. But for most of the locations they will have to calculate the average.

g. To obtain the average click on the **f(x)** button at the top-center of the page ⇒ select AVERAGE ⇒ enter the first and last cell numbers you want to average separated by a colon. At the Children’s Park location that would be (E5:E9).

Note: If the average (or standard deviation functions have not been used recently, under the function category select “statistical.”)

h. To obtain the standard deviation click on the **f(x)** ⇒ select STDEV ⇒ enter the first and last cell numbers you want to average separated by a colon. At the Children’s Park location that would be (E5:E9).

Introduction to Excel – Cont'd

CREATE A GRAPH

A. Highlight C10:G10 (averages)
B. Click on the Chart icon or go to "Insert" ™ "Chart"
C. Under "Chart Type" highlight column, select "Next"
D. Check to make sure the "Data Range" has the correct squares (the ones you highlighted). Leave "Series in rows" selected.
E. Click on the "Series" tab (top of gray box).
F. Click in the box "Category (X) axis labels" and then highlight your locations. (You should see the X axis labels change from 1, 2, 3… to Alvernon & 22nd, Cherry & Glenn, or whatever your locations are.)
G. In the "Name" box type in "Week in January," select "Next."
H. In the "Chart Title" type in the title "Carbon Monoxide by Location."
I. In the "Category (X) Axis" type in "Location."
J. In the "Category (Y) Axis" type in "Air Quality Index."
K. Save chart "As New Sheet." And label "Chart Example."
L. Select "finish."
M. Now we are going to add error bars.
N. Double click on one of the bars.
O. A window titled "Format Data Series" should come up.
P. Click on the tab titled "Y Error Bars."
Q. Select "Display Both."
R. Under "Error Amount" select "Custom" and click in the "+" field.
S. Now go back to the "Carbon Monoxide" spread sheet by clicking on the lower left tab.
T. Highlight the cells C11:G11 (standard deviation.).
U. Go back to the chart. Under "Error Amount" select "Custom" and click in the "-" field.
V. Again, go back to the "Carbon Monoxide" spread sheet and highlight the cells C11:G11 (standard deviation.). You should see the error bars on the columns.

(Example of the chart is in OVERHEADS and on the student instructions)

Introduction to Statistics Activity – Teacher Notes

1. Hand out the “Introduction to Statistics Activity” student sheet.

2. Measure the height of each person in the class. (Be sure to measure the height in one unit, such as *only* inches or *only* meters, not feet and inches)

3. Have each student write down the individual heights on their sheet called “Introduction to Statistics Activity.”

4. Place a mark for each individual height on the “Height Statistics Overhead” (OVERHEAD).

5. Explain to the students that what they see on the overhead is called a bell curve. The bell curve is a visual representation of the average height (the peak of the curve) and the deviation from the average (the outer edges).

6. Using calculators have the students find the average of height in the class. How closely does their average match the peak of the bell curve?

7. Have the students calculate the deviation of a few samples using the following formula: (This is so they can see how the standard deviation is actually calculated)

$S=\text{Öå}(x_i-x)^2/n-1$

where x_i is an individual result, x is the mean, and n is sample number.

The table below is on the student “Introduction to Statistics Activity” to guide them through the process step-by-step.

Sample #	Height (Inches or meters)	Deviation (measured value – average) OR (column 2 – average)	Deviation Squared (deviation X deviation) OR (column 3)^2
1			
2			
3			
	Sum = Average =		Sum of deviations =

Standard Deviation (sum of deviations/n-1):

You may want to ask the students what happens to the standard deviation when ***n*** *gets bigger and then ask them if this is good or bad? Having a small standard deviation is good because you can better tell if your result is different from the norm.*

They will see this happen when they find the Standard Deviation for all of the heights measured in the class (using Excel).

8. Have the students enter the class heights into one column of an Excel spreadsheet.

9. Have them find the Average and the Standard Deviation using Excel.

10. How closely does the Standard Deviation match the outer edges of the bell curve?

The Standard Deviation will typically not encompass the outer edges of the bell curve, but it will encompass the majority of the samples. This is because the Standard Deviation tells you that 68% of the time subsequent samples will fall between those numbers.

11. Explain that scientists need to know the average and the deviation of their data in order to tell if something is different. For example, say a scientist was studying the heights of people around the world. The working hypothesis was that people in China are shorter than people in the U.S. If the scientist measured the height of 10,000 people in the U.S. and 10,000 people in China and found that the average U.S. height was 5’10” ± 1” and the average Chinese height was 5’9” ± 1” the scientist would have to say there was no significant difference. This is because both numbers overlap (U.S. 5’9” –5’11”, China 5’8” –5’10”). But if the deviation was only ¼” then there would be a significant height difference between the two populations.

Guess & Know Activity– Teacher Notes

1. After the students set up their group notebooks, have them find the page titled “Guess & Know”.

2. Explain that they will work together as a group fill out the “Guess & Know” sheet.

3. The students will answer each question or address a topic. If they are guessing the answer or *think* they have the answer, but are uncertain, then they will write their answer in the “Guess” column. If they are certain about their facts/answer, then they will write it in the “Know” column.

4. The students will also write a hypothesis (an educated guess) about:

   How the weather affects a particular pollutant (such as temperature, wind, humidity)

   How pollution levels vary throughout the day.

   How pollution levels vary at different locations within the city (such as downtown, freeway, North, South, East, West)

5. You can use this activity as a pre-test, and have them do it again at points throughout the entire Real-time Data Collection Activity (for example half-way through and at the end).

Data Collection Practice – Teacher Notes

This is the first real data collection for the students, but it is assigned a separate name and time frame because it takes practice before the students get the hang of the process. This is a time for "flailing" and lots of questions…Don't worry after a few times of entering data they will do it diligently on their own!

1. Have the students break up into their color groups and get their individual folders.
2. Tell them they will be following the instructions on the "Group Details" sheets.
3. Have the students read the instructions.
4. The students need to select or be assigned their individual roles (listed on "Group Details" sheets).
5. Have the students go to http://www.airinfonow.com/html/airexercise/materials.html and download "Your Spreadsheet" for their color group. EACH STUDENT WILL HAVE HIS/HER OWN SPREADSHEET.
6. Provide instructions about where they should save the file.
7. Have the students go back to the website and select the link to their data.
8. Have the students record the data for yesterday, or the previous few days (how they access this data will vary between groups. Specific instructions are provided on the "Group Details" sheets.)
9. Have the students enter the dates and data into their spreadsheet.
10. Have the students save their data!

TIPS:

- Have the groups work at side-by-side computers.
- Encourage the group to help each other if they have questions (typically 1 or 2 students understand what to do).
- Students who help other students need to remember that the person they are helping will have a different role & collect different data (e.g. the ozone person has to collect ozone data not carbon monoxide).
- Show the students that there are STEP-BY-STEP instructions in their folders! (Otherwise they may ask for help without reading the instructions).

Group Details

Yellow Group: Health

Group Summary:	Roles:	Assignment Summary:
This group will monitor the frequency of asthma attacks at several schools within the school district. They will compare asthma attack trends with Air Quality ratings at the nearest tracking locations.	Assign roles. 1. Health Tracker (number depends on how many schools participate) 2. Ozone Tracker 3. Carbon Monoxide Tracker 4. Particulate Tracker (PM_{10} & $PM_{2.5}$)	Each student will enter asthma or pollution data into a spreadsheet.

COLLECT DATA: Set-up (1st time)

1. Decide on each of your roles (see above).

2. Decide on the location you are going to monitor (try to pick one close to your school)

   Note: The Particulate tracker will need to monitor at Rose Elementary & Geronimo (to get both PM types), or Green Valley.

3. Go to the activity website (http://www.airinfonow.com/html/airexercise/materials.html) and download the Excel Spreadsheet for the "Yellow Group: Health."

4. Save the spreadsheet onto your disk or computer.

Yellow Group Instructions, pg. 2

5. Go back to the website and look at "The Nurse Form."

6. Compose a letter or phone call dialogue to contact nurses to invite their participation in your research. Be sure to mention that they can use the website form to enter their data, or you can make other arrangements to get the data from the nurses.

COLLECT DATA: Everytime

Open the Excel spread sheet for "Yellow Group: Health"

1. Go to the activity web site, click "Pollution Tracker Data" to obtain air quality/pollution data.

2. Choose the date you need.

3. Click on "**view" PSI Report text/html**. You see the locations listed.

4. Enter the date you have chosen into the "Yellow Group: Health" spreadsheet.

5. Enter the data for your pollutant into the spreadsheet.

Health Trackers: When you receive the data from the nurses, enter it into the spreadsheet for the correct date and location.

6. Repeat until all of the data is entered.

Be sure to save your worksheet!

PRESENTATION PREP: Research

1. Do some research to add to your background knowledge. (Do this during the first two weeks while you wait for the nurses to respond).

2. Each group member should try to select a different activity. The information you gather will be shared as your 1st report.

a. Conduct research about asthma.

Yellow Group Instructions, pg. 3

b. Research the number of people admitted to local emergency rooms for asthma attacks.
c. Research the number of people with asthma nationally and locally.
d. Interview someone with asthma.
e. Pick a topic related to health and air pollution.

PRESENTATION PREP: Daily Data Graphs

1. Plot the data on a graph (pollutant level vs. time or asthma attacks vs. time).

2. Go to your spreadsheet and highlight the data for the first 2 weeks (or whatever time period you are reporting).

   Note: Health trackers will highlight the "Total" column.

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Columns."

6. Now click on the "Series" tab (top of gray box) "Category (x) axis labels", go back to your spreadsheet, and highlight the corresponding dates. (This will change the X-axis labels to the dates you want.)

7. Select "Next."

8. Enter a "Chart Title" such as "Asthma Incidence: Location" (or whatever your pollutant).

9. Enter a "Category (X) Axis" such as "Dates."

10. Enter a "Value (Y) Axis" such as "Asthma Incidents" " (or whatever units go with what you track) then select "Next."

11. Select "Place Chart: As New Sheet" and enter a label such as "Asthma Graph 1."

12. Select "Finish."

Yellow Group Instructions, pg. 4

PRESENTATION PREP: Find Averages (monthly)

DO THIS AFTER EACH FULL MONTH OF DATA IS ENTERED (20 DAYS).

1. Find the average and standard deviation for each time at the end of each reporting period.

2. **HEALTH TRACKERS**: Because you need to combine your asthma data before you can average it, calculate the total number of asthma incidents. Days 1 & 2 are calculated for you. To get the total highlight the row you want to add including the square for the answer (e.g. C7, D7, E7, F7) and then type **=sum(C7:E7)** in the square F7.

3. **POLLUTION & HEALTH TRACKERS:** You will notice there are some squares with the words “#DIV/0!”. These squares already have the formula to find the average of your data. (Notice that the average changes as you enter the data.)

4. You will need to enter the formula for the average for the remaining squares. There are several ways to do this – try one of each of the ways.

a. *Go to INSERT Þ FUNCTION Þ select AVERAGE Þ enter the first and last cell numbers you want to average separated by a colon. In the next blank average box that would be (H5:H24).*

OR

b. *Type =average(H5:H24) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains an average calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the average of.*

5. You will need to find the Standard Deviation (which tells you how variable your data is). There are several ways to do this – try one of each of the ways.

a. *go to INSERT Þ FUNCTION Þ select STDEV Þ enter the first and last cell numbers you want to average separated by a colon. In the third Standard Deviation box that would be (H5:H24)..*

OR

b. *Type =stdev(H5:H24) then hit enter. You can also highlight/select the cells you want to include.*

OR

c. *Select a cell that already contains a Standard Deviation calculation. Copy the cell and paste the formula into the cell you want. Be sure to double check that the formula includes the correct cells you want the Standard Deviation of.*

Yellow Group Instructions, pg. 5

PRESENTATION PREP: Monthly Data Graphs

1. Graph the average monthly data only after at least 2 months' worth of data has been collected. Otherwise, create a graph that contains all of the days (see above "Daily Data" graphing instructions).

2. Go to your spreadsheet, hold down the "Control" button and highlight the average for each month (you do not need to highlight the daily data).

3. Click on the bar graph icon OR go to the "Insert" menu and select "Chart."

4. Select "Column" for chart type then select "Next."

5. Leave the data range alone and select "Series In: Columns" then select "Next."

6. Now click on the "Series" tab (top of gray box).

7. Click in the box "Category (X) axis labels" and then type in the date range for each month separated by commas (January 1-31, February 1-28).

8. Select "Next."

9. Enter a "Chart Title" such as "Monthly Asthma Attacks: Location" (or whatever your pollutant is for whatever location).

10. Enter a "Category (X) Axis" such as "Dates."

11. Enter a "Value (Y) Axis" such as "Number of Asthma Attacks" then select "Next."

12. Select "Place Chart: As New Sheet" and enter a label such as "Monthly Asthma Graph."

13. Select "Finish."

Yellow Group Instructions, pg. 6

PRESENTATION PREP: Find Trends

1. As a group, analyze trends in asthma incidents and individual air pollutants (ozone, carbon monoxide, PM_{10}, and $PM_{2.5}$.)

Consider the following:

- Are there increases in asthma attacks with increases in any of the pollutants you are monitoring (ozone, carbon monoxide, PM_{10}, and $PM_{2.5}$.)?
- Are there other factors to consider with each asthma attack (e.g. was it induced by exercise)?
- Are these trends consistent over the month, 2 months, 5 months?
- Develop one or more hypothesis to describe the trends. Be careful not to draw conclusions or overstate your data.

PRESENTATION

Present your data, graphs, hypothesis, and/or conclusions to your class.

AQI

AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

United States
Environmental Protection
Agency

Air and Radiation

EPA-454/R-00-005
June 2000
http://www.epa.gov

Washington, DC 20460

EPA

Air Quality Index

A Guide to Air Quality and Your Health

Printed on paper containing at least
30% postconsumer recovered fiber.

"Local air quality is unhealthy today."

"It's a code red day for ozone."

Increasingly, radio, TV, and newspapers are providing information like this to local communities. But what does it mean to you
...if you plan to be outdoors that day?
...if you have children who play outdoors?
...if you are retired? ...if you have asthma?
This booklet will help you understand what this information means to you and your family and what you can do to protect your health.

"Today's Air Quality Index is 105, which is unhealthy for sensitive groups."

Air Quality Index

A Guide to Air Quality and Your Health

Local air quality affects how we live and breathe. Like the weather, it can change from day to day or even hour to hour. The U.S. Environmental Protection Agency (EPA) and others are working to make information about outdoor air quality as available to the public as information about the weather. A key tool in this effort is the Air Quality Index, or AQI. EPA and local officials use the AQI to provide the public with timely and easy-to-understand information on local air quality and whether air pollution levels pose a health concern.

This booklet tells you about the AQI and how it is used to provide air quality information. It also tells you about the possible health effects of major air pollutants at various levels and suggests actions you can take to protect your health when pollutants in your area reach unhealthy concentrations.


Air quality directly affects our quality of life.

What is the AQI?

The AQI is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health concerns you should be aware of. The AQI focuses on health effects that can happen within a few hours or days after breathing polluted air. EPA uses the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect against harmful health effects.

How does the AQI work?

You can think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health danger. For example, an AQI value of 50 represents good air quality and little potential to affect public health, while an AQI value over 300 represents hazardous air quality.

An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. So, AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy—at first for certain sensitive groups of people, then for everyone as AQI values get higher.

Understanding the AQI

The purpose of the AQI is to help you understand what local air quality means to your health. To make the AQI as easy to understand as possible, EPA has divided the AQI scale into six categories, shown below:

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Each category corresponds to a different level of health concern. For example, when the AQI for a pollutant is between 51 and 100, the health concern is "Moderate." Here are the six levels of health concern and what they mean:

- **"Good"** The AQI value for your community is between 0 and 50. Air quality is considered satisfactory and air pollution poses little or no risk.

- **"Moderate"** The AQI for your community is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of individuals. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.

- **"Unhealthy for Sensitive Groups"** Certain groups of people are particularly sensitive to the harmful effects of certain air pollutants. This means they are likely to be affected at lower levels than the general public. For example, children and adults who are active outdoors and people with respiratory disease are at greater risk from exposure to ozone, while people with heart disease are at greater risk from carbon monoxide. Some people may be sensitive to more than one pollutant. When AQI values are between 101 and 150, members of sensitive groups may experience health effects. The general public is not likely to be affected when the AQI is in this range.

- **"Unhealthy"** AQI values are between 151 and 200. Everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.

- **"Very Unhealthy"** AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.

- **"Hazardous"** AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

AQI colors

EPA has assigned a specific color to each AQI category to make it easier for people to understand quickly the significance of air pollution levels in their communities. For example, the color orange means that conditions are "unhealthy for sensitive groups"; the color red means that conditions may be "unhealthy" for everyone, and so on. You may see these colors when the AQI is reported in the newspaper or on television, or on your state or local air pollution agency's web site. The colors can help you rapidly determine whether air pollutants are reaching unhealthy levels in your area.

How is a community's AQI calculated?

Air quality is measured by networks of monitors that record the concentrations of the major pollutants at more than a thousand locations across the country each day. These raw measurements are then converted into AQI values using standard formulas developed by EPA. An AQI value is calculated for each of the individual pollutants in an area (ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide). Finally, the highest of the AQI values for the individual pollutants becomes the AQI value for that day. For example, if on July 12 a certain area had AQI values of 90 for ozone and 88 for sulfur dioxide, the AQI value would be 90 for the pollutant ozone on that day.

Children active outdoors can be sensitive to some air pollutants.

When and how is the AQI reported to the public?

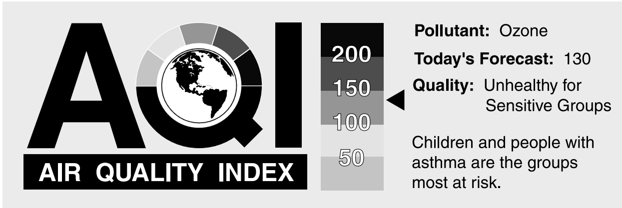
In large metropolitan areas (more than 350,000 people), state and local agencies are required to report the AQI to the public daily. When the AQI is above 100, they must also report which groups (e.g., children, people with asthma or heart disease) may be sensitive to the specific pollutant. If two or more pollutants have AQI values above 100 on a given day, agencies will report all the groups that are sensitive to those pollutants. Although it is not required, many smaller communities also report the AQI as a public health service.

Many metropolitan areas also report an AQI forecast that allows local residents to plan their activities to protect their health.

The AQI is a national index, so the values and colors used to show local air quality and the associated level of health concern will be the same everywhere you go in the U.S. Look for the AQI to be reported in your local newspaper, on television and radio, on the Internet, and on state and local telephone hotlines.

AQI in the Newspaper

Newspapers may use different formats to report the AQI. Here is one example:



AQI in Television and Radio Weather Reports

Your local television or radio weathercasters may use the AQI to provide information about air quality in your area. Here's the type of report you might hear:

> *The Air Quality Index today was 160, a code red day. Air quality was unhealthy due to ozone. Hot, sunny weather and stagnant air caused ozone in Center City to rise to unhealthy levels. Children and people with asthma are the groups most at risk.*

You might also hear your weathercasters use the AQI to forecast air quality levels for the coming day. They may provide suggestions about how to protect your health when the air is unhealthy to breathe:

> *Tomorrow, the AQI for Center City is predicted to be between 160 and 170, a code red day. This means that air pollution will be at unhealthy levels. The combination of cold winter air and morning rush-hour traffic will cause carbon monoxide to rise to unhealthy levels. People with heart disease should plan to limit moderate exertion and avoid sources of carbon monoxide, such as heavy traffic.*

AQI on the Internet

EPA's AirNow web site (**www.epa.gov/airnow**) contains general information about air pollution plus real-time and forecast data for ground-level ozone. The web site also contains facts about the health and environmental effects of air pollution, steps you can take to protect your health and reduce pollution, and links to state and local air pollution control agency web sites with local AQI information.

What are typical AQI values in most communities?

In many U.S. communities, AQI values are mostly below 100, with values greater than 100 occurring several times a year. Several metropolitan areas in the United States have more severe air pollution problems, and the AQI in these areas may often exceed 100. AQI values higher than 200 are very infrequent, and AQI values above 300 are extremely rare.

AQI values can vary significantly from one season to another. In winter, for example, carbon monoxide is likely to be the pollutant with the highest AQI values in some areas, because cold weather makes it difficult for car emission control systems to operate effectively. In summer, ozone is the most significant air pollutant in many communities, since it forms in the presence of heat and sunlight.

AQI values also can vary depending on the time of day. For example, ozone levels often peak in the afternoon, while carbon monoxide is usually a problem during morning or evening rush hours.

How can I avoid being exposed to harmful air pollutants?

The following charts and text tell you where each pollutant comes from, what health effects may occur for each pollutant, and what you can do to protect your health.

Air Quality Index (AQI): Ozone

Index Values	Levels of Health Concern	Cautionary Statements
0 - 50	Good	None
51 - 100*	Moderate	Unusually sensitive people should consider limiting prolonged outdoor exertion.
101 - 150	Unhealthy for Sensitive Groups	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
151 - 200	Unhealthy	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.
201 - 300	Very Unhealthy	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.
301 - 500	Hazardous	Everyone should avoid all outdoor exertion.

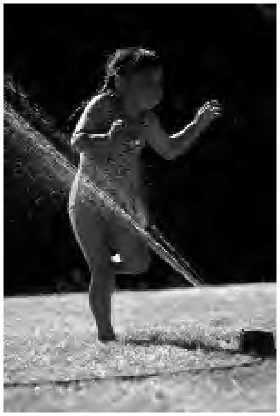
*Generally, an AQI of 100 for ozone corresponds to an ozone level of 0.08 parts per million (averaged over 8 hours).

What is ozone?

Ozone is an odorless, colorless gas composed of three atoms of oxygen. Ozone occurs both in the Earth's upper atmosphere and at ground level. Ozone can be good or bad, depending on where it is found:

Good Ozone. Ozone occurs naturally in the Earth's upper atmosphere—10 to 30 miles above the Earth's surface—where it forms a protective layer that shields us from the sun's harmful ultraviolet rays. This beneficial ozone is gradually being destroyed by manmade chemicals. An area where ozone has been significantly depleted—for example, over the North or South pole—is sometimes called a "hole in the ozone."

- **Bad Ozone.** In the Earth's lower atmosphere, near ground level, ozone is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight. Ozone at ground level is a harmful pollutant. Ozone pollution is a concern during the summer months, when the weather conditions needed to form it—lots of sun, hot temperatures—normally occur.



The risk of exposure to unhealthy levels of ozone is greatest during summer months.

What are the health effects and who is most at risk?

Roughly one out of every three people in the United States is at a higher risk of experiencing ozone-related health effects. Sensitive people include children and adults who are active outdoors, people with respiratory disease, such as asthma, and people with unusual sensitivity to ozone.

- One group at high risk from ozone exposure is active children because this group often spends a large part of the summer playing outdoors. However, people of all ages

who are active outdoors are at increased risk because, during physical activity, ozone penetrates deeper into the parts of the lungs that are more vulnerable to injury.

- People with respiratory diseases that make their lungs more vulnerable to ozone may experience health effects earlier and at lower ozone levels than less sensitive individuals.

- Though scientists don't yet know why, some healthy people experience health effects at more moderate levels of outdoor exertion or at lower ozone levels than the average person.

- Ozone can irritate the respiratory system, causing coughing, throat irritation, and/or an uncomfortable sensation in the chest.

- Ozone can reduce lung function and make it more difficult to breathe deeply and vigorously. Breathing may become more rapid and shallow than normal. This reduction in lung function may limit a person's ability to engage in vigorous outdoor activities.

- Ozone can aggravate asthma. When ozone levels are high more people with asthma have attacks that require a doctor's attention or the use of additional medication. One reason this happens is that ozone makes people more sensitive to allergens, the most common triggers of asthma attacks.

- Ozone can increase susceptibility to respiratory infections.

- Ozone can inflame and damage the lining of the lungs. Within a few days, the damaged cells are shed and replaced—much like the skin peels after a sunburn. Animal studies suggest that if this type of inflammation happens repeatedly over a long time period (months, years, a lifetime), lung tissue may become permanently scarred, resulting in less lung elasticity, permanent loss of lung function, and a lower quality of life.

Air Quality Index (AQI): Particulate Matter (PM)

Index Values	Levels of Health Concern	Cautionary Statements*	
		$PM_{2.5}$	PM_{10}
0 - 50	Good	None	None
51 - 100**	Moderate	None	None
101 - 150	Unhealthy for Sensitive Groups	People with respiratory or heart disease, the elderly, and children should limit prolonged exertion.	People with respiratory disease, such as asthma, should limit outdoor exertion.
151 - 200	Unhealthy	People with respiratory or heart disease, the elderly, and children should avoid prolonged exertion; everyone else should limit prolonged exertion.	People with respiratory disease, such as asthma, should avoid outdoor exertion; everyone else, especially the elderly and children, should limit prolonged outdoor exertion.
201 - 300	Very Unhealthy	People with respiratory or heart disease, the elderly, and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.	People with respiratory disease, such as asthma, should avoid any outdoor activity; everyone else, especially the elderly and children, should limit outdoor exertion.
301 - 500	Hazardous	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly, and children should remain indoors.	Everyone should avoid any outdoor exertion; people with respiratory disease, such as asthma, should remain indoors.

* PM has two sets of cautionary statements, which correspond to the two sizes of PM that are measured:
- Particles up to 2.5 micrometers in diameter ($PM_{2.5}$)
- Particles up to 10 micrometers in diameter (PM_{10})

**
- An AQI of 100 for $PM_{2.5}$ corresponds to a $PM_{2.5}$ level of 40 micrograms per cubic meter (averaged over 24 hours).
- An AQI of 100 for PM_{10} corresponds to a PM_{10} level of 150 micrograms per cubic meter (averaged over 24 hours).

What is particulate matter?

The term "particulate matter" (PM) includes both solid particles and liquid droplets found in air. Many manmade and natural sources emit PM directly or emit other pollutants that react in the atmosphere to form PM. These solid and liquid particles come in a wide range of sizes. Particles less than 10 micrometers in diameter tend to pose the greatest health concern because they can be inhaled into and accumulate in the respiratory system. Particles less than 2.5 micrometers in diameter are referred to as "fine" particles. Sources of fine particles include all types of combustion (motor vehicles, power plants, wood burning, etc.) and some industrial processes. Particles with diameters between 2.5 and 10 micrometers are referred to as "coarse." Sources of coarse particles include crushing or grinding operations, and dust from paved or unpaved roads.

What are the health effects and who is most at risk?

Both fine and coarse particles can accumulate in the respiratory system and are associated with numerous health effects. Coarse particles can aggravate respiratory conditions such as asthma. Exposure to fine particles is associated with several serious health effects, including premature death. Adverse health effects have been associated with exposures to PM over both short periods (such as a day) and longer periods (a year or more).

- When exposed to PM, people with existing heart or lung diseases—such as asthma, chronic obstructive pulmonary disease, congestive heart disease, or ischemic heart disease—are at increased risk of premature death or admission to hospitals or emergency rooms.
- The elderly also are sensitive to PM exposure. They are at increased risk of admission to hospitals or emergency rooms and premature death from heart or lung diseases.
- When exposed to PM, children and people with existing lung disease may not be able to breathe as deeply or vigorously as they normally would, and they may experience symptoms such as coughing and shortness of breath.
- PM can increase susceptibility to respiratory infections and can aggravate existing respiratory diseases, such as asthma and chronic bronchitis, causing more use of medication and more doctor visits.

Air Quality Index (AQI): Carbon Monoxide (CO)

Index Values	Levels of Health Concern	Cautionary Statements
0 - 50	Good	None
51 - 100*	Moderate	None
101 - 150	Unhealthy for Sensitive Groups	People with cardiovascular disease, such as angina, should limit heavy exertion and avoid sources of CO, such as heavy traffic.
151 - 200	Unhealthy	People with cardiovascular disease, such as angina, should limit moderate exertion and avoid sources of CO, such as heavy traffic.
201 - 300	Very Unhealthy	People with cardiovascular disease, such as angina, should avoid exertion and sources of CO, such as heavy traffic.
301 - 500	Hazardous	People with cardiovascular disease, such as angina, should avoid exertion and sources of CO, such as heavy traffic; everyone else should limit heavy exertion.

* An AQI of 100 for carbon monoxide corresponds to a CO level of 9 parts per million (averaged over 8 hours).

What is carbon monoxide?

Carbon monoxide (CO) is an odorless, colorless gas. It forms when the carbon in fuels does not completely burn. Vehicle exhaust contributes roughly 60 percent of all carbon monoxide emissions nationwide, and up to 95 percent in cities. Other sources include fuel combustion in industrial processes and natural sources such as wildfires. Carbon monoxide concentrations typically are highest during cold weather, because cold temperatures make combustion less complete and cause inversions that trap pollutants low to the ground.

What are the health effects and who is most at risk?

Carbon monoxide enters the bloodstream through the lungs and binds chemically to hemoglobin, the substance in blood that carries oxygen to cells. In this way, carbon monoxide reduces the amount of oxygen reaching the body's organs and tissues.

- People with cardiovascular disease, such as angina, are most at risk from carbon monoxide. These individuals may experience chest pain and more cardiovascular symptoms if they are exposed to carbon monoxide, particularly while exercising.

Vehicle exhaust contributes roughly 60 percent of all carbon monoxide emissions nationwide.

- People with marginal or compromised cardiovascular and respiratory systems (for example, individuals with congestive heart failure, cerebrovascular disease, anemia, chronic obstructive lung disease), and possibly fetuses and young infants, may also be at greater risk from carbon monoxide pollution.
- In healthy individuals, exposure to higher levels of carbon monoxide can affect mental alertness and vision.

Air Quality Index (AQI): Sulfur Dioxide (SO_2)

Index Values	Levels of Health Concern	Cautionary Statements
0 - 50	Good	None
51 - 100*	Moderate	None
101 - 150	Unhealthy for Sensitive Groups	People with asthma should consider limiting outdoor exertion.
151 - 200	Unhealthy	Children, asthmatics, and people with heart or lung disease should limit outdoor exertion.
201 - 300	Very Unhealthy	Children, asthmatics, and people with heart or lung disease should avoid outdoor exertion; everyone else should limit outdoor exertion.
301 - 500	Hazardous	Children, asthmatics, and people with heart or lung disease should remain indoors; everyone else should avoid outdoor exertion.

* An AQI of 100 for sulfur dioxide corresponds to an SO_2 level of 0.14 parts per million (averaged over 24 hours).

What is sulfur dioxide?

Sulfur dioxide (SO_2), a colorless, reactive gas, is produced during the burning of sulfur-containing fuels such as coal and oil, during metal smelting, and by other industrial processes. Major sources include power plants and industrial boilers. Generally, the highest concentrations of sulfur dioxide are found near large industrial sources.

What are the health effects and who is most at risk?

- Children and adults with asthma who are active outdoors are most vulnerable to the health effects of sulfur dioxide. The primary effect they experience, even with brief exposure, is a narrowing of the airways (called bronchoconstriction), which may cause symptoms such as wheezing, chest tightness, and shortness of breath. Symptoms increase as sulfur dioxide concentrations and/or breathing rates increase. When exposure ceases, lung function typically returns to normal within an hour.

Children and adults with asthma who are active outdoors are most vulnerable to the health effects of sulfur dioxide.

- At very high levels, sulfur dioxide may cause wheezing, chest tightness, and shortness of breath in people who do not have asthma.

- Long-term exposure to both sulfur dioxide and fine particles can cause respiratory illness, alter the lung's defense mechanisms, and aggravate existing cardiovascular disease. People who may be most susceptible to these effects include individuals with cardiovascular disease or chronic lung disease, as well as children and the elderly.

Air Quality Index (AQI): Nitrogen Dioxide (NO_2)

Index Values	Levels of Health Concern	Cautionary Statements
0 - 50	Good	None
51 - 100	Moderate	None
101 - 150	Unhealthy for Sensitive Groups	None
151 - 200	Unhealthy	None
201* - 300	Very Unhealthy	Children and people with respiratory disease, such as asthma, should limit heavy outdoor exertion.
301 - 500	Hazardous	Children and people with respiratory disease, such as asthma, should limit moderate or heavy outdoor exertion.

* Short-term health effects for nitrogen dioxide do not occur until AQI values are above 200; therefore, the AQI is not calculated below 201 for NO_2. An AQI of 201 for NO_2 corresponds to an NO_2 level of 0.65 parts per million (averaged over 24 hours).

What is nitrogen dioxide?

Nitrogen dioxide (NO_2) is a reddish brown, highly reactive gas formed when another pollutant (nitric oxide) combines with oxygen in the atmosphere. Once it has formed, nitrogen dioxide reacts with other pollutants (volatile organic compounds). Eventually these reactions result in the formation of ground-level ozone. Major sources include automobiles and power plants.

What are the health effects and who is most at risk?

- In children and adults with respiratory disease, such as asthma, nitrogen dioxide can cause respiratory symptoms such as coughing, wheezing, and shortness of breath. Even short exposures to nitrogen dioxide affect lung function.

- In children, short-term exposure can increase the risk of respiratory illness.

- Animal studies suggest that long-term exposure to nitrogen dioxide may increase susceptibility to respiratory infection and may cause permanent structural changes in the lungs.

For more information on air quality in your area, visit EPA's AirNow web site at http://www.epa.gov/airnow or call EPA's Office of Air and Radiation at (202) 564-7400.

For technical information on reporting the AQI, see EPA's publication *Guideline for Reporting of Daily Air Quality—Air Quality Index (AQI),* EPA-454/R-99-010, at http://www.epa.gov/airnow/publications.html.

The focus of the AQI is on outdoor air quality. For information on indoor air quality, contact EPA's Indoor Air Quality Information Clearinghouse at (800) 438-4318.

Air Quality Index Kids Website
Teacher's Reference

Clean Air and Dirty Air

On a clear breezy day, the air smells fresh and clean. Clean air is air that has no pollutants (dirt and chemicals) in it. Clean air is good for people to breathe.

On a hot day with no wind, the air can feel heavy and have a bad smell. Once in a while, the air can even make your chest feel tight, or make you cough. Dirt and chemicals that get into the air make the air dirty or polluted. Dirty air is not good for people to breathe.

Dirty Air Can Make You Sick

When the air has some dust, soot or chemicals floating in it, people who are inside probably won't notice it. People who are outside might notice it.

People with asthma, a disease that can make it hard to breathe, and children who play outside a lot might feel a little strange. When you are active outdoors, for example, when you run and jump a lot, you breathe faster and take in more air. Any pollutants in the air go into your lungs.

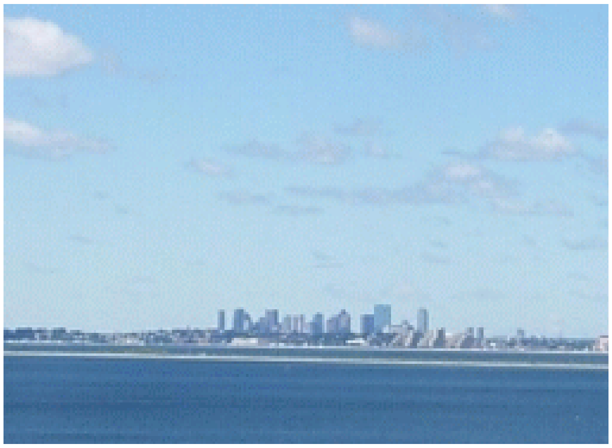
When the air is very dirty, almost everyone will notice it. It would be good if we could stop breathing on those days, but of course we can't!

How Can I Tell if the Air is Clean or Dirty?

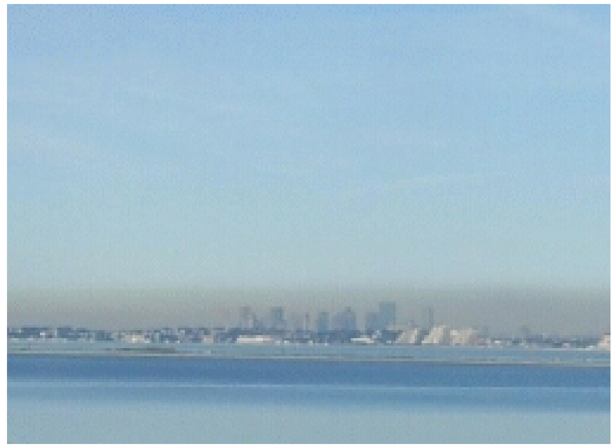
For information about visibility: http://www.epa.gov/air/visibility/

Have you ever been stopped behind a truck or a bus at a traffic light? When it starts up, sometimes a puff of dark smoke comes out of the exhaust pipe.

Air Quality Index Kids Website
Teacher's Reference



Clean Air



Dirty Air or Pollution

At times like that you can see dirty air - it looks hazy and brownish. If your window is open, you might be able to smell the pollution. But sometimes the air can be dirty and you can't see it or smell it. So you need another way to tell if the air is dirty. This is why EPA devel oped the Air Quality Index, which we will describe in the "What is the AQI?" section.

Air Quality Index Kids Website
Teacher's Reference

For information about the United States Environmental Protection Agency: http://www.epa.gov/

The Environmental Protection Agency

The environment is everything around you - the air, the land, and the rivers and oceans. The Environmental Protection Agency (EPA) is a government office that works to keep the air, the land, and the water clean. Clean air, land, and water help keep us healthy. The EPA works with State environmental agencies to keep the air clean. State environmental agencies take samples of the air at more than 1000 places in the United States to see if the air is dirty or clean.

Pollutants

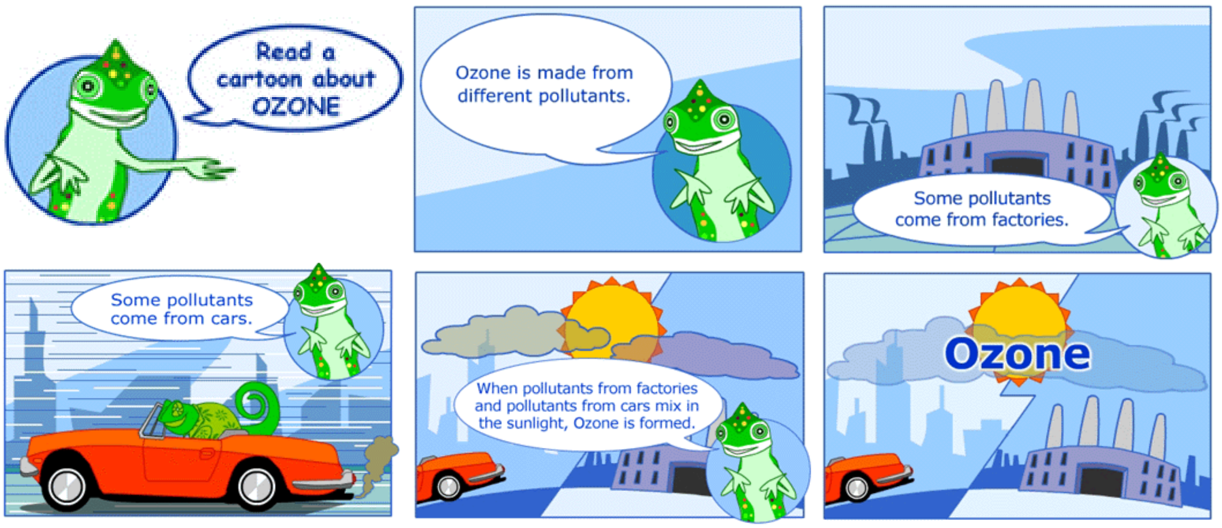
Pollutants are what make the air dirty and cause pollution. Five pollutants are used by the EPA to determine the Air Quality Index (AQI). Two of the pollutants, **Ozone** and **Particulate Matter**, make up most of the air pollution in this country.

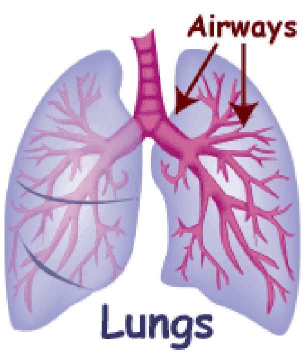
More information about ozone: http://www.epa.gov/air/urbanair/ozone/

Ozone: Ozone can be good or bad. It all depends on where it is. Ozone is good when it is high up in our atmosphere. It protects us from sunburn. Ozone is bad when it is near the ground where we can breathe it in. You can't see ozone in the air. Bad ozone is sometimes called smog. It is formed when chemicals coming out of cars and factories are cooked by the hot sun. Ozone is more of a problem in the summer.

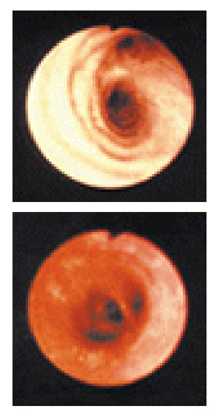
Air Quality Index Kids Website

Teacher's Reference





Breathing in ground-level ozone can make you cough. It can also make it harder for you to breathe. Ozone might even make it hurt to take a breath of air. When you breathe in ozone, it can make the lining of your airways red and swollen, like your skin would get with a sunburn.



Inside Airway
Top: Normal
Bottom: Red and Swollen

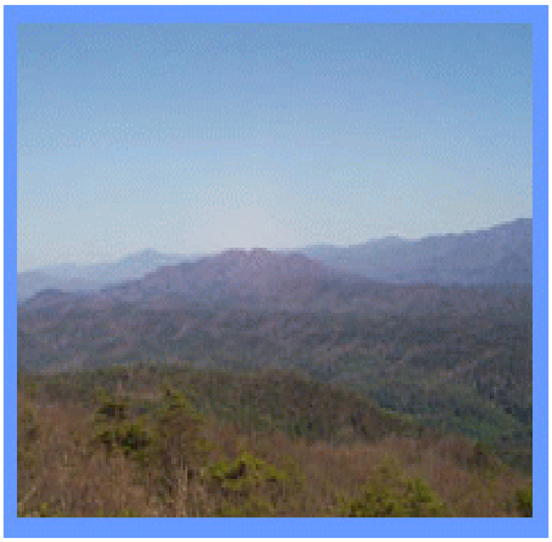
Information about the health effects of ozone can be found at: http://www.epa.gov/airnow/brochure.html

Particles in the Air - Particulate Matter: Have you ever noticed a sunbeam with lots of little specks of dust floating in it? That is particulate matter. Particulate matter is mostly dust and soot so small that it floats in the air. Soot comes from anybody burning anything. When you burn gasoline in your car engine or burn wood in a campfire, soot happens! Dust comes from lots of places, too. When a company's business is to grind things up very small or when someone drives down a dirt road, dust is thrown into the air. Soot and dust make the air look hazy.

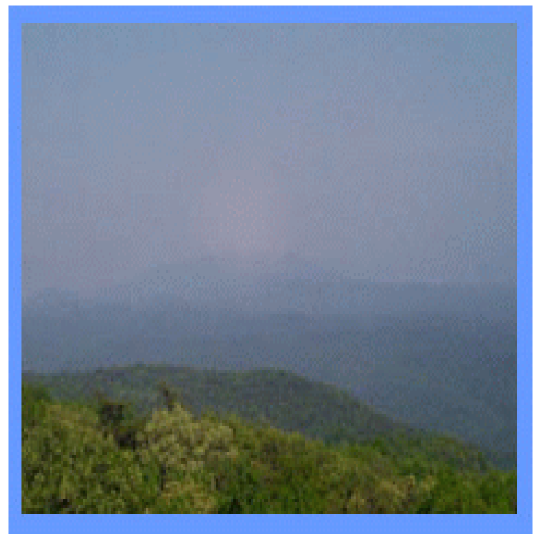
Information about particulate matter: http://www.epa.gov/air/urbanair/pm/

Air Quality Index Kids Website
Teacher's Reference

Soot and dust make the air look hazy!



Clear Day



Hazy Day

Some particles in the air are so small you can't see them. It is not good for you to breathe in too much of the tiny particulate matter. Particles in the air can make you cough. Particulate matter can also make it hard for you to take a deep breath and you might get more colds. If you already have asthma or problems with your heart, particulate matter could make you sick enough to go to the hospital. To reduce exposure to particulate matter when the AQI is orange or worse, don't play near streets with heavy traffic. Heavy traffic areas are highways and busy streets where there are a lot of cars, buses, and trucks.

Air Quality Index Kids Website
Teacher's Reference

The Air Quality Index

The EPA and your State environmental agency measure pollution in the air. Then they use the Air Quality Index, or AQI, to tell the people about the air. An index can be a quick way to tell people how good or bad something is.

The AQI uses colors, and numbers, and words to tell you about the air.

Information about the Air Quality Index is available at:
http://www.epa.gov/airnow/aqibroch/

AQI Colors

These are the AQI colors. Each day the AQI is one of these colors. The colors tell you how healthy the air is to breathe that day. The colors go from Green to Yellow to Orange to Red to Purple to Maroon, each color telling you that the air is less clean than the color before. Green is the best air quality.

GREEN	YELLOW	ORANGE	RED	PURPLE	MAROON

When the AQI is green, the air is clean!

We see a lot of Yellow, Orange, and Red AQI colors in the summer when air quality often isn't at its best. Purple and Maroon are the worst air quality! Luckily we hardly ever see the AQI get to Purple. Because of people working to clean up the air, the AQI has not reached Maroon in many years! This is why Maroon is usually not shown with the AQI.

AQI Numbers

An index with numbers can be a quick way to tell people how good or bad something is. For example, you might say your school lunch is a 1 (very good) or a 5 (yucky). The Air Quality Index uses numbers from 0 to 500. These numbers are used to decide the AQI color. On days measuring less than 100, the air is clean. If the air is dirtier, the numbers get bigger. On days measuring more than 100, the air can be bad for you to breathe.

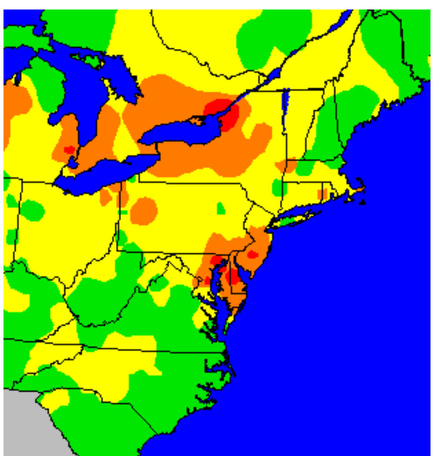
Air Quality Index Kids Website
Teacher's Reference

Here is how the AQI numbers match up with the AQI colors:

AQI Numbers	Colors
0 to 50	Green
51 to 100	Yellow
101 to 150	Orange
151 to 200	Red
201 to 300	Purple
301 to 500	Maroon (usually not shown)

Where is the AQI?

You can find the AQI in several places. If you have a computer connected to the Internet, go to www.epa.gov/AIRNOW, and click with your mouse on "Where I Live." When you see the map of the United States, click on your state. Then you will see a chart with a list of cities. The AQI for many, but not all, large cities can be found there. Look for your city and you will see if the air in your city today is clean or not.



June 27, 2001

You can see an AQI Ozone Map for many areas in the United States. Here is an example. It looks like a weather map, except this shows ozone. This shows the AQI colors for ozone going from green (good) to red (unhealthy) in the eastern part of the United States.

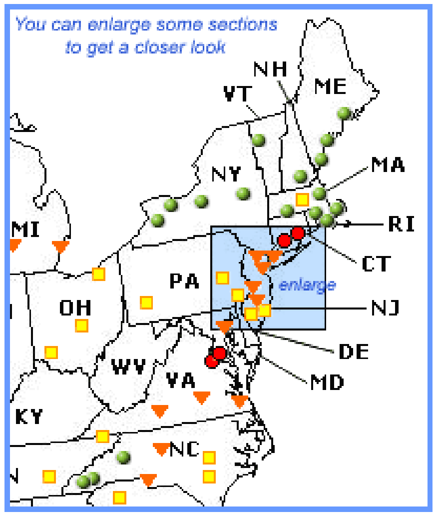
If you would like to see an AQI Ozone Map for your state, go to www.epa.gov/AIRNOW, then click on Ozone Maps. You can also see an AQI Forecast Map of the United States. Here is an example of the air quality forecast for the eastern part of the United States.

This shows the AQI forecast from green (good) to red (unhealthy) for many cities in the eastern part of the United States.

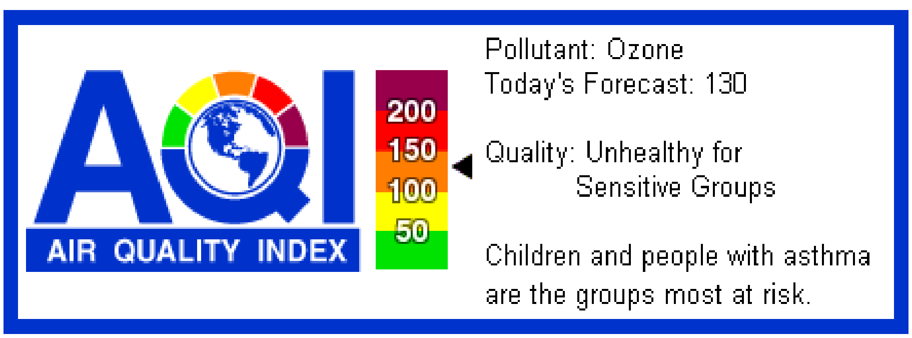
Air Quality Index Kids Website

Teacher's Reference

If you would like to see an AQI Forecast Map for the United States, go to www.epa.gov/AIRNOW, then click on Air Quality Forecast.



You can find the AQI in the newspaper, often in the weather section. It might look something like this:



Air Quality Index Kids Website
Teacher's Reference

Air Pollution and Health

One thing the AQI does is help you understand what the air quality around you means to your health. Each of the AQI colors has a word or phrase to go with it that tells you something about health. These are the colors and the health words that go with them.

Two brochures explaining the health effects of ozone are available:
http://www.epa.gov/airnow/brochure.html
http://www.epa.gov/airnow/health/

AQI Colors	Health Word(s)
Green	Good
Yellow	Moderate
Orange	Unhealthy for Sensitive Groups
Red	Unhealthy
Purple	Very Unhealthy
Maroon (usually not shown)	Hazardous

Sometimes the weatherperson on TV or the radio will talk about the AQI for today and may also tell you what tomorrow's AQI will be...

Air Quality Index Kids Website
Teacher's Reference

What is a Sensitive Group?

Sometimes people with asthma need help breathing.

Some people are more sensitive to air pollution than other people. Different people can be sensitive to different air pollutants. For example, ozone might make you cough. Particulate matter may not bother you, but it may make your grandmother cough and need to rest.

One sensitive group is people with asthma. Asthma is a disease that can make it hard to breathe. If people who have asthma are careful and do what the doctor tells them to do, they may never have trouble breathing.


Children active outdoors can be sensitive to some air pollutants.

Another sensitive group is children. Why are you part of a sensitive group? Because you're young, and that means your body is still growing, and your lungs are still developing. Also, you tend to play outside more, where the air pollution is. Does this mean you must stay inside when the air is dirty? Not really! Check out what the AQI colors and health words tell you to do:

How can I tell if air pollution is affecting me?

If you are playing hard outside when the AQI is orange or worse you may cough, feel some discomfort when you breathe, or your chest may feel tight. If you do, you should tell your parents or teachers. People with asthma may wheeze the day after pollution levels are high. If you have asthma, be sure and follow your doctor's advice when pollution levels are high.

Air Quality Index Kids Website
Teacher's Reference

AQI for Ozone

Color & Health Word(s)	What To Do?
GREEN is Good	Just enjoy the clean air!
YELLOW is Moderate	Air quality is fine for most people, including children like you. However, if you know you are extra sensitive to pollution, you might want to limit the time you spend playing outside.
ORANGE is Unhealthy for Sensitive Groups	People with lung disease, such as asthma, and active kids and grown-ups should limit how long or how hard they play or are active outside. Remember, it's important to think about how the air quality is making you feel! If you don't feel so great, take it a little easier.
RED is Unhealthy	People with lung disease, such as asthma, and active kids and grown-ups should not spend a long time playing or being active outdoors. Everybody else should limit how long they are active outside.
PURPLE is Very Unhealthy	People with lung disease, such as asthma, and active kids and grown-ups should not spend any time playing or being active outdoors. Everybody else should limit outdoor activities.
MAROON is Hazardous (usually not shown)	No one should play or be active outside.

Air Quality Index Kids Website
Teacher's Reference

So if the AQI is orange, red, or worse, do I have to stay in all day?

No, you can go out and play. Outdoor exercise and play make your body stronger. It is just that when the AQI is orange or worse there is some risk that if you go outside and play, you may feel some of the health effects described here.

What is risk?

Risk is the chance that something bad will happen, and it is a normal part of everyday life. There are bigger risks and smaller risks. If you were to play on a busy street, your risk of being injured would be big. We can compare the risk from air pollution to other kinds of risk you know about, such as eating "junk food." Junk food is bad for kids, too, but most kids won't be hurt eating a little bit of it once in a while. Likewise, even though dirty air is bad for kids, most kids won't be hurt by playing outside, once in a while, when the air is dirty.

Often, you can lower the risk by being smart, for example by wearing a bike helmet when you ride your bike. To lower your risk from air pollution, you can play outdoors at the times of day when air pollution levels are lower. In the summer, this is often in the morning or in the evening. Another good way to lower your risk is by taking it easier if you do play outdoors when air pollution levels are high. Also, if you do play outside when the AQI is orange, red, or worse, pay attention to how you feel. Does your chest feel strange? Is it hard to breathe? Do you feel tired? If you can answer "yes" to any of those questions, stop playing outside, and tell your parents or teachers.

Air Quality Index Kids Website
Teacher's Reference

What Can I Do?

What can I do to lower my risk from air pollution?

If pollution levels are forecast to be high:

- ✓ Play outside at the time of day when levels will be lower

If you know pollution levels are high:

- ✓ Playing outside is okay, just take it easier

Pay attention to symptoms like coughing, pain when taking a deep breath, chest tightness or wheezing If you have any of these symptoms, stop playing and tell your parents or teachers

> Information about what you can do to help lower air pollution can be found at:
> http://www.epa.gov/air/actions/

What can I do to lower pollution?

- ✓ Conserve energy

> http://www.epa.gov/globalwarming/actions/efficiency/

- ✓ Carpool, ride your bike, walk, take the bus
- ✓ Don't make trips you don't need to make
- ✓ Ask your Mom and Dad to help (by keeping cars tuned, filling up early or late in the day, inflating tires, etc.)

- ✓ Visit other kids' Web sites to learn about recycling, global warming, etc.

Waste & Recycling	http://www.epa.gov/students/waste&.htm
EPA Explorers Club	http://www.epa.gov/kids/garbage.htm
Global Warming	http://www.epa.gov/globalwarming/kids/
Recycle City	http://www.epa.gov/recyclecity/

Air Quality Index Kids Website
Teacher's Reference

Air Quality Index Dictionary

Asthma: Asthma is a disease that can make it hard to breathe.

Atmosphere: Our atmosphere is the air and gases surrounding the earth.

Chemical: Chemicals are everywhere. There are chemicals inside your body, and there are chemicals in the ground, in the water, and in the air. You can see most chemicals, but not all chemicals. Some are clear or so small we can't see them. Some chemicals are good, like the medicine the doctor gives you when you are sick. Some chemicals are useful, but dangerous, like gasoline. Gasoline makes cars run, but you wouldn't want to drink it, because it would make you very sick. Some chemicals make the air dirty and cause pollution, like Ozone.

Disease: A disease is a type of illness. A disease is something that makes you sick.

Global: Global means the whole world.

Hazardous: Hazardous means dangerous.

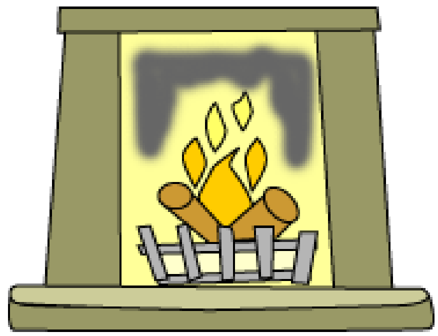
Haze: Soot and dust make the air look hazy!

Ozone: Ozone can be good or bad. It all depends on where it is. Ozone is good when it is high up in our atmosphere. It protects us from sunburn. Ozone is bad when it is near the ground where we can breathe it in. You can't see ozone in the air. Bad ozone is sometimes called smog. It is formed when chemicals coming out of cars and factories are cooked by the hot sun. Ozone is more of a problem in the summer.

Particulate Matter: Have you ever noticed a sunbeam with lots of little specks of dust floating in it? That is particulate matter. Particulate matter is mostly dust and soot so small that it floats in the air. Soot comes from anybody burning anything. When you burn gasoline in your car engine or burn wood in a campfire, soot happens! Dust comes from lots of places, too. When a company's business is to grind things up very small or when someone drives down a dirt road, dust is thrown into the air. Soot and dust make the air look hazy.

Pollutant: Pollutants are what make the air dirty and cause pollution. Sometimes you can see pollutants and sometimes you can't. Ozone is a pollutant that you can't see. Dust and soot are pollutants that you can see. Dust and soot are also called Particulate Matter.

Smog: Bad ozone is sometimes called smog.



Soot: Soot comes from burning something. When you burn gasoline in your car engine or burn wood in a campfire, soot happens! You may have noticed the walls on the fireplace after a fire has burned. The walls are covered in a black powder. That is soot.

Stagnant: When air is still and not moving, and smells musty or stale, it is called stagnant. Water that is not moving also is called stagnant.

Today is a
Green day.
It's a great day to go
outside and play!
AQI
AIR QUALITY INDEX
Good 0-50
Moderate 51-100
Unhealthy for Sensitive Groups 101-150
Unhealthy 151-200
Very Unhealthy 201-300

AQI
AIR QUALITY INDEX

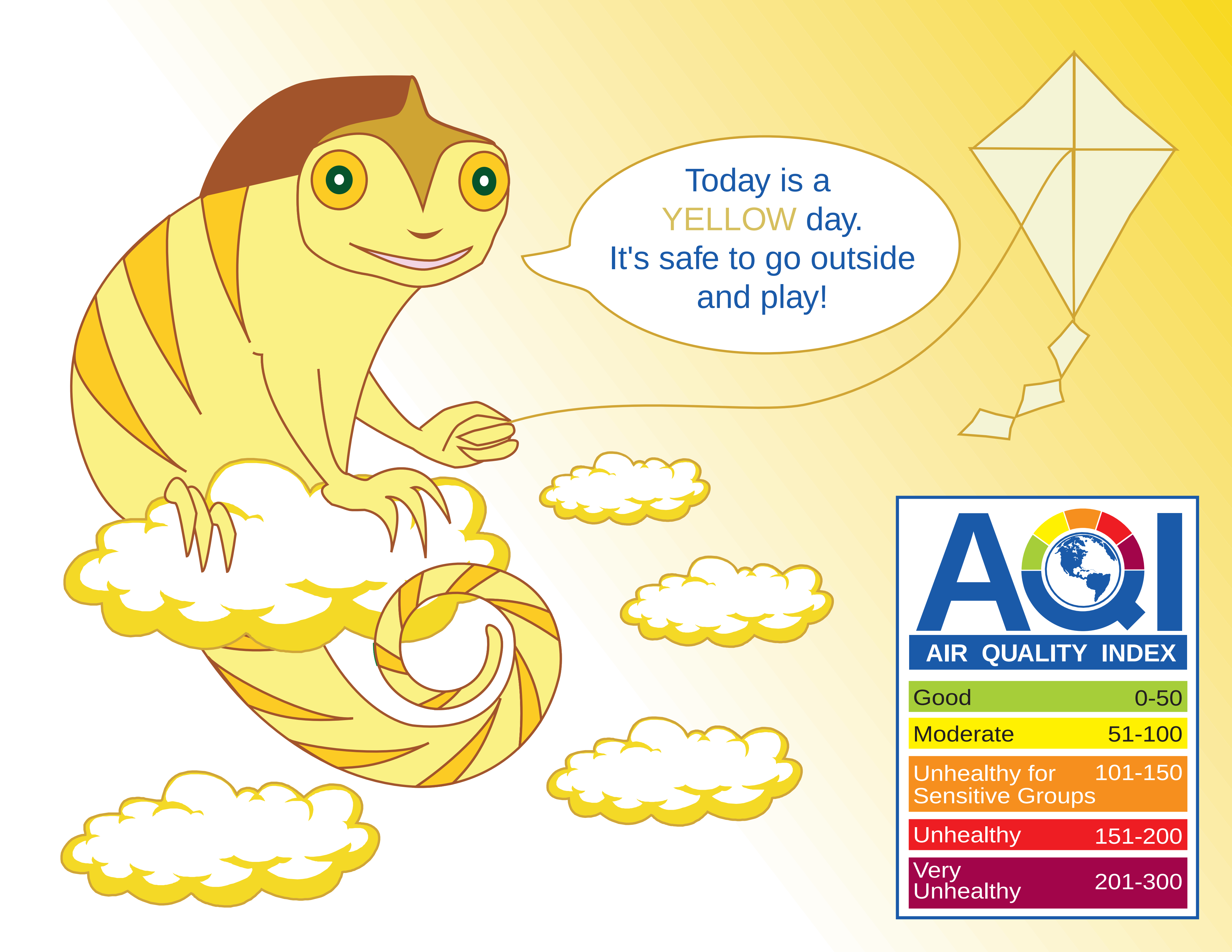
Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

AQI

AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300


Today is a Green day. It's safe to go outside and play!
AQI
AIR QUALITY INDEX
Good 0-50
Moderate 51-100
Unhealthy for Sensitive Groups 101-150
Unhealthy 151-200
Very Unhealthy 201-300


Today is a YELLOW day. It's safe to go outside and play!
AQI
AIR QUALITY INDEX
Good 0-50
Moderate 51-100
Unhealthy for Sensitive Groups 101-150
Unhealthy 151-200
Very Unhealthy 201-300

AQI
AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

AQI
AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

AQI
AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

AQI
AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

AQI
AIR QUALITY INDEX

Good	0-50
Moderate	51-100
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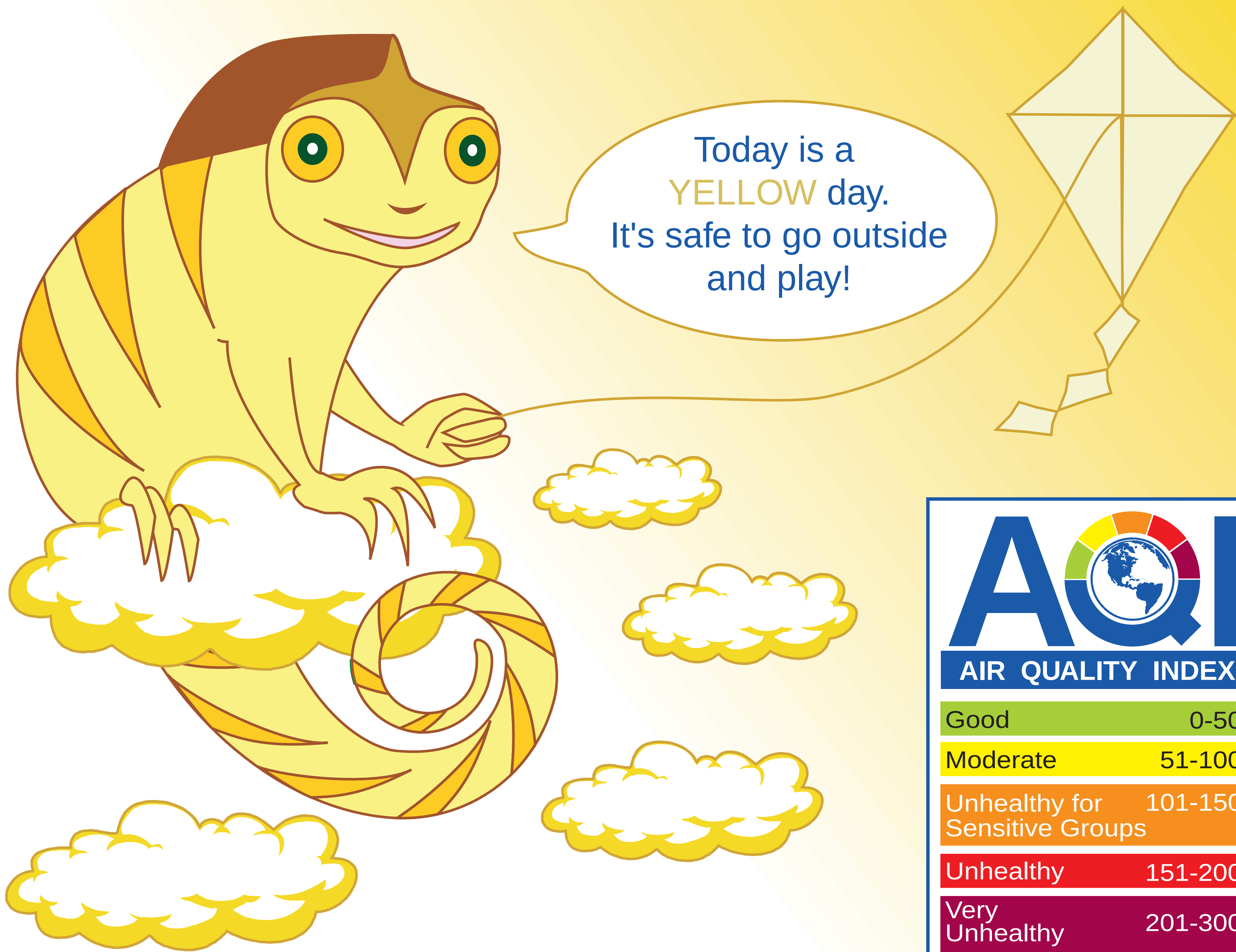
Unhealthy	151-200
Very Unhealthy	201-300



AQI

AIR QUALITY INDEX

Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very Unhealthy	201-300

Name:___________________
Date:___________________
Class:___________________

UV/7-2

SPOTLIGHT THE SUN DATA TABLE

Record the results of your thermometer temperatures in the chart below and answer the discussion questions below.

	5 min	10 min	20 min	25 min	30 min	35 min	40 min	45 min
Direct Light Thermometer								
Indirect Light Thermometer								

1 What was the difference in temperatures of the two lights on the thermometers?

____

2 How does this explain why it is warmer in the middle of the day than in the early morning?

____
____
____

3 Why is it colder in the Arctic Circle?where there is continuous light, then it is in the United states?

____
____
____

4 Discuss how the angle of light on the thermometer affected the temperature and compare this activity to the angle of sunlight directed on the Earth.

____
____
____
____
____

Name: _______________
Date: _______________
Class: _______________

UV/8-1
OZONE CHEMISTRY: FORMATION & DEPLETION

Notes:

Ozone is formed and destroyed naturally in the stratosphere by light waves which have a wavelength between 200-300 nanometers (approximately one billionth of a meter). This process absorbes a high percentage of UV-B and UV-C high energy light waves, keeping our levels of exposure to these rays safe for us and life in the troposphere.

The formation and use of chemicals called halogens has created an unbalanced reaction in the destruction of ozone. Chlorine is believed to have the most damaging effect on the balance of ozone in the stratosphere. As it continually breaks down the natural process of ozone, more and more UV-B and UV-C high energy light waves are reaching the troposphere causing long term damage to us and life in the troposphere.

1: Solar Formation of Ozone:

$$\mathbf{O_2} \xrightarrow{\text{light } <\mathbf{200nm}} 2\ \mathbf{O}$$

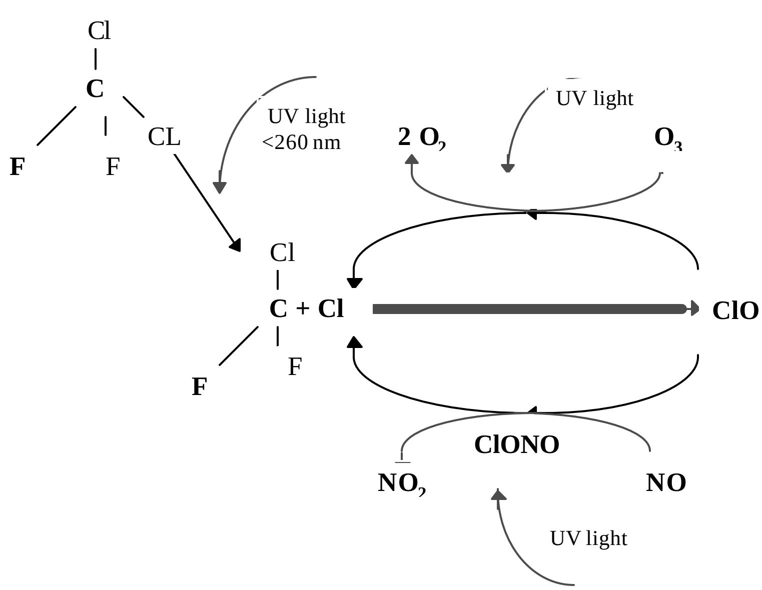
$$\mathbf{O + O_2} \longrightarrow \mathbf{O_3}$$

2: Solar Destruction of Ozone:

$$\mathbf{O_3} \xrightarrow{\text{light } \mathbf{200\text{-}300nm}} \mathbf{O_2 + O}$$

$$\mathbf{O + O_3} \longrightarrow 2\ \mathbf{O_2}$$

3: Halogen effects on Ozone destruction:



Name: _______________
Date: _______________
Class: _______________

UV/8-1

OZONE CHEMISTRY: FORMATION & DEPLETION

In this way one molecule of chlorine can destroy over 100,000 molecules of ozone before it is finally removed from the stratosphere. Eventually chlorine forms the compound HCl which is water soluable and attaches to precipitation falling to the ground as rain.

8 th Grade
Lesson Plan

UV: Chemistry of Ozone Depletion

LEARNING OBJECTIVE:

destruction of ozone and the effects it has on UV.

STUDENT PERFORMANCE OBJECTIVE:

- The student will define sunlight as the major energy source for both making and destroying stratospheric ozone.
- The student will be able to define VOCs as Volatile Organic Compounds and determine they are both man-made and natural formations.
- The student will be able to define Halogens as the chemical family containing fluorine, chlorine, bromine and iodine.
- The student will begin to understand that Halogens have the ability to catalyze ozone breakdown and they have an unequal impact on the ozone layer.
- The student will begin to understand that chlorine removal in the stratosphere involves the formation of HCl which is water soluble.
- The student will determine how CFCs get into the stratosphere when they are heavier than air.

BACKGROUND:

The Earth's atmosphere can be divided into several layers. The lowest layer, the troposphere, extends above the Earth about 10km. The next layer is the stratosphere which extends from 10km to approximately 50km. The mesosphere extends from approximately 50km to approximately 80km with the thermosphere directly above that.

The temperature increases with the altitude in the stratosphere due to the absorption of UV light by oxygen and ozone. As sunlight is the major energy source for both making and destroying stratospheric ozone it causes the constant exchange between ozone and oxygen. UV light such as UV-B and UV-C are the sun's high energy rays which we cannot see, but aid in keeping the balance of ozone in the atmosphere. Approximately 98% of these rays are absorbed by the formation and destruction of atmospheric ozone.

While ozone is mainly produced and destroyed in the stratosphere where it protects the earth from the harmful effects of UV rays, certain pollutants (both natural and man-made are causing ozone to be produced in the troposphere. Ozone in the troposphere causes the greenhouse properties that warm the Earth; surface. The concentration of ozone in the troposphere only remains for a short amount of hours. Therefore high levels of ozone in the troposphere are often found in cities where high levels of pollutants are found.

The student will begin to understand the formation and

UV: Chemistry of Ozone Depletion

Compounds). These compounds, primarily made of carbon and hydrogen often contain halogens such as chlorine, fluorine and/or bromine. They are defined as volatile because of their tendency to evaporate. Elements from the halogen family (listed above) all have the ability to catalyze the breakdown of ozone, however their impact is an unequal one. While the natural process of sunlight and ozone both forms and destroys ozone, the halogens only destroy ozone leaving what many scientist classify as a “hole” in the ozone layer.

CFCs (ChloroFluoroCarbons) are a class of VOCs that have been used as refrigerants, aerosol propellants, solvents, degreasers, cleaning solutions, dry cleaning fluids and components of pesticides and plastics. These chemicals have been considered safe to work with due to the fact that they are chemically unreactive. They are so unreactive or inert that the natural reagents that remove most atmospheric pollutants do not react with them. Therefore they tend to stay in the atmosphere and after many years they make their way into the upper atmosphere where the UV radiation from the sun breaks them down into their component molecules. This releases the potentially damaging chlorine (as well as bromine and fluorine) atoms which work to destroy ozone. Chlorine becomes the catalyst which reacts with ozone and breaks it down ($Cl + O_3 \text{--->} ClO + O_2$). One molecule of chlorine is estimated to degrade over 100,000 molecules of ozone before it is removed from the stratosphere.

In the stratosphere chlorine will eventually form into an inactive compound of hydrogen chloride (HCl) which is water soluable and will precipitate out of the stratosphere by water droplets.

See other lessons on UV and sun, the UV index, UV and ozone in our breathing space, UV and ozone depletion, UV monitoring, and benefits, dangers and choices of UV, the Earth’s tilt, seasons and UV.
<for more>

MATERIALS:

Demonstration Materials

?? Sucrose $C_{12}H_{22}O_{11}$ (60 grams)
?? Sulfuric acid, concentrated 18M, H_2SO_4 (60 mL)
?? Sodium carbonate, Na_2CO_3
?? 250 mL beaker
?? 100 mL graduated cylinder
?? tongs
?? balance
?? paper towels

These pollutants are often known as VOCs (Volatile Organic

8 th Grade
Lesson Plan

UV: Chemistry of Ozone Depletion

Activity Materials

- ?? Worksheet UV/8-1 Ozone Chemistry: Formation and Depletion
- ?? Litmus paper
- ?? Cups
- ?? Water from pond, puddle, and/or lake

SAFETY CONCERNS

Please follow safety precautions carefully. Do not allow students to perform demonstration.
Complete in a well ventilated area.
Wear safety goggles and safety apron.
Have students wear goggles also.
Use tongs to handle carbon product.
Do not touch Sulfuric acid with hands (Sulfuric acid is very corrosive to eyes, skin and other tissue).
Do not mix Sulfuric acid with water. (Carbon product will need to be completely neutralized with sodium carbonate before rinsing.)
Disposal:
When reaction is finished and the container is cool, pour sodium carbonate over the product to neutralize the acid.
Once neutralized, rinse the carbon product thoroughly under running water. Place in a sealed plastic bag and place in the trash.

OPENING:

Ask the Class:
How do you know when a chemical reaction takes place? Chemical reactions take place all the time in the atmosphere, but we cannot see them. How do we know they are taking place

Discuss with the Class:
We have often heard the reports of the ozone layer being depleted. This is caused by compounds being released when they reach the atmosphere. These specific compounds alter the natural formation and destruction of ozone in the atmosphere which protects us from UV rays from the sun. Today we are going to demonstrate how compounds get separated in a reaction. We will then test water samples and discuss how those chemicals (once neutralized) fall as rain into our water supplies.

- ?? Stirring rod, glass
- ?? Safety Goggles
- ?? Safety Apron

UV: Chemistry of Ozone Depletion

students in a well ventilated area.

2. Follow all safety precautions and demonstrate safety to the students.
3. Set up sodium carbonate and have ready to neutralize any acid spills
4. Measure 60 grams of sucrose and place in the 250mL beaker.
5. Set the beaker on paper towels.
6. Measure 60mL of sulfuric acid in a 100mL graduated cylinder (neutralize any spills with sodium carbonate)
7. Pour the sulfuric acid into the beaker containing the glucose very slowly.
8. Stir briefly with a glass stirring rod. Leave the rod inside the beaker during the activity to support the column of carbon.
9. Stand back and observe. Reaction will be complete in approximately 15 minutes.
10. Discuss with the students the reaction and that carbon and water are both products of the reaction. Discuss the chemical changes and the heat and gas produced in the reaction.

PROCEDURES:

1. Discuss that harmful VOCs are constantly being put in the atmosphere by chemical reactions. These reactions happen naturally on their own and unnaturally from factories, power plants and other human activities.
2. Define VOCs (Volatile Organic Compounds) as pollutants made primarily of carbon and hydrogen which contain halogens such as chlorine fluorine and/or bromine.
3. Define CFCs (ChloroFluoroCarbons) as a class of VOCs that have been used as refrigerants, aerosol propellants, solvents, degreasers, cleaning solutions, dry-cleaning fluids and components of pesticides and plastics.
4. Distribute worksheet UV/8-1 Ozone Chemistry: Formation and Depletion. Discuss the natural formation and depletion of ozone in the stratosphere. Go over the diagrams and discuss the effects of halogens on ozone destruction.
5. Discuss chlorine as a halogen that upsets the natural formation and destruction of ozone. Discuss one molecule of chlorine can destroy over 100,000 molecules of ozone before it is finally removed from the stratosphere.
6. Explain that chlorine eventually becomes inactive in the stratosphere when it forms the molecule HCl which is water soluble and falls to the earth as rain.

Demonstrate to the Class:

1. Set up your materials on a table in view of your

8 th Grade
Lesson Plan

UV: Chemistry of Ozone Depletion

7. Explain to the students that while we do not have the technology in the classroom to test the formation and destruction of ozone in the stratosphere, we do have the technology to test the water for evidence of chlorine from the inactive compound HCl.
8. Have the students get samples of the water (puddle, pond and/or lake) and litmus paper and take to their lab stations.
9. Students will use the paper to test the water's PH to determine if there is chlorine present in the water.
10. If you have access to several different samples of water, have the students test each sample to compare and discuss their results.
11. Discuss how chlorine becomes soluable in water once it has formed the compound HCl and determine how this activity proves the presence of chlorine in the stratosphere.
12.
13.

SO WHAT? LIFE APPLICATIONS:

Have the students explain their part in releasing these VOCs and CFCs in the environment (use of products that release VOCs or purchase of products that release VOCs during production). Have them come up with a plan of how they can help prevent the release of these chemicals and write a letter to a company explaining their concern relating to this process.

CURRICULUM EXTENSIONS:

Math/Science:
Have the students test the samples of water over a period of time (hopefully before and after rainfall) and chart and graph their results.

Language Arts:
Have the students create a model or a skit demonstrating the effects of halogens on the natural formation and destruction of ozone in the stratosphere.

Have the students write a letter to their congressman asking for stronger laws to prevent the release of VOCs into the stratosphere.

Technology:
Use the spreadsheet program to create a chart and graph of their results from the Math/Science activity.

UV: Chemistry of Ozone Depletion

relationship between VOCs that release chlorine and the depletion of the ozone in the stratosphere.

Have the students look up the Ecoplex website to determine the ozone alert status and find out more about ozone.

TEKS: 8.9A,C

Denton ISD SPO:

RESOURCES:

Ecoplex web site
http://www.nas.nasa.gov/Services/Education/Resources/TeacherWork/Ozone/Ozone_chem.html
http://www.atm.ch.cam.ac.uk/tour/part2
http://www.egs.uct.ac.za/csag/faq/ozone-depletion/intro/faq-doc-8.html
http:home.larc.nasa.gov/org/pao/PAIS/Aerosols.html
http://www.epa.ohio.gov/ddagw/voc.html

Have the students use the inspirations program on the computer to create a concept map explaining the

5TH Grade
UV Lesson

UV: CHECK IT OUT!

LEARNING OBJECTIVES

Identify health dangers due to UV-A and UV-B. Learn to use and read a UV meter.

STUDENT PERFORMANCE OBJECTIVE

- The student will identify some dangers of UV.
- The student will identify some types of protection from UV.
- The student will learn to use a UV meter.
- The student will learn to use the UV area on the ECOPLEX web site.

BACKGROUND

Because of ozone depletion, more UV-A and UV-B rays are passing into the troposphere (our breathing space). UV-A causes skin aging, wrinkles and damage to outdoor plastics and paints. UV-B is known to cause skin cancer and cataracts. It also reduces growth of plants and may affect the health of wildlife. The UV Index on the ECOPLEX site allows students to check the UV ratings and determine what precautions should be taken to protect themselves from UV rays. The Index is a scale from 0-2 (minimal), 3 to 4 (low), 5 to 6 (moderate) 7 to 9 (high) and 10+ (very high). Protective measures include wearing a hat, sunglasses, sunscreen, lip balm with sunscreen, or choosing to stay indoors between 10:00 a.m. and 4:00 p.m. on very high UV Index days.

See other lessons on the following subjects: UV and sun, UV Index, UV and ozone, UV and ozone in our breathing space, what depletes ozone.
<for more>

MATERIALS

- Sun pretest
- UV meter
- Internet access
- Construction paper
- Markers

OPENING

Ask the students to complete the sun survey at http://www.biorap.org/tg/tgsun2surv.html.

PROCEDURE

1. Discuss the dangers of our over exposure to UV rays.

2. Discuss the student survey answers. After the discussion, ask students if they see a behavior in the survey that they need to change.

5. Demonstrate how to use a UV meter. Have students determine the UV ratings throughout the day.

6. Create a comparison between the UV meter and the Ecoplex UV data. Compare for an extended period of time (for instance one week per month for the school year). Create a graph of the results. Ask the students to determine if there is any pattern to the data.

7. Create a brochure that makes your friends and family aware of UV rays and explains where to find the UV rating and how to use the UV rating.

SO WHAT? (LIFE APPLICATION)

By becoming aware and understanding the UV data, students are empowered to make appropriate choices concerning protection of UV rays.

CURRICULUM EXTENSIONS

Art and Writing
Create a UV superhero comic strip.

Math
Find the average UV rating for each season or month at noon.

TEKS: 5.1.A, 5.2.B,C,D, 5.3.A, 5.4.A, 5.5.B, 5.8.A

Denton ISD SPO: S1.2, S3.3

RESOURCES

http://www.nsc.org/EHC/sunwise/UV.htm
http://www.napenet.org/uvfacts.html
http://www.ecoplex.unt.edu

3. Ask students to generate possible ways to protect themselves from UV rays.

4. Show students the UV Index site on Ecoplex.

FIRST GRADE
UV

CATCHING AND COUNTING UV RAYS!

LEARNING OBJECTIVE

Using archived UV Index data, the students will find patterns and discover that Ultraviolet (UV) measurements are affected by time of day and seasons. The students will apply these patterns to personal choices and attitudes about sun safety.

STUDENT PERFORMANCE OBJECTIVES

* The student will understand that exposure to UV radiation can be dangerous.
* The student will use the UV Index to create graphs necessary to observe patterns in UV readings.
* The student will draw conclusions about personal choices for sun safety

BACKGROUND

Energy from the sun sustains all life on earth. However, the sun's ultraviolet rays can be harmful to plant growth and to human life, causing sunburns, skin cancer, and eye damage. We can't see UVrays. Fortunately, there are ways to protect ourselves from overexposure to UV rays. The amount of UV rays which reach the earth depend on:

The time of day: UV is greatest at midday (when the sun is highest in the sky), and less in the early morning and late afternoon.

The season: UV is greatest in the summer (May to August), less in spring and fall, and least in the winter.

Cloud cover: A thick, heavy layer of clouds blocks some UV. Puffy, fair weather clouds or layers of thin, light clouds let most of it through. The darker the clouds, the less the UV. Be careful under thin clouds--the sun's rays don't feel as hot, but they can still burn!

The type of surface you are on: You get much more UV on snow, since the white surface reflects the sun's rays back onto your skin just like a mirror Fresh snow reflects the greatest amount of UV while other bright surfaces, such as dry sand and concrete, reflect less.

Your elevation: You get more UV on a mountain (the air is cleaner and thinner) than at lower elevations.

Where you are on the earth's surface: UV is strongest at the equator and gets weaker as you go towards the earth's poles. The poles receive the least UV.

How long you are in the sun: The longer you are

out in the sun, the more UV you will receive.
What you're wearing: Summer clothes often expose more skin to UV. Don't confuse temperature and UV. Light clouds or a breeze, can make you feel cooler, but they don't reduce the UV!

The UV Index is a daily forecast of the UV radiation levels people might experience, and is based on a scale of 0-10+. People use the UV Index data to make responsible decisions about outdoor activities and sun protection behaviors.

How to Read The UV Index:

0-2 Minimal--Minimal danger from the sun's UV rays for the average person. Most people can stay in the sun for up to one hour during the hours of peak sun strength, 10 a.m. to 4 p.m., without burning. People with very sensitive skin and infants should always be protected from prolonged sun exposure.
3-4 Low--Low risk of harm from unprotected sun exposure. Fair-skinned people, however, might burn in less than 20 minutes.
5-6 Moderate--Moderate risk of harm from unprotected sun exposure. Fair-skinned people might burn in less than 15 minutes. Apply a sunscreen with a Sun Protection Factor (SPF) of at least 15. Wear a wide brimmed hat and UV absorbing sunglasses to protect your eyes.
7-9 High--High risk of harm from unprotected sun exposure. Fair-skinned people might burn in less that 10 minutes. Minimize sun exposure during midday hours, from 10 a.m. to 4 p.m. Protect yourself by liberally applying a sunscreen with a SPF of at least 15. Wear protective clothing and sunglasses. When outside, seek the shade.
10+ Very High--Very high risk of harm from unprotected sun exposure. Fair-skinned people might burn in less than 5 minutes. Avoid being in the sun as much as possible. Wear protective sunglasses and apply sunscreen of at least SPF 15 liberally every 2 hours. Wear a cap or hat with a wide brim.
If possible, stay indoors when the UV Index is very high.
See the lesson on UV and Sun.
<for more>

MATERIALS

*Graph paper with 12 columns on the horizontal axis and 12 rows on the vertical axis [**UV/1-1**]
*www.ecoplex.unt.edu
*Samples of sun protectors: sunscreen (SPF 15 or above), UV absorbing sunglasses, wide brimmed hat

OPENING

Ask the class:
Why is the sun important to us? (record ideas) Are there any times when the sun is not good for us? (record ideas) Lead the discussion to suntans, sunburns, skin cancer and eye damage (cataracts) from overexposure to the sun.
TIP: See the UV and Sun lesson background information and activities if you feel you or your class need more

information before proceeding with this lesson.

PROCEDURE

1. Show students samples of sun protectors that the teacher has provided. Lead an active discussion of each sample and ask if the students have ever used them. Ask for other ideas on protection from UV rays. Ask for ideas on nature's protection: shade, trees, clouds, the ozone layer around the earth.

2. Identify the dangers of overexposure to UV radiation (see UV and Sun if your students are not ready to proceed.). Provide information from the Background section. Explain the UV Index. Explain that the students will be using the archived data from the ECOPLEX web site to develop graphs of the UV readings for the second Monday of each month (any date can be chosen) at 8:30 a.m., 11:30 a.m., 2:30 p.m., and 5:30 p.m. Demonstrate how to retrieve the data and record the numbers on the graphs. This could be managed in several ways: the class could be divided into teams -one team does one time, the class could work in partners-one partner retrieving the data while the other partner graphs it, the teacher may choose to work with half the class at a time to retrieve data while the rest of the class is engaged in other work. [See worksheet UV/1-1]

3. When the data are graphed, ask the children to present their data to the rest of the class. Lead a discussion that allows the children to see the patterns in the UV data. The students should conclude that the time of day and season are two factors that affect the UV readings.

4. Use the ECOPLEX page to gather information necessary to record safety practices and precautions for the Minimal, Low, Moderate, High, and Very High readings. The teacher can record these and the students could illustrate precautions for each reading.

SO WHAT?
(LIFE APPLICATIONS)

Ask the children to develop a "Personal Sun Safety Plan" for themselves based on the UV information gathered. This can be accomplished as a class or as individuals. Display graphs and conclusions in the school to inform others of the UV information learned.

CURRICULUM
EXTENSIONS

MATH/SCIENCE

As part of the daily calendar activities, record the day's weather as sunny, cloudy, windy, or rainy. Take this data over a period of time and compare it to the UV Index at the same time of day that the weather is recorded. Watch for patterns of how weather is an additional factor that affects the UV Index. Graph these data over a period of time. **GLOBE** schools can look at cloud cover and cloud type data for comparison to UV Index and discover another factor which affects the UV Index.

LANGUAGE ARTS
Have students develop a poster with information learned about the UV Index. Display it in a prominent place at school to inform others about the UV Index. Allow your students to present the poster and information to other classes.

GEOGRAPHY
Log on to the web site:
http://www.l.tor.ec.gc.ca/cd/uv_e.cfm
to find the UV Index from around the world. Lead the children to notice that location is also a factor affecting the UV readings. The closer to the equator-- the higher the reading.

ART
Children collect magazine pictures of items and locations (ex: shade) needed for their "Personal Sun Safety Plan" and create a collage display.

SOCIAL STUDIES
Discuss hats and why people wear them (careers, fashion, sun protection). Investigate "Hats Around the World" discovering how people who live in high UV areas use hats and head covering as part of their daily clothing. Designate one day for children to bring hats that provide sun protection. Allow children to "show and tell" about each hat. Perhaps you could stage a hat parade for the school!

TEKS
Science: 1.1A, 1.2.A,B,C,D,E, 1. 3.A,B,C, 1.4.B.

RESOURCES

FAQs
Sun Up, Sun Down by Gail Gibbons
The Sun by Simon Seymour

4th Grade
UV Lesson

WHAT DEPLETES OUR OZONE? ME AND MY ZONE!

LEARNING OBJECTIVE

Identify what depletes ozone.

STUDENT PERFORMANCE OBJECTIVE

- The student will understand that ozone in the stratosphere blocks most UV rays.
- The student will identify some of the items that deplete ozone in the stratosphere.

BACKGROUND

Ozone in the stratosphere is a necessary protective layer for the Earth. Ozone at this level blocks most of UV-A and UV- B. It blocks all of UV-C. The UV-B that does enter the troposphere (our breathing space) acts on the chlorofluorocarbons (CFCs) and volatile organic compounds (VOCs) to release atomic chlorine. Common CFCs include refrigerants and solvents. One chlorine atom can destroy 100,000 ozone molecules. Chlorine atoms are also produced naturally by some marine life, fires, and electric discharges like lightning. However, CFCs produce 85% of the chlorine in the atmosphere. This depletes ozone in the stratosphere faster than it is created. Therefore, more UV-B and UV-A enter our atmosphere.

See other lessons on the following subjects: UV and sun, UV Index, UV and ozone, UV and ozone in our breathing space.
<for more>

MATERIALS

- Magazines
- Internet
- Poster board

OPENING

Class Lecture
Explain the process for ozone depletion without naming specific CFCs or VOCs.

PROCEDURES

1. Play Ozone Depletion Tag. See instructions provided.

2. Students begin a discovery lesson. Provide magazines for students to cut out pictures of things that they believe cause ozone depletion.

3. Take students to a computer lab with internet access. Using environmental web sites (some are mentioned under resources

students will discover if their pictures are examples of ozone depleting products or events.

4. Based on research from the internet, students must support their picture choices.

5. Create a class collage of those pictures that are ozone depleting.

6. Each student will write a letter to a senator expressing concern about the ozone layer and offering suggestions on ways to protect the environment.

OZONE DEPLETION TAG

1. One student should be assigned the role of the chlorine atom that has been released from a CFC. The chlorine representative should wear an armband or label.

2. The rest of the class members will become oxygen atoms. Students will number off in sets of four. The first three will link arms. They will represent O_3 (ozone). The fours will become free oxygen atoms.

3. Give the start signal and begin timing. “Chlorine” will try to tag the O_3 molecules. The O_3 must remain linked, but try to avoid the chlorine.

4. If chlorine tags an O_3 member, that member must join chlorine. The untagged oxygen molecules now link both arms (this represents a double bond). Free O will not link with O_2 because it takes a great deal of energy to form a bond.

5. The chlorine atom must stay linked to O until chlorine is close to another O_3. When this occurs, chlorine releases the O it has and breaks the O_3 bond, collecting a new O and creating another O_2.

6. The game continues until there is no longer any O_3. At this point, stop timing.

7. The game should be played again and timed using two chlorines and finally three chlorines.

8. Students should notice that it requires less time to deplete O_3 when more chlorine is present.

4th Grade
UV Lesson

SO WHAT? (LIFE APPLICATION)

After researching types of CFCs, ask the students to brainstorm all of the CFCs they may have released as they prepared and left for school. Ask them to think of 2 or more things they could have done differently to change to lessen the CFCs they released.

CURRICULUM EXTENSIONS

Science
Using marshmallows or clay and toothpicks, demonstrate the chemical reactions in the depletion process.

Writing
Create a list of what you could do today to stop ozone depletion.

Math
Graph the game results.

Art
Create a logo for products that are shown to be safe for the atmosphere.

TEKS: 4.2.B,C,D, 4.3.D, 4.4.A, 4.5.A,B, 4.6.A, 4.11.C

Denton ISD SPO: S3.2, S3.5, S7.5

RESOURCES

http://www.mb.ec.gc.ca/ENGLISH/AIR/HLWS/menu.html
http://www.encyclopedia.com
http://whyfiles.news.wisc.edu
http://www.epa.gov/ozone/science
http://www.ecoplex.unt.edu

4th Grade
UV Lesson

WHAT DEPLETES OUR OZONE? ME AND MY ZONE!

KINDERGARTEN
UV

UV AND ME!

LEARNING OBJECTIVE

The student will learn that the sun is essential for life on Earth and has rays that we cannot see called ultraviolet (UV) rays. Too much UV exposure is dangerous, but there are simple ways for people to protect themselves from overexposure to harmful UV rays.

STUDENT PERFORMANCE OBJECTIVES

* The student will understand the sun is essential for life.

* The student will identify benefits of the sun.

* The student will identify harmful effects of the sun.

* The student will understand that UV rays cannot be seen, but can be measured.

* The student will identify practices, choices and products that protect him/her from overexposure to UV rays

BACKGROUND

All life on Earth--human, animal and plant--depends on the sun. The sun gives us light, heat, and ultraviolet (UV) rays. UV rays--not the warmth or brightness of the sun--cause changes in skin color and other materials. UV rays also can damage eyes and are the major cause of cataracts. Children are at high risk for overexposure to UV radiation due to thinner skin. Also, children spend three times more time outdoors than adults. Skin cancer and other UV related health problems are largely preventable if sun protection practices are followed. To be protected from UV rays, a sunscreen of at least Skin Protection Factor (SPF) 15 or sunblock should always be used. Sunscreens should be applied 20 minutes before exposure and reapplied at least every two hours while in the sun. Eye protection from sunlight can be obtained by using a brimmed hat or cap and by wearing UV absorbing eyewear.
<for more>

MATERIALS

* Chart paper
* UV Beads
* Sun protectors: sunscreen (SPF15), UV absorbing sunglasses, wide brimmed hats
* Recording sheet [**UV/K-1**]
* Crayons to match the UV beads as they change colors
* A pair of glasses -not UV protected
*Various materials to use when testing UV beads (see #6

KINDERGARTEN
UV

in Procedure section)
*www.ecoplex.unt.edu

OPENING

Ask the students:
What do you know about the sun?

PROCEDURE

1. After the children name things they know about the sun, ask them to think about helpful and harmful effects of the sun. Record their comments on chart paper. It may look like this:

Helpful	**Harmful**

Helpful: light, heat, warmth, helps plants grow, feels good, etc.
Harmful: sunburns, suntans, too hot while playing, hurts eyes, makes playground equipment hot, etc.
Ask what would happen if we didn't have the sun.
Conclude that we must have the sun to live on earth.

2. Ask if any of the students have ever worn sunscreen. Ask if they know why they wear sunscreen. Discuss with the students that the sun has ultraviolet rays that cause our skin to turn colors and can hurt our eyes. Both of these are dangerous. Although we cannot see UV rays, they can be measured. We use the measurements to know when to protect ourselves from too much sun.

3. Show the students the UV beads. Explain that the UV beads are sensitive to UV light rays and get darker when UV rays get stronger. Tell the students that they will go outside and around the school to see how the beads change colors--discovering where the UV rays are strongest/most dangerous. Ask the class for ideas for where to "test" the beads. Some suggestions: playground where children have recess (sunny and shady areas), PE areas, inside the classroom, by windows, in rooms without windows.

4. As the children go from location to location, have them record (using **UV/K-1**) the changes, if any, in the UV beads. Be sure to try this ahead of time so that the crayons are the correct colors for the UV beads your class is using.

5. After returning to the classroom, help the students summarize their UV bead findings. These should include statements about sun vs. shade and indoor vs. outdoor areas. Summarize their findings on chart paper. Tell the students that *tomorrow* you will take them to the same places and they should bring something from home that they think might protect the beads (as well as themselves) from UV rays.

6. On the following day, allow the students who brought things from home to show them and explain why they think their object will protect the UV beads. Be sure to have ready your supply of UV protectors: sunscreen, hat, sunglasses (both UV and non UV absorbing), different types of clothing (material-tight and loose weave), a pair of clear non-tinted glasses (to apply sunscreen to one lens and not to the other), wax paper, foil, plastic bag, newspaper, colored paper, white paper and anything else you can think of that would be fun to test!

7. Revisit the same locations around the school as yesterday. Use record sheets to record the UV bead changes with the various materials acting as a UV screen.

8. On chart paper list the objects which did/did not provide protection for the UV beads.

9. Give each child a UV bead and a record sheet to take home. Ask each student to test the bead in at least one place at home (brainstorm places that would be good choices-don't forget cars) and to return the record sheet and bead tomorrow. Discuss findings.

10. Repeat this lesson on an overcast day! Ask the students if they think UV rays are dangerous on such a cloudy day.

SO WHAT?
(LIFE APPLICATION)

Help the students draw conclusions about sun safety habits based on the UV bead experiments. The students will realize that using UV protection is a daily health habit, like brushing teeth. Discuss safe ways to apply sunscreen--using precaution with eyes!!

CURRICULUM EXTENSIONS

ART
Create sunglasses in art center. Provide a frame pattern, cellophane, and scraps for decoration. Let the children wear their glasses outside. Rub glue on one lens to simulate vision impaired by cataracts (caused by UV overexposure).

Draw a picture of yourself playing on a sunny day wearing proper UV protection.

LANGUAGE ARTS
Dictate or write all the ways the child in the above picture is “Sun Smart”.

MATH
Use the UV Index on the ECOPLEX web site to graph the

KINDERGARTEN
UV

daily UV reading at your class's recess time and outdoor PE class time. Follow these readings for the year!

SCIENCE

Teach students the shadow rule as a simple way to be "Sun Smart". If your shadow is taller than you, UV exposure is usually low. If your shadow is shorter than you, the UV exposure is usually high. Ask if they can draw any conclusions about the safest times to play outside based on the shadow rule. Check conclusions using the UV Index data on Ecoplex.

Set up a classroom experiment using colored paper with a die-cut design over part of it. Leave it in a sunny spot or windowsill and ask children what they think will happen. Check the paper each day and record changes over a period of time.

SOCIAL STUDIES

Have the students talk to friends and family about what they have learned about sun safety.

TEKS

Science: K.1.A, K.2.A,B,C,D,E, K.3.A,B,C, K.9.A,C,

RESOURCES

FAQs

Sun Up, Sun Down by Gail Gibbons
The Sun by Seymour Simon

SECOND GRADE
UV

THE AIR OUT THERE--UV AND OZONE

LEARNING OBJECTIVE

The student will learn the differences between stratospheric and tropospheric ozone, and that depletion of stratospheric ozone affects the amount of ultraviolet radiation that reaches the earth.

STUDENT PERFORMANCE OBJECTIVES

* The student will identify the layers of the atmosphere.

* The student will understand the differences between stratospheric and tropospheric ozone.

* The student will understand how stratospheric ozone depletion affects the amount of UV radiation which reaches the earth.

* The student will use ECOBADGE™ badges to measure ozone in their "breathing space".

* The student will use the UV index to make choices about safety in the sun.

BACKGROUND

The Earth's atmosphere can be divided into several layers. The lowest layer, the troposphere, extends above the Earth about 10 km (about 6 miles). Virtually all human activities occur in the troposphere. Mt. Everest, the tallest mountain on the planet, is only 9 km high. Most clouds occur in the troposphere.

The next layer, the stratosphere, continues from 10 km to approximately 50 km (about 30 miles). Most commercial airline traffic occurs in the lower stratosphere. Research balloons gather data in the stratosphere. The ozone layer surrounding the Earth is located in the stratosphere from approximately 19 km - 48 km (12 to 30 miles) above the earth's surface.

The mesosphere is from approximately 50 - 80 km (30 - 50 miles) above the Earth and the thermosphere follows from 80 km and extends on into space.

The ozone layer in the stratosphere is our natural shield against ultraviolet radiation (UV) from the sun. Ninety percent of all ozone is in the stratosphere. Ozone is a molecule containing three oxygen atoms (O_3). It is blue and has a strong odor. If you've ever noticed the sharp "clean" smell after a lightning storm, you've smelled ozone. Oxygen which we breathe has two oxygen atoms (O_2) and is colorless and odorless. Ozone is much less common than oxygen we breathe. Out of each 10 million air molecules, about 2 million are oxygen we breathe (O_2), but only three are ozone (O_3). If we brought all the ozone down to earth it would only be as deep as the thickness of three dimes.

This small amount of ozone plays a key role in the atmosphere by absorbing dangerous UV rays which have been linked to harmful effects including various types of skin cancer, cataracts, and harm to some crops, certain materials, and some forms of marine life. Ozone in the stratosphere is continually created and destroyed in a natural cycle that continually creates our shield against UV rays. The problem is that human actions have tipped the balance toward too much ozone destruction resulting in an increase of UV rays reaching the surface of the Earth. In nature, there is not enough ozone in the ozone layer to intercept all the sun's UV rays. The thinner the ozone layer becomes, the more UV rays will pass through and reach the Earth.

In the early 1970s, researchers began to investigate the effects of various chemicals on the ozone layer, particularly CFCs, which contain chlorine. They also examined the potential impacts of other chlorine sources. Chlorine from swimming pools, industrial plants, volcanoes, and sea salt does not reach the stratosphere. Chlorine compounds from these sources rapidly combine with water and repeated measurements show that they rain out of the troposphere very quickly. In contrast, CFCs are very stable and do not dissolve in rain. Thus, there are no natural processes that remove the CFCs from the lower atmosphere. Over time, winds drive the CFCs into the stratosphere.

The CFCs are so stable that only exposure to strong UV radiation breaks them down. When that happens, the CFC molecule releases atomic chlorine. One chlorine atom can destroy over 100,000 ozone molecules. The net effect is to destroy ozone faster that it is naturally created.

Large fires and certain types of marine life produce one stable form of chlorine that does reach the stratosphere. However, numerous experiments have shown the CFCs and other widely-used chemicals produce roughly 85% of the chlorine in the stratosphere, while natural sources contribute only 15%.

The initial concern about the ozone layer in the 1970s led to a ban on the use of CFCs as aerosol propellants in several countries, including the US However, production of CFCs and other ozone-depleting substances grew rapidly afterward as new uses were discovered.

Through the 1980s, other uses expanded and the world's nations became increasingly concerned that these chemicals would further harm the ozone layer. In 1985, The Vienna Convention was adopted to formalize international cooperation on this issue. Additional efforts resulted in the signing of the Montreal Protocol in 1987. The original protocol would have reduced the production of CFCs by half by 1998.

Because of measures taken under the Protocol, emissions of ozone-depleting substances are already falling. Assuming continued compliance, stratospheric chlorine levels will peak in a few years and then slowly return to normal. The good news is that the natural ozone production process will heal the ozone layer in about 50 years.

For each 1% drop in ozone levels, scientists estimate about 1% more harmful UV-B will reach the earth's surface. Increased intensities of ground-level ultraviolet radiation caused by stratospheric ozone depletion would have significant adverse consequences. One major effect would be on plants, including crops for food. The destruction of microscopic plants that are the basis of the ocean's food chain could severely reduce the productivity of the world's seas. Human exposure would result in an increased incidence of cataracts. The effect of most concern is the elevated occurrence of skin cancer in individuals exposed to UV radiation.

Ironically, ozone, which serves an essential protective function in the stratosphere, is the major culprit in the tropospheric pollution (smog). The major source of ozone in our "breathing space", tropospheric ozone, is the automobile. Ozone in our breathing space is responsible for most of the respiratory system distress and eye irritation characteristic of human exposure to smog. Ozone in the troposphere is now monitored and Ozone Alert Days are announced for use by the general public to make choices about outdoor activities. See the lessons on the UV and Sun and the UV Index.
<for more>

MATERIALS

*Visual of the layers of the earth's atmosphere
*ECOBADGE™ badges (to detect ozone)
*www.ecoplex.unt.edu
*Materials to make UV flags (see Procedure #6)

OPENING

Ask the class:
What is ozone? Is ozone helpful or harmful? Record all the ideas the class has about ozone and refer to this chart throughout the lesson as knowledge is gained to prove or disprove ideas.

PROCEDURES

1. After listing the students' ideas about ozone, show a picture of the layers of the Earth's atmosphere. This could also be made into a model by creating circles of various sizes representing the Earth and each layer of atmosphere. (For example: If the Earth model is a circle with a diameter of 8 inches, the troposphere would have

a diameter of 8 1/2 inches, stratosphere 10 1/2 inches, mesosphere 15+ inches-extending on into space. Color the ozone layer, about 1/8 inch at the top of the stratosphere, blue.) Discuss each layer and the activities that take place there. Discuss the importance of the ozone layer in protecting Earth from too much UV radiation.

2. Discuss with the students stratospheric ozone depletion and what causes it. Check frequently for their knowledge and correct any misconceptions. The background section contains information needed for this discussion. When students understand the concept of stratospheric ozone and its depletion, continue. Note: It is important for the students to know that under current conditions, the natural ozone process will heal in about 50 years. They must be vigilant during their lifetime to insure that precautions are continued

3. Ask the class if they have heard of "Ozone Alert Days"? Ask: Is ozone bad for us? Have the students generate a chart listing the differences between stratospheric ozone and "breathing space" ozone (tropospheric ozone). Make certain they understand the differences and dangers associated with each type of ozone.

4. Distribute an ECOBADGE™ to each student to be worn for a specified period of time (depending on the type of badge you have). Show and explain the color reading scale. Have the students record what they think their reading will be. At a later time, after taking a reading on the badges, have the class brainstorm what can be done in their lives to cut down on tropospheric ozone (most common is to cut down on automobile use, invent alternatives to the internal combustion engine, become knowledgeable on air pollution laws and vote to keep strict regulations on air quality, more mass transit, fight the political action committees who encourage lawmakers to weaken air quality controls).

5. Since the depletion of stratospheric ozone results in increased risk of UV exposure on Earth, the students will now find ways to use information to help them make choices about UV exposure. Have the students access the UV Index and archived UV data on the Ecoplex web site. Ask the students to discover when the UV readings indicate the most danger to humans. Find today's UV readings. Was there a time today when the UV Index indicated protection was needed? If so, when? Lead the students to discover the most dangerous times of the day and the year. Continue the discussion about types of outdoor activities and the times of the day to safely participate in them.

6. The students will design UV Index Flags to be displayed

at the school when the UV reading indicates caution and protection are needed. This could be a contest, if you choose, with judges from around the school to increase awareness. A variety of materials could be used depending on the enthusiasm level of the class.

7. Send teams of students to other classes/grade levels to show their flags and to discuss the dangers of too much UV exposure and the protection practices to prevent overexposure. Also, they will explain that a UV Flag will be placed around the school and on playground and PE areas when the UV Index is high and precautions should be taken. If you need more information on precautions, see the lesson on the UV Index.

<for more>

SO WHAT?
(LIFE APPLICATIONS)

Ask the students to develop a plan for their personal reduction of exposure to UV rays and to develop goals for how they can reduce the formation of smog and ozone in our "breathing space". Ask each student to use his/her own UV Flag to alert family and friends to the dangers of UV exposure and to "pass the word" about ozone depletion and ozone in our breathing space.

CURRICULUM EXTENSIONS

SCIENCE

Ask each student (or student team) to develop a model of the earth's atmosphere, including the stratospheric ozone layer.

Assign children different animals and compare how the animals are "sun safe" thanks to body design or habitat. (Interesting animals include: desert animals, camels, turtles, zoo animals/zoo design, and jungle animals.)

MATH

Use the UV Shadow Rule and compare it to UV Index reading. The shadow rule: If your shadow is taller than you, UV exposure is usually low. If your shadow is shorter than you, UV exposure is usually high. Have the students record shadow lengths at different times of the day for several days (be sure to include sunny and cloudy days). Then compare the UV Index data to the shadow lengths to prove or disprove the shadow rule.

LANGUAGE ARTS

Use the information learned to create a brochure or newsletter informing others of ozone depletion, tropospheric ozone, using the UV Index, or UV exposure dangers (or any other related topics that the students show interest and enthusiasm for).

SOCIAL STUDIES/LANGUAGE ARTS

Draw a map of the school's outdoor play areas--be sure to include trees and other shady places. Use the map to explain the "sun safe" areas to play at different times of the day. Do the same with a favorite city park or one's own home and yard.

TEKS
Science: 2.1A, 2.2A,B,C,D,E,F, 2.3 A,B,C, 2.4A,B, 2.6D

RESOURCES FAQs
Sun Up, Sun Down by Gail Gibbons
The Sun by Seymour Simon

Name:____________________
Date:____________________
Class:____________________

UV/7-1

DISTRIBUTION OF THE SUN'S RAYS

Record your Estimations and Data in the spaces below. Answer the discussion questions that follow.

Direct and Indirect Solar Energy around the world:

1 Tape a piece of graph paper to the globe.

2 Hold a flashlight 15 cm from the surface of your desk parallel to the globe. Estimate how many squares will be completely filled with light when the flashlight is turned on:____________________.

3 Turn on the flashlight and draw a circle on the graph paper indicating how many squares are completely filled with light. Count and record your results: _________

4 Angle the flashlight approximately 24 degrees and estimate how many squares will be completely filled with light when the flashlight is turned on: ________________

5 Turn on the flashlight and draw a circle on the graph paper indicating how many squares are completely filled with light. Cound and record your results: __________

6 Compare the difference between the two activities and write your observations below:

____

____

___

Name:___________________
Date:___________________
Class:___________________

UV/7-1

DISTRIBUTION OF THE SUN'S RAYS

Record your Estimations and Data in the spaces below. Answer the discussion questions that follow.

7 How is direct solar energy (light, heat and UV) affected by the seasons and the time of day?

____
____
____
____

8 When the Earth tilts on its axis what happens?

____
____
____

9 Are the seasons and UV ratings the same around the world? _________ Explain your answer:

____
____
____
____
____
____

10 Draw a picture of the Earth revolving around the sun on its axis. Show (with arrows) the difference between the direct and indirect rays from the sun:

6th Grade
UV

Friend or Foe

LEARNING OBJECTIVES

The student will understand where ultraviolet light (UV) fits in the spectrum of light and its affects on all life.

STUDENT PERFORMANCE OBJECTIVES

- ?? The student will understand what UV rays are and where they fit in the spectrum of light.
- ?? The student will learn how UV is beneficial to all life on Earth.
- ?? The student will begin to understand the dangers of UV radiation
- ?? The student will identify practices, choices and products that protect from overexposure to UV radiation

BACKGROUND

The sun delivers light and heat in a spectrum of rays called the electromagnetic spectrum. The electromagnetic spectrum breaks down by wavelengths into a table that is easy to use and understand. Short waves (UV) correspond to high energy, while long waves (IR heat) correspond to low energy. This spectrum is more than the visible colors we see when light is refracted or bent. The rainbow of light displayed is only a small part of the spectrum we see. The electromagnetic spectrum also consist of rays that we cannot see, such as **ultraviolet (UV) rays**, infrared rays and heat rays. While these rays are not visible to the human eye, we can detect them and observe their effects in the world around us. While some exposure to these rays is normal, healthy and sometimes beneficial, *overexposure* can be extremely dangerous.

Exposure to UV has some immediate, adverse effects as well as long term, adverse effects. Some immediate effects are sunburns, sunblisters and sunspots. Some long-term effects are skin cancers, premature aging, photosensitivity, and cataracts.

See other lessons on UV and sun, the UV Index, UV and ozone, UV and ozone in our breathing space, UV and ozone depletion, and UV monitoring.
<for more>

MATERIALS

Day 1:

- ?? prisms (for opening: optional)
- ?? Light set ups: UV light, fluorescent light, softwhite light, and control with no light (Controlled variables: lights should be the same height, size, etc.,)
- ?? Prepared, sterile Agar plates (4 per group)
- ?? Microscopes
- ?? Magnifying glass

Day 2:

- ?? [Worksheet UV/6-1: Skin Diagram]
- ?? [Information sheet UV/6-2: Dermatologist Information]
- ?? or [Dermatologist Video]
- ?? [Worksheet UV/6-3: Skin Type]

Day 3:

- ?? Clear plastic cups (3-5 per group)
- ?? UV beads of a single color (1-2 per cup)
- ?? Clear plastic wrap
- ?? Auto glass tint samples (min: 2 shades)

Cloth samples such as cotton , wool, rayon, polyester, etc. (Control Variable: same approx.: size, color, thickness, etc.)

SAFETY CONCERNS

- ?? Bacteria will grow and multiply in any stagnant materials, it is unlikely that they will be dangerous, but be sure to get rid of cultures as soon as the activity is complete.
- ?? Wash containers and hands with hot water and soap.

Caution students not to put their hands to their mouths after handling any lab specimens. Wash hands when done.

OPENING

Ask the Class:
What colors do you see in a rainbow or prism? What do you know about the electromagnetic spectrum? What are the visible parts of the electromagnetic spectrum?

Demonstrate to the Class:
Demonstrate the bending and refraction of light by using a prism. Have students tell you about the colors they see and possible reasons why they see them.

Discuss with the Class:
Discuss the sun's light as an array of color. Explain that the colors are separated when they are bent or refracted. The colors of the visible spectrum are red, orange, yellow, green, blue, indigo, and

violet. Have the students imagine the warmth of the sun on a summer day. Discuss the heat of the sun as part of other rays from the sun which are not visible. Tell the students that the invisible rays are called infrared, heat waves, and ultraviolet (UV) rays. Tell the students that the labs and lessons they will be doing will help them to determine the benefits and dangers of UV light and how to protect themselves from overexposure to the harmful effects of UV.

PROCEDURE

Day 1:

1. Outline the electromagnetic spectrum for the students.

2. Label the parts of the electromagnetic spectrum.

3. Determine where UV light fits on the electromagnetic spectrum and discuss its different wavelengths and why it is not visible.

4. Discuss energy as a function of wavelength (IR, less energy, UV more energy).

5. Discuss some of the benefits of UV light:
   a) plant growth
   b) heating foods at restaurants
   c) correcting jaundice in babies
   d) disinfecting foods and food areas

6. Tell the students that the lab they will begin today will demonstrate which of the lights will best prevent bacteria growth.

7. Distribute prepared Agar plates to student groups. Be careful not to contaminate the cultures.

8. Discuss the lab procedures and read the directions with the students.

Directions:

1. Have students place their thumbprints into the prepared Agar plates and label them.

2. Have students observe Agar plates under a microscope and draw a representation of what they see in their journals.

3. Have students place Agar plates under the different light setups.

4. Have students check Agar plates daily for at least one week

5. Have students observe their Agar plates under a microscope and diagram the bacteria growth they see.

6. Have students estimate percentage of growth change and draw a pie graph to display their estimates.

7. Have students compare the percentage of growth change from the first day to the last day of their observation. Have students make inferences and conclusions based on their data.

Day 2:

1. Ask the students if they have ever tried to get a sun tan or if they have ever had a sun burn.

2. Ask the students if they burn rapidly or if it takes them a long time to burn in the sun. Have the students explain why they think there is a difference.

3. Explain to the students that different skin types and pigmentation in the skin allow different people to burn or tan at different rates to varying degrees.

4. Demonstrate the bending or refracting of light using a prism. Have the students complete the Skin Survey [see worksheet: UV/6-3].

5. Explain that tanning is a skin's response to UV light. Tanning is a protective reaction, but it does not prevent skin cancer or other damaging effects from the UV rays.

6. Ask the students what they know about the layers of the skin.

7. Distribute the [Skin Diagram worksheet: UV/6-1]. Discuss the layers, functions, and different skin types.

8. Explain that the skin is made up of several layers to protect the body from: injury and infection, heat and light, and losing water.

9. Have the students complete their skin diagrams and list the functions of the skin on their worksheet.

10. Discuss with the students short term and long term effects of overexposure to the sun.

11. Have the students work in groups to create sun and UV awareness slogans. Slogans must tell what is UV and the dangers of UV.

12. Bring the class back together to discuss their slogans.

Day 3:

1. Discuss with the students different ways we can protect ourselves from ultraviolet (UV) radiation.

2. Ask the students if they think that different fabrics, window coverings or car tints can protect us from the sun.

3. Show the students UV beads and explain that they change color in the presence of UV light.

4. Tell the students that each group is going to test a variety of items to determine if they will provide protection from UV rays.

5. Have students place 1-2 UV beads in each of their cups.

6. Have the students place clear plastic wrap on one cup for the control.

7. Have the students place various items over the other cups.
   a) Group 1: Control and 2 or more auto tints
   b) Group 2: Control and 2 or more fabrics
   c) Group 3: Control and 2 or more SPF sunscreens on plastic wrap

   (Other groups can do the same or come up with their own test items)

8. Have each group of students place their cups sun. Make sure that they place their cups in the same place at the same time.

9. Have the students observe the changes in the UV beads and record their results on data sheet [UV Protection Data Sheet: UV/6-4]

10. Have the students graph and compare their data to determine which item had created the least amount of color

change in the UV beads.

11. Have the students make inferences and draw conclusions based on their data.

12. Ask the students to discuss their observations and explain if their was any difference in color change under the different items. Did one item protect the beads from more UV light than another? Students need to explain their answer.

13. Have the students check the UV rating at the Ecoplex website to learn more about the UV ratings and when they need to use protection from UV rays.

SO WHAT?
(LIFE APPLICATION)

Have the students come up with a plan to inform their families of ways to protect themselves from the harmful effects of UV rays.

CURRICULUM EXTENSIONS

Math:
Create a graph that compares the effect the items had on the UV beads.

Language Arts:
Have the students write a lab report on their experiments, focusing on analysis and conclusions.

Technology:
Using a spreadsheet program, have the students create a graph using their data.

Art/Music:
Have the students create posters to inform their peers of the dangers of tanning and display the posters around the school.

Science:
Have the students check the effect of UV light on different bacteria growth by getting bacteria samples from different places around the school (remember, when comparing the effect of the light you must control the type of bacteria, so make sure students use samples from each area for each light)

Have the students create sun safety surveys and determine the percentages of students in their grade level who protect themselves from UV rays.

Social Studies:
Have students research the role of the sun in different cultures.

TEKS: 6.1(A,B), 6.2 (A,B,C,D,E), 6.4 (A,B)

RESOURCES

http://www.ecoplex.unt.edu/main.html
http://imagine.gsfc.nasa.gov/docs/teachers/lessons/roygbiv/roygbiv.html
http://members.aol.com/EnidHighIN/
http://www.maui.net/~southsky/introtohtml
http://www.c-hawks.org/webaa/websun/Skinqfc.htm

3rd Grade
UV Lesson

WHEN GOOD OZONE GOES BAD

LEARNING OBJECTIVES

The student will identify the conversion of the oxygen we breathe (O_2) to ozone (O_3). The student will describe how ozone formed in the troposphere can be dangerous.

STUDENT PERFORMANCE OBJECTIVE

- The student will understand the difference between the stratosphere and troposphere.
- The student will be able to identify oxygen, ozone, and free oxygen.
- The student will be able to use the ECOPLEX web site to find ozone alert announcements.

BACKGROUND

UV-A, UV-B and UV-C are rays that we are unable to see. At the stratosphere level, UV-C splits oxygen molecules (0_2) into separate oxygen atoms. These oxygen atoms now join pairs of oxygen creating ozone (0_3). UV-C does not pass through the ozone into the troposphere. UV-C aids in the creation of ozone. UV-B breaks the bond of O_3 releasing one oxygen molecule (O_2) and one oxygen atom (O). Some UV-B passes through the ozone layer into the troposphere. UV-A is a weaker form of UV-B and some UV-A passes into the troposphere. Ozone in the stratosphere protects us from harmful levels of UV rays.

Air pollution and chemicals found naturally in our breathing space (troposphere) mix to create ozone (O_3) in the troposphere. Ozone in the troposphere can be harmful to our lungs and eyes when it reaches high levels. Ozone Alert days are announced when ozone at the troposphere is over 125.

See other lessons on the following subjects: UV and sun, UV Index, UV and ozone.
<for more>

MATERIALS

- 16 yellow pattern blocks
- 7 green pattern blocks
- 2 red pattern blocks
- 2 blue pattern blocks
- Construction paper for demonstration
- SKIT MATERIALS
- Blue streamer for UV-C
- 2 red streamers for UV-B
- 2 yellow streamers for UV-A
- Construction paper
- Yarn

3rd Grade
UV Lesson

PROCEDURES

1. Using a sheet of 12x18 inch construction paper and pattern blocks demonstrate the O_2 conversion as explained in the Background.

2. Draw a sun at one end of the paper and Earth at the other. From the Earth, label and mark a 3inch section as the troposphere. The next three-inch section should labeled and marked as the stratosphere. For more information on atmospheric layers see the lesson for UV and ozone.

3. The green pattern blocks represent UV rays. Label three as UV-C, three others as UV-B, and the last three as UV-A. Place them on the sun.

4. Place eight yellow pattern blocks in the stratosphere. Each represents a single oxygen. Pair them to create O_2 in the stratosphere and four more pairs in the troposphere. In the troposphere, place a single red pattern block upon a pair of oxygens and repeat with the other red block The red blocks represent car exhaust. Place each blue pattern block on the remaining pairs of yellow oxygen in the troposphere. The two blue pattern blocks should be labeled volcanic ash.

5. Begin the demonstration by moving the UV-C's to the stratosphere. These will split O_2 creating free oxygen. Move three free O's together to create O_3. Explain that UV-C stays in the stratosphere because it cannot pass through the ozone layer.

6. Move the UV-B's into the stratosphere. The UV-B's break the bonds of the O_3 creating O_2 and a free O. One UV-B continues to the troposphere. The ozone layer blocks some UV-B but not all. Therefore leave one UV-B stratosphere.

7. Move the UV-A's into the stratosphere. One UV-A should remain in the stratosphere while the other moves to the troposphere. You may want to stop at this point and complete the skit that follows the procedure section.

8. In the troposphere, explain that the red pattern blocks are car exhaust, the blue pattern blocks are chemicals from a volcanic eruption. UV-A moves to the troposphere but further study will be needed to find out its relationship to ozone. The two UV-B blocks will touch and break the bonds of the car and volcano molecules. This will release the O under each red and blue

blocks. These free O's will now join with O_2's, creating ozone in the troposphere. Ozone in our breathing space in large amounts create lung and eye health problems. This happens quickly and simultaneously.

9. Check the ECOPLEX site to determine if an ozone alert has been announced for today. Ozone alerts are announced when the ozone in our breathing space reaches 125 parts per billion. At this level ozone can irritate our lungs and eyes. Each student will create an ozone flag that we can hang in the halls on ozone alert days.

10. While half the class is working on the flag, the others will work on a quick skit that shows the natural process of creating and destroying ozone. Then switch groups so they can perform for each other.

11. NATURES WAY SKIT

Cast – Narrator, UV-A1, UV-A2, UV-B1, UV-B2, UV-C, 4 pairs of O

SETTING

One wall is the Earth's surface. Measure 2 meters from the earth and that is the spot where the troposphere changes to the stratosphere. The opposite wall is the sun. Each student should have a construction paper tag identifying his or her part. All of the UV rays stand at the sun. An optional prop for the UV characters might include the students holding a different color of streamer. The streamers should be attached to the sun at one end. The section of the stratosphere closest to the sun should have students who are wearing the tag O (oxygen molecule). Four pairs of students should link arms to create four sets of O_2. The linked students should stand around a table decorated for a party. They can pretend to eat, drink and talk.

Narrator - (Spoof on a wildlife commentator, may wear binoculars, pith helmet, canteen) - Welcome to another episode of Wildlife in the Atmosphere. The sun is rising. It appears to be a beautiful morning. Let's watch, as the UV rays appear to be awake and moving. Let's move a little closer to watch and listen. Shhhh.

UV-C - Hey! It looks like there is a party in the stratosphere. Let's go down and take a look. I am a party animal.

UV-B1 – Great idea. I love a party! I think I'll freshen up a bit before I go.

UV-A1 – I'll wait for you.

UV-B2 – Me too!

UV-A2 – I think I'll clean up a little too!

UV-C - C'mon, c'mon. Hurry up.

UV-B1 - We'll meet you there. (Mumbling to himself as UV-C leaves) Gee, UV-C is sooo pushy. (UVA's and B's stay with the sun)

UV-C - (moves to the stratosphere, he drags the streamer behind him. At the stratosphere, he pushes between a linked O) Hey! What's up! Now that I'm here the party can really get started!

1 of the O_2 - The two O's give UV-C a disdainful look. As separate O's, they each join with another pair. This creates two sets of O_3 or ozone.

UV-C – (shrugs his shoulders and focuses on the food at the table)

Narrator - (Whispering into his microphone) Wow! Did you see that? We have just witnessed UV-C separating O_2 to create ozone. Ozone is three oxygen atoms linked together. It is a strong-smelling, colorless gas. Oh. Here comes UV-B. Let's see what happens.

UV-B1 and A1/ UV-B2 and B1 - (dragging streamers, B1 set and B2 set move to different O_3 groups. Speak at the same time) How is everyone?

O_3 with UV-B1 and A1 - (one of the O_3 members says) It's a little crowded now. I'm going to take off. See ya! (moves to food table)

Narrator - That was amazing. Never before has the depletion of ozone been seen. Let's watch an instant replay. (Have UV-B and ozone move in reverse and repeat one of the O_3 members leaving.) Amazing. Let's rejoin the party.

O_3 with UV-B2 and A2 – (one of the O_3 members says) It's a little stuffy. I think I'll go to the food table. (one of the O_3 breaks away and moves to the table)

UV-B1 – Where is the music? Are there any games?

3rd Grade
UV Lesson

Any O near UV-B1 – There aren't any games or music. We're just hanging out talking and eating.

UV-B1 and A1 - (moves to UV-C and UV-B&A2) This party is boring. I think I'll head on down to Earth and see what's going on. Do you two want to go?

UV-C – No. I'm going to hang around here.

UV-B2 – I like it here.

UV-A2 – I think I'll stick around.

UV-B1 – OK. See ya. (drags streamer to Earth)

UV-A1 – I'm going too. Bye. (drags streamer to Earth)

Narrator - There you have it. Natures way to create and destroy ozone. Because the process is simultaneous, the ozone amounts stay virtually the same. Some UV- B moves down to Earth, while there is enough ozone to keep UV- C and other UV-B rays in the stratosphere. Ozone is very helpful in the stratosphere because it blocks UV-C and most of UV-B and UV-A. Tune in for the next exciting journey into the atmosphere.

SO WHAT?
(LIFE APPLICATIONS)

After learning about ozone in our breathing space, ask students to generate a list of appropriate safe activities for school on an ozone alert day.

Art
Create a flip book of ozone being created and depleted.

Language Arts/Writing
Write an announcement for the loudspeaker or imaginary TV station that explains what an Ozone Action Day is and some of the alternatives for outdoor activities on these days.

UV-A1 – Yea. This is kinda boring.

CURRICULUM EXTENSIONS

3rd Grade
UV Lesson

TEKS: Science: 3.2.C,D,E, 3.3.C,D, 3.4.A, 3.5A,B, 3.6.C,D, 3.7.A, 3.11.D

RESOUCES

http://www.mb.ec.gc.ca/ENGLISH/AIR/HLWS/menu.html
http://www.ecoplex.unt.edu/

Science
Create a diagram of ozone being created and destroyed.

Third Grade
Water Quality

Test, Test, Is This Water Safe?

LEARNING OBJECTIVES

The students will begin to understand how pollution enters surface water. The students will conduct chemical and physical testing of water samples. The students will begin to understand how they can affect water pollution.

STUDENT PERFORMANCE OBJECTIVES

* The student will understand the difference between point and nonpoint pollution.
* The student will begin to understand Limnology.
* The student will conduct temperature, dissolved oxygen, pH, nitrogen, and phosphate testing of water.

BACKGROUND

All living things need water to survive. Different bodies of water require different levels of purity based on the purpose of the body of water. Water in a pond that supports aquatic life requires a different level of purity than water that is removed and purified for human consumption.

The human body is approximately 70% water. It is recommended that each person drink eight 8-oz glasses of water per day. Safe, drinkable water is an important resource. Water that is contaminated with pollution or hazardous wastes is dangerous for human or animal consumption. Controlling pollution or hazardous waste before it enters water supplies benefits all of us.

Pollution sources are divided into 2 types: point and nonpoint source pollution. Point pollution is pollution that enters a stream at a specific, detectable source, such as industrial or sewage treatment plants. Nonpoint source (NPS) pollution is caused when rainfall or snowmelt moves over and through the ground. This runoff picks up and carries away natural and man-made pollutants. The polluted runoff enters surface and groundwater. NPS pollutants include:
*excess fertilizers
*oil or grease
*sediments from improperly managed construction sites, crop and forest lands, and sediments from eroding stream banks
*salt from irrigation practices

*bacteria from livestock, pet wastes, and faulty septic systems

According to the Environmental Protection Agency (EPA), as reported in the Environmental Pointer Number 10 (EPA841-F-96-004J), NPS pollution is the leading cause of water quality problems.

Individuals can prevent NPS pollution. Using alternatives to chemical fertilizers and pesticides, or using chemicals sparingly can help reduce pollutants. Disposing of oil, antifreeze, paint, and other household chemicals properly is another way people can prevent NPS pollution. Oil can be recycled at many automotive stores. Check the product labels for disposal information. Contact your solid waste facility for additional disposal directions. Chose detergents that are phosphate free. Avoid hosing oil, antifreeze, or grease down driveways into street gutters; instead, sprinkle kitty litter or sand across the spilled liquid. The litter or sand will soak up much of the spill. It can then be swept up and thrown into the trash. Plant ground cover to stabilize areas prone to erosion.

According to Encarta? Encyclopedia, limnology is the study of the physical, geographical, chemical, and biological aspects of inland freshwater systems. The physical properties of water are temperature, turbidity (suspended matter in the water creates a murky look), color, taste, and odor. Chemical aspects of water include pH (acidity of water), dissolved minerals, such as, phosphates, calcium, magnesium, and gasses like, oxygen, nitrogen, hydrogen sulfide, carbon dioxide, and methane. Limnologists use tests to discover the presence and amount of these chemicals.

Temperature of natural waters is an important factor for aquatic life. Each creature is adapted to particular temperatures. Trees and brush provide shade for natural waters such as creeks, ponds, and lakes. When these areas are cleared for construction, the temperature of the water may be raised due to the increase in sunlight on the once shaded area. Changes in water temperature can affect aquatic habitats. This may result in the death aquatic creatures.

An important gas in water is oxygen. It is referred to as dissolved oxygen or DO. Oxygen is necessary for aquatic life. DO is found in cold water at higher levels than warm waters because oxygen is more soluble in cold waters. Cold waters have a DO measurement of 5.0 milligrams per liter or higher. Oxygen is found in warm water at not less than 4.0 mg/L. Oxygen can also indicate the corrosiveness of water. When DO is found with carbon dioxide and slightly acidic water it will corrode metal pollutants in the water.

The pH indicates the amount of hydrogen ion concentration. The acid, neutral, or alkaline nature of materials can be determined by using a pH test. Natural bodies of freshwater should have a pH of 5.0 to 8.5. Seawater has a pH content of 8.1. An acid level of less than 5.0 indicates that mine drainage or acid industrial waste may have polluted the water. Industrial alkaline wastes are indicated when the pH is 8.5 to 9.0. A neutral pH of 7.0 is considered best for human consumption.

Nitrogen (nitrate) is naturally found in bodies of water at low levels. It is essential for plant growth. Pollution is present when nitrates are found at excessive levels. Nitrates are found in fertilizer, sewage, industrial, and livestock wastes. Methemoglobinemia (hemoglobin is abnormal and cannot transport oxygen) can be found in infants less than six months of age when exposed to high levels of nitrates. High levels of nitrates when paired with phosphates can stimulate the growth of algae causing fish kills. For safe drinking water, the nitrates should not exceed 10 ppm.

Phosphorus (phosphate) is found naturally in bodies of water. It is a nutrient for aquatic plants and is generally found at 0.1 ppm in natural waters. When phosphorus levels increase, it is a sign that agricultural wastes or wastewater has polluted the body of water. Several detergents include phosphates (dishwashing and clothes washing products). The phosphorus increases algal growth which increases oxygen levels from photosynthesis. Several cloudy days in a row can result in the algae dying. Oxygen is used in the decomposition of the algae resulting in fish kills due to a lack of oxygen.

See other lessons on: water, properties of water, and water changes
<for more>

MATERIALS

* 1 clear beaker labeled A and filled with 3 cups of tap water
* 1 clear beaker labeled B and filled with 3 cups of water and ¼ teaspoon of Miracle-Gro? stirred until it dissolves
* 1 clear beaker labeled C and filled with 2 cups of water and 1 cup of vinegar
* Water Quality Datasheet [WQlty/3-1] (copy a class set)
* Masking tape

* Watering can (1 per salt dough map)
* Cake decorations: multi-colored balls, multi colored confetti bars, chocolate confetti bars, snowflakes, red sugar crystals
* Ward's Water Quality Snap Test Kits (dissolved oxygen, pH, nitrate, phosphate) 1-800-962-2660
* Thermometer
* www.ecoplex.unt.edu
* Salt dough relief map **TEACHER PREPARATION – *Several days prior*** to the opening activity create a salt dough map. Make 3 batches for the relief map. (For the best results, do not double the recipe. One map per small group of students is suggested.)

  Foil lasagna pan
  Food coloring
  1 cup flour
  ½ cup salt
  1 cup water
  1 tablespoon cooking oil
  2 teaspoons cream of tartar
  Paintbrush
  Waterproof paint

Mix ingredients until a ball forms. Food coloring may be added. Place dough into a foil lasagna pan. Press dough out to the edges of the pan. On one end create 2 depressions that will join in the middle of the pan in the shape of a "V". On the opposite end of the pan create another depression that will join the "V" creating a "Y". These depressions will serve as rivers. Create a depression where all the rivers join. This will create a lake. Use a paintbrush to "paint" the model with food coloring (land - green, rivers - blue). Allow the model to dry for 3 days. Paint the dough with clear, waterproof paint so that it can be reused. (Students can make group maps on a Friday, spray with waterproof paint on Monday morning, and be ready for the lesson Monday afternoon. The salt dough map will also be used in the <u>surface water lesson</u>.)

OPENING

Ask students:

What do humans need to live? (water, food, shelter etc.)

Where does the water come from that you drink?

Would you drink water from a creek?

Show the students the three beakers of water. **Without tasting** the water in the beakers, using only your observation skills, ask the students to pick beaker A, B, or C as the water they would prefer to drink. Distribute the <u>Water Quality Datasheet.</u> Students record their answers on the datasheet. (Move the beakers aside and explain that the class will come back to the beakers and datasheets at the end of the lesson.)

PROCEDURE

1. Place the salt dough model in front of the class. (Distribute student group models if appropriate.) Explain to the students that they are looking at the city of Salt Dough. In and around the city, there are farms, factories, schools, shopping, and residential neighborhoods. In the center of the city, is a lake where the people get water for drinking.

2. Using masking tape, divide the salt dough map into sections. Label the sections farmland, Sudsy Soap Detergent factory (place close to one of the rivers), 3 or 4 residential sections. (If students have group maps, ask them to label their maps in the same way as the teacher map.)

3. Explain to the students that the farmland has been sprayed with a fertilizer to promote crop growth. Sprinkle cake-decorating balls on the farm section to represent the fertilizer.

4. In the Sudsy Soap Detergent factory, excess detergent is washed down the drain. Sprinkle the multi-colored cake decorating confetti bars to represent the excess detergent. Make a thin line of the bars to show how it would move through a pipe into the river.

5. In all of the residential sections, a neighbor is changing his automobile's oil. He collects it in a bucket, then dumps it in the drainage ditch behind his house. Sprinkle chocolate cake decorating confetti bars around the residential sections. The bars represent the oil. Another neighbor pours gasoline on fire ant nests. Use snowflake cake decorations to symbolize the gas. Pesticides are being used to keep the neighborhood grass from being eaten by bugs. Use red sugar crystals to symbolize pesticides. Fertilizer is sprayed on neighborhood yards to promote a thick, dark green grass. Sprinkle cake-decorating balls in the residential area to symbolize the fertilizer.

6. Discuss what the students think will happen if it rains.

7. Using a watering can filled with water, "rain" on the salt dough map. Discuss what happens to the pollutants (cake decorating items).

8. Explain to the students that the oil, fertilizer, and gas are nonpoint pollutants. These pollutants enter rivers as runoff. Water that is not absorbed by the earth moves across the land towards rivers, lakes, etc. (You may choose to repeat the

demonstration.)

9. Explain that limnology is the study of the physical, geographical, chemical, and biological properties of water. It is this type of scientist that tests water for contamination by pollutants. Today we will become limnologists to determine which beaker of water (displayed at the beginning of the lesson) is safe to drink. (Ask students to check their datasheet for their hypothesis). Each test result will be compared to the list of safe chemical levels as mandated by the Texas Department of Health and the Safe Drinking Water Act.

10. Focus the student's attention back to the beakers. Explain that the student's will conduct water testing to determine which sample would be the best to drink. (Remind students that tasting the water is not an option. Determine the best way to divide the students and materials to complete the pH, nitrate, phosphate, DO, and temperature test for your class.)

11. Conduct the pH water quality test according to the test instructions (litmus paper or a pH meter can be used). Record the results on the worksheet. Compare pH results to the safe levels for drinking water. Beaker C should show a low pH because of the vinegar. Explain to the students that this means the water is acidic. Small amounts of acidic water would not be life threatening for humans because of the human digestive system, however it is not recommended. If the water were found in a river, it's high acidic levels would cause any metal that might be in the river to break down and release secondary pollution. High acid levels damage the gills of aquatic creatures. This water is harmful to a river environment.

12. Test each water sample for nitrates (nitrogen). Record the results on the datatsheet. Compare the results to the list of safe levels. This water would be dangerous to humans and the river environment.

13. Test the water samples for phosphates. Record the results on the datasheet. Compare the results to the list of safe levels. Sample B should show a high level of phosphorus. This is dangerous to river environments because it is a nutrient for algae. The algae will grow quickly and produce and use a great amount of oxygen. It is possible for the algae to require such great amounts of oxygen that it depletes the oxygen supply and some aquatic creatures may die.

14. Test the water samples for dissolved oxygen. Record the results on the datasheet.

15. Using thermometers, measure the temperature of each water sample. Record the temperature of each sample.

16. Complete the datasheet.

17. Ask students which sample is the safest to drink. Compare the test results to the hypothesis of each student. How many students chose the "safest" sample?

18. Take students to a computer lab. Ask students to locate www.ecoplex.unt.edu. Compare the class water test results to those on the web site for Lake Lewisville.

19. Referring to the salt dough map, remind students of the difference between NPS and point source pollution. Ask students to think about what part of the map would be the source of pollutants found in the beakers of water. (Beaker B may have been the results of agricultural wastes from the farmland). Explain ways to prevent NPS and point source pollution.

SO WHAT? (LIFE APPLICATION)

Water is necessary for life. More and more the quality of drinking water and natural bodies of water is in question. Each of us can actively play a role in the quality of our water by practicing proper disposal of household chemicals and educating others about nonpoint and point source pollution. Create a slogan and poster explaining one of the ways to prevent NPS pollution. Display your posters at a PTA meeting.

CURRICULUM EXTENSIONS

Science

Allow students to bring swimming pool, creek or lake water samples from home to test purity.

Create bar graphs from the water testing data.

Math

Compare the Fahrenheit boiling point, freezing point, body temperature, and the day's Fahrenheit temperature to the Celsius temperature.

Social Studies

Use the internet to research the Safe Drinking Water Act. A suggested site for research is www.epa.gov/safewater/sdwa25/25years.html.

Invite a guest from the EPA or water treatment plant to speak to the class.

Language Arts

Write thank you notes to EPA or other water protection service employees.

TEKS

Science: 3.1A,B, 3.2A,B,C,D,E, 3.3C, 3.4A, 3.7A, 3.8A,B,C

RESOURCES

Fourth Grade
Water Quality

Chain, Chain, Chain, Chain of Food

LEARNING OBJECTIVES

The students will begin to understand the concept of food webs and chains. The students will begin to understand the impact of losing an element of the food chain. The students will begin to understand how pollutants affect organisms within a body of water.

STUDENT PERFORMANCE OBJECTIVES

* The student will identify an aquatic food chain.
* The student will test a natural water source to acquire physical and chemical data.
* The student will begin to understand that an aquatic environment is interdependent.

BACKGROUND

An aquatic environment is made up of the plants and creatures within a body of water. The number and types of creatures in a body of water would depend on the health of the water. Aquatic biologists and entomologists are scientists who study things that live in and around a body of water. These biologist determine the health of a body of water by looking at the following 5 attributes: amount of dissolved oxygen (DO), algae content, health of fish, diversity of bottom-dwelling insect larvae (worms, clams, crayfish), amounts and types of pollution that settles into the mud on the bottom of the body of water. All of these attributes are dependent on one another to create a healthy body of water. If one area is altered it affects the remaining attributes.

When a body of water becomes unhealthy, every living thing in the water and outside of the water that depends on the body of water for life are affected. A food web shows how all living things, energy, and materials are interconnected within an ecosystem. A pond's food web includes carbon dioxide, heat, light, plants, drainage water, nutrients, suspended solids, dissolved salts, planktonic algae, invertebrates, detritus, mud dwellers and scavengers, bottom deposits and bacteria, and foragers. Each form of life within the food web has its own food chain. The food chain follows the path of a single creature in search of food. A grazing food chain would include sunlight, plants, herbivores, and finally carnivores; for example, the sun provides energy for grass to grow; it is eaten by a grasshopper which is eaten by a frog, which is eaten by a snake, which is eaten by a hawk. An aquatic food chain example found in north Texas lakes would begin with the sun providing energy for microscopic algae, zooplankton, gizzard shad, white bass, osprey (or other birds or humans).

Water purity plays a part in the health of an aquatic environment. If the purity is not acceptable for the body of water, the organisms within the water and organisms that eat aquatic life can be harmed. Pollutants such as excess fertilizers, oil, grease, sediments from improperly managed construction sites, crop and forest lands, bacteria from livestock, pet wastes, and faulty septic systems can enter natural waters and kill or seriously harm the plants and animals that live within the water. Aquatic biologists and limnologists study the physical, geographical, chemical, and biological aspects of inland freshwater systems. Tests are performed to determine temperature (physical) and the amounts of pH, nitrates, phosphates, copper, etc. (chemical) within the water.

Temperature of natural waters is an important factor for aquatic life. Each creature is adapted to particular temperatures since fish and other aquatic life have no control over their body temperatures. Water temperature of 95?F is considered the maximum for most aquatic life. Trees and brush provide shade for natural waters such as creeks, ponds, and lakes. When these areas are cleared for construction, the temperature of the water may be raised due to the increase in sunlight on the once shaded area. Changes in water temperature can affect aquatic habitats. This may result in the death of many aquatic creatures.

An important gas in water is oxygen. It is referred to as dissolved oxygen or DO. Oxygen is necessary for aquatic life. DO is found in cold water at higher levels than warm waters because oxygen is more soluble in cold waters. Cold waters have a DO measurement of 5.0 mg/L or higher. Oxygen is found in warm water at not less than 4.0 mg/L. Different organisms require different water temperatures and DO amounts. Some examples include carp, which is a warm water fish and lives in water with as little as 3 ppm of oxygen, while largemouth bass require 5 to 8 ppm.

The pH indicates the amount of hydrogen ion concentration. The acid, neutral, or alkaline nature of materials can be determined by using a pH test. Natural bodies of freshwater should have a pH of 5.0 to 8.5. Seawater has a pH content of 8.1. An acid level of less than 5.0 indicates that mine drainage or acid industrial waste has polluted the water. Industrial alkaline wastes are indicated when the pH is 8.5 to 9.0. A neutral pH of 7.0 is considered best for human consumption.

Nitrogen (nitrates) are found naturally in bodies of water at low levels. It is essential for plant growth. Pollution is present when nitrates are found at excessive levels. Nitrates are found in fertilizer, sewage, industrial, and livestock wastes. Methemoglobinemia (hemoglobin is abnormal and cannot transport oxygen) can be found in infants less than six months of age when exposed to high levels of nitrates. High levels of nitrates when paired with phosphates can stimulate the growth of algae causing fish kills. A nitrate reading of 0.1 ppm is considered normal; however, it is possible that due to the water source, or sensitivity of the test, a reading of zero may occur.

Phosphorus (phosphates) is found naturally in bodies of water. It is a nutrient for aquatic plants and is generally found 0.1 ppm in natural waters. When phosphorus levels increase, it is a sign that agricultural wastes or wastewater has polluted the body of water. Several detergents include phosphates (dishwashing and clothes washing products). The phosphorus increases algal growth which increases oxygen levels from photosynthesis. Several cloudy days in a row can result in the algae dying. Oxygen is used in the decomposition of the algae resulting in fish kills due to a lack of oxygen.

Copper salts enter natural waters from industrial waste. These salts are used in electroplating, photography, textile manufacturing, and pesticides. A concentration of 0.015 to 3.0 ppm can be harmful to aquatic life. Copper salts destroy growths of algae which can deplete oxygen supplies.

The University of North Texas is monitoring water quality using clams. Each clam is submerged in Lake Lewisville and attached to a sensor. The sensors are connected to a computer system that records to what degree the clamshell is closed. Clams begin to close their shells when irritants are in the water making them natural indicators of pollutants.

See other lessons on: water, properties of water, water changes, nonpoint and point source pollution
<for more>

MATERIALS

* 3x5 notecards
* Water Quality Datasheet [WQlty/4-1] (copy a class set)
* Ward's Water Quality Snap Test Kits (dissolved oxygen, pH,

nitrate, phosphate, copper) 1-800-962-2660
* Thermometer
* Locate a creek, river, pond, lake to collect a water sample (if possible take the class to the site)
* Water collection containers (1 per group)
* www.ecoplex.unt.edu

OPENING

Ask the class to:

Identify and record items that may be found in a river (pebbles, mud, fish, algae).

What would happen if pollutants like fertilizer from a neighborhood entered the pond?

PROCEDURE

1. Explain to students the concept of a food web and chain.

2. Place students into partnerships or small groups. Ask the partners to choose one of the aquatic creatures named during the opening. Students will research the creature and identify its food chain.

3. Create food chain cards. On a 3 x 5 notecard, illustrate an item in the food chain. Include a fact about the item. Continue until there is a notecard for each item in the chain.

4. The partners present their food chain cards to the class.

5. Place 3 sets of partners together, creating a larger group. The larger group will shuffle all of their food chain cards into one deck. The students will work together to sort the cards back into the appropriate food chains.

6. Explain to the students that pollutants can enter a body of water through runoff and disrupt food chains. Discuss various types of pollutants.

7. Explain that aquatic biologists and limnologists test water to determine the health of a body of water. Healthy pond water will support aquatic plants and organisms such as zooplankton and fish.

(If possible, the students need to be taken to a water site to conduct the tests. If not, the teacher needs to record the temperature while at the site collecting the samples for later use.)

8. Divide students into small groups. Pass out testing datasheet. Assign temperature, pH, DO, nitrate, phosphate, and copper tests to different groups. (Temperature and pH can be grouped together due to the small amount of time it takes to conduct these tests.)

9. Complete the tests. Record data on WQlty/4-1. (Instruction and safety measures will be determined by the brand of tests purchased.)

10. Review the test results and compare to the freshwater requirements as mentioned in the background. Discuss the results.

11. Take students to the computer lab. Ask students to locate www.ecoplex.unt.edu. Compare the pH, DO, and temperature from the class samples to those at Lake Lewisville. Ask the students to notice if the clams are open.

12. Ask students why it is important to determine if water is polluted.

13. Using the white bass food chain mentioned in the background, ask the students to pretend that the phosphorus level of the water the bass lives in is unhealthy. What would happen to the white bass food chain? (This would cause fish kills due to the oxygen being depleted from decaying algae, which in turn would affect the birds that eat the fish.)

14. Ask the students, "Would the additional phosphorus affect their food chain?"

SO WHAT? (LIFE APPLICATION)

All life is interdependent. Create a mural of a pond, river, or lake that reflects the interdependency in an aquatic environment. Label the aquatic organisms and write paragraphs that correspond to the labels explaining each organism's role in the food web. The paragraphs could be displayed to the side of the mural for classmates and visitors to read.

CURRICULUM EXTENSIONS

Science
Test additional water samples that students bring to class.

Art
Create a food chain mobile.

Create a freshwater environment diorama.

Language Arts
Create class or group food chain raps.

Write "When I was a Fish"

Pretend that the student is a gizzard shad that is about to be eaten by a white bass. Write "excuses" to explain why the white bass should not eat you.

TEKS
Science: 4.1A,B, 4.2B,C,D, 4.4A,B, 4.5A,B

RESOURCES

http://www.broadwaters.fsnet.co.uk
http://www.ecoplex.unt.edu

Fifth Grade
Water Quality

Tick Tock Toxins

LEARNING OBJECTIVE

The students will begin to understand bioaccumulation of toxins and where they originate. The student will begin to understand that testing for toxins is necessary.

STUDENT PERFORMANCE OBJECTIVES

* The student will define bioaccumulation of toxins.
* The student will research animals that have been affected by bioaccumulation of toxins.
* The student will participate in physical and chemical testing of water.

BACKGROUND

All living things require water for life. Water purity plays a part in the health of an aquatic environment. If the purity is not acceptable for the body of water, the organisms within the water and organisms that eat aquatic life can be harmed. Pollutants such as fertilizers, pesticides, oil, grease, sediments from improperly managed construction sites, crop and forest lands, bacteria from livestock, pet wastes, and faulty septic systems can enter natural waters and kill or seriously harm the plants and animals that live within the water. Pollutants can enter a stream at a specific, detectable source, such as industrial or sewage treatment plants. This is called point pollution. Nonpoint source (NPS) pollution is caused when rainfall or snowmelt moves over and through the ground. This runoff picks up and carries away natural and man-made pollutants. The polluted runoff enters surface and groundwater.

Pesticides are one of many pollutants that continually undergo scientific testing to verify their safety for human use and environmental health. DDT (dichlorodiphenyitrichloroethane) was a pesticide used in the 40's and 50's. The pesticide was thought to be safe, however, it was discovered that DDT collects in the fats of organisms and is not broken down. This results in the pesticide being passed through the food chain. In the 70's, DDT was outlawed.

One of the most widely studied affects of DDT was the near extinction of eagles. Runoff carried DDT into streams and lakes where it entered the Eagles food chain. Fish had ingested DDT through their food supplies. The eagles ate the fish and began to accumulate DDT in their bodies. Eventually the toxicity of the chemical built up (bioaccumulation of toxins) in the eagles leaving them sterile or causing the eggshells of their young to be so thin that they were easily broken by the weight of the adult eagles.

Chemical pollutants that have caused serious concern include DDT, PCB (polychlorinated biphenyl), and mercury. DDT has an affect on eagles and brown pelicans. PCB's have an affect on beluga and killer whales. Mercury is a problem for fish, such as tuna. Some pollutants such as oil are very obvious. On the other hand, DDT and other chemical pollutants are generally revealed through tissue sampling. These chemicals may be found in trace amounts in water; however to identify bioaccumulation scientists must look at the tissue of the organism. Limnologists study the physical, geographical, chemical, and biological aspects of inland freshwater systems. Tests are performed to determine temperature (physical) and the amounts of pH, nitrates, phosphates, copper, cyanide, etc. (chemical) within the water.

Temperature of natural waters is an important factor for aquatic life. Each creature is adapted to particular temperatures since fish and other aquatic life have no control over their body temperatures. Water temperature of 95?F is considered the maximum for most aquatic life Trees and brush provide shade for natural waters such as creeks, ponds, and lakes. When these areas are cleared for construction, the temperature of the water may be raised due to the increase in sunlight on the once shaded area. Changes in water temperature can affect aquatic habitats. This may result in the death of many aquatic creatures.

An important gas in water is oxygen. It is referred to as dissolved oxygen or DO. Oxygen is necessary for aquatic life. DO is found in cold water at higher levels than warm waters because oxygen is more soluble in cold waters. Cold waters have a DO measurement of 5.0 mg/L or higher. Oxygen is found in warm water at not less than 4.0 mg/L. Different organisms require different water temperatures and DO amounts. Some examples include carp, which is a warm water fish and lives in water with as little as 3 ppm of oxygen, while largemouth bass require 5 to 8 ppm.

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Phosphorus (phosphates) is found naturally in bodies of water. It is a nutrient for aquatic plants and is generally found at 0.1 ppm in natural waters. When phosphorus levels increase, it is a sign that agricultural wastes or wastewater has polluted the body of water. Several detergents include phosphates (dishwashing and clothes washing products). The phosphorus increases algae growth which increases oxygen levels from photosynthesis. Several cloudy days in a row can result in the algal dying. Oxygen is used in the decomposition of the algae resulting in fish kills due to a lack of oxygen.

Copper salts enter natural waters from industrial waste. These salts are used in electroplating, photography, textile manufacturing, and pesticides. A concentration of 0.015 to 3.0 ppm can be harmful to aquatic life. Copper salts destroy growths of algae resulting in depleted oxygen supplies.

Cyanide is a pollutant that would enter water as a metal finishing plant waste. This chemical is very toxic and should not be present in water.

The University of North Texas is monitoring water quality using clams. Each clam is submerged in Lake Lewisville and attached to a sensor. The sensors are connected to a computer system that records to what degree the clamshell is closed. Clams begin to close their shells when irritants are in the water making them natural indicators of pollutants.

See other lessons on: water, properties of water, water changes, nonpoint and point source pollution, and food chains.
<for more>

MATERIALS

* Water Quality Datasheet [WQlty/5-1] (copy a class set)
* LaMOTTE Water Quality Test Kits (dissolved oxygen, pH, nitrate, phosphate, copper, cyanide) 410-778-3100
* Thermometer
* Locate a creek, river, pond, lake to collect a water sample (if possible take the class to the site)
* Water collection containers (1 per group)
* www.ecoplex.unt.edu

OPENING

Brainstorm pollutants that can be found in natural bodies of water. (cans, tires, oils, pesticides etc.)

PROCEDURE

1. Explain to students how pollutants enter bodies of water.

2. Define bioaccumulation and describe how DDT entered the eagle food chain. Describe how DDT affected the eagles.

3. Divide students into research groups. Each group will research a toxin and its affect on wildlife. Suggested toxins and wildlife pairs include: DDT - eagles or brown pelicans, mercury - fish, PCB - beluga or killer whales. (Some research web sites are listed in resources.)

4. The students will create a public service video (mail to your local television station), grade level presentation or public address announcement. Within the video, presentation, or announcement, ask students to identify the pollutant, explain the impact to wildlife, and if possible, a suggested personal solution (using natural “pesticides” like ladybugs).

5. Define limnology. Explain to students that they will be taking on the roles of a limnologists and conduct temperature, pH, DO, nitrate, phosphate, copper, and cyanide.

(If possible, the students need to be taken to a water site to conduct the tests. If not, the teacher needs to record the temperature while at the site collecting the samples for later use.)

6. Divide students into small groups. Pass out testing datasheet.

Assign temperature, pH, DO, nitrate, phosphate, copper, and cyanide tests to different groups. (Temperature and pH can be grouped together due to the small amount of time it takes to conduct these tests.)

7. Complete the tests. Record data on WQlty/5-1. (Instruction and safety measures will be determined by the brand of tests purchased.)

8. Review the test results and compare to the freshwater requirements as mentioned in the background. Discuss the results.

9. Take students to the computer lab. Ask students to locate www.ecoplex.unt.edu. Compare the pH, DO, and temperature from the class samples to those at Lake Lewisville. Ask the students to notice if the clams are open. If the clams are closed, ask the students to brainstorm what they would do next. (Go to the lake and test the water to find out what type of irritant is present.)

10. Why would we want limnologists testing water from Lake Lewisville? (It's our drinking water source and recreation area.)

SO WHAT? (LIFE APPLICATION)

Why would bioaccumulation of toxins matter to humans? (We are a consumer of the plants and animals that might be affected.) Create postage stamps of those organisms affected by water pollution. Write a letter to the postmaster suggesting a series of environmental awareness stamps.

CURRICULUM EXTENSIONS

Science

Conduct water testing on a variety of water samples the students bring from home.

Math

Determine the difference between the class data and the healthy water or Ecoplex data.

Art

Create dioramas of the wildlife and habitat researched earlier in the lesson.

TEKS

Science: 5.1A,B, 5.2A,B,C,D, 5.4A,B

RESOURCES

DDT

http://www.ma.org/classes/oceanography/swong/ddt.html

http://www.dnr.state.oh.us/odnr/wild life/publications/wildnotes/eagle.html

Mercury

http://www-seafood.ucdavis.edu/pubs/mercury.htm

http://wwwdwimdn.er.usgs.gov/pubs/FS-216-95/

PCB

http://www.tgmag.ca/envbrain/beluga.html

http://www.msnbc.com/news/327797.asp?cp1+1

http://home.earthlink.net/-sloturtle/elissa.html

Food webs

http://www.broadwaters.fsnet.co.uk/food-web.htm

6th Grade
Water Quality Lesson

Water O_2 and You!

LEARNING OBJECTIVES

The student will begin to understand the relationship between photosynthesis, dissolved oxygen and the quality of water.

STUDENT PERFORMANCE OBJECTIVES

* The student will be able to define photosynthesis.
* The student will make observations about terrestrial and aquatic plants undergoing photosynthesis.
* The student will determine that photosynthesis is one way oxygen gas dissolves in water.
* The student will define dissolved oxygen and begin to understand its affect on the quality of water.
* The student will use probes to determine the dissolved oxygen content of water.
* The student will look up the dissolved oxygen levels of Lake Lewisville on the ECOPLEX web site.

BACKGROUND

Water quality refers to the condition of water in relation to the number of contaminants in the water. Many contaminants are man made; however, natural processes such as erosion can cause natural contaminants as well. Contaminants, such as nitrates found in fertilizers and soil, can cause plants such as algae to become abundant. As the algae die and begin to decompose they use up much of the oxygen in the water. Oxygen is the primary source of life for plants and animals, one way to determine the quality of water is to determine the amount of dissolved oxygen in the water.

Oxygen available to aquatic organisms is found in the form of dissolved oxygen. Oxygen gas is dissolved in a stream or lake through aeration, diffusion from the atmosphere and photosynthesis of aquatic plants and algae.

Plants and algae create oxygen through a process called photosynthesis. Plants combine sunlight with carbon dioxide and water to produce glucose and oxygen ($6CO_2$ + 12 H_2O ----light ----> $C_6H_{12}O_6$ + $6O_2$ + $6H_2O$). Photosynthesis occurs in the chloroplasts of plants and algae cells and on the plasma membrane of some bacterial cells. It is the main energy source for all living things because it supplies carbohydrates for both plants and animals.

Photosynthesis, aeration and diffusion from the atmosphere supply oxygen in the water for consumption by organisms in the water. Dissolved oxygen in water is necessary for sustaining aquatic life. Plants and animals in the lakes or streams consume oxygen in order to produce energy through respiration. In a healthy stream or lake, oxygen is replenished faster than it is used by aquatic organisms.

Different organisms need different amounts of oxygen to survive. Organic pollutants can consume large amounts of dissolved oxygen. When aerobic bacteria decompose and oxygen is depleted faster that it can be replaced, the decrease in dissolved oxygen is known as the biochemical oxygen demand. This lowers the amount of oxygen in the water and may change the population dynamics of the organisms in the water.

Adequate dissolved oxygen is necessary for good water quality. Dissolved oxygen concentrations can range from 0 to 15 mg/L. The ecological quality of water depends largely on the amount of oxygen the water can hold. The higher the level of dissolved oxygen the better the quality of the water system. By testing for dissolved oxygen, scientist may determine the quality of the water and the healthiness of the ecosystem.

See other lessons on water, properties of water, water changes, non-point and point source pollution, food chain, and bioaccumulation of toxins.
<for more>

MATERIALS

* Fast growing plant seeds (such as Wisconsin fast plants, grass seeds, radishes or peas)
* Potting soil
* Fertilizer (as needed for plant seeds)
* 6 inch pots, styrofoam cups or potting trays (enough for each group of students to plant at least two plants)
* Lighted area for growing plants (window sill or UV lamp)
* Darkened area for growing plants (cabinet or cardboard box)
* 2 glass jars
* Elodea plants in an aquarium if you cannot get to a pond, lake or stream
* Locate a pond, lake or stream (to demonstrate photosynthesis in the water and for the dissolved oxygen test)
* Dissolved Oxygen Probe and instructions for use

OPENING

Discuss with the class:

All living things need oxygen.

Ask the class:

How do aquatic organisms get oxygen?

PROCEDURE

1. Define photosynthesis as the process by which plants combine sunlight with carbon dioxide and water to produce glucose and oxygen.

2. Discuss the importance of sunlight for photosynthesis to take place.

3. Divide the class into groups of 2-4.

4. Explain to the students that they will be conducting an experiment demonstrating the process of photosynthesis and the need for sunlight to complete photosynthesis.

5. Distribute planting materials for each group.

* Fast growing plant seeds (such as Wisconsin fast plants, grass seeds, radishes or peas)
* Potting soil
* Fertilizer (as needed for plant seeds)
* 6 inch pots, styrofoam cups or potting trays (enough for each group of students to plant at least two plants)

6. Explain that each group will set up an experiment using two plants; one to place in the lighted area and one to place in the darkened area.

7. Have the students plant their seeds in their containers and label the containers with their group information (name, etc.).

8. Have the groups place one plant in the lighted area and one plant in the darkened area.

9. Have the students observe, draw and label their plants each day for one week or 10 days. Students will water their plants as needed during the observation time.

10. At the end of the observation time, have the students compare their drawings and make inferences as to the need for sunlight for plant growth and photosynthesis.

11. Have the students place the plant that was in the dark in the light for a few days. Students will observe, record and make inferences about the plant growth.

12. Have the students place a glass jar over the plant that was in the light and place it back into the light.

13. Discuss the condensation that occurs on the glass. Explain to the students that the condensation is water vapor given off by the plant during photosynthesis when it exchanges oxygen for carbon dioxide. This condensation is called transpiration.

14. Discuss the formula for photosynthesis ($6CO_2$ + 12 H_2O ----light ----> $C_6H_{12}O_6$ + $6O_2$ + $6H_2O$) and explain that water is a product of photosynthesis along with glucose and oxygen.

15. Take another glass jar and and completely submerge the jar in the water of an aquarium or pond so that there is no air in the jar. Then place the jar over the elodea in an aquarium or over a green plant in a pond, lake or stream. Make sure that the jar is completely filled with water over the plant.

16. Have the students observe, draw and label what their plants look like in the jar when the jar is first placed on the plant.

17. Have the students observe, draw and label their plants in the jar after a period of time (Students should check every 15 to 30 minutes for changes. The amount of time necessary for observations depends on the amount of light the plant receives.) They should see oxygen bubbles in the top and sides of the jar.

18. Explain to the students that the bubbles are oxygen, a product of photosynthesis. Explain that this is one way that oxygen gas dissolves in water.

19. Have the students test for dissolved oxygen by using a PROBE, following the instructions for their probe.

20. Discuss the importance of dissolved oxygen for the plant and animal life in the pond.

21. Have the students explain what would happen to the plants and animals if there was not enough oxygen in the water.

22. Have the students look up the ECOPLEX web site and determine the amount of dissolved oxygen in Lake Lewisville

and discuss the quality of the water based on the amount of dissolved oxygen.

a) Go to Ecoplex web site.
b) Click on Clams under Water Quality
c) Click on Water Quality Data
d) Click on Water Quality Sonde 1
e) Scroll down to Dissolved Oxygen and record the current level of dissolved oxygen. (Teachers may want to have the students discuss the data and the graphs on this page)

SO WHAT? (LIFE APPLICATION)

Discuss the importance of dissolved oxygen on water quality.

Photosynthesis is important to life. Have the students complete a food chain to demonstrate the importance of the sun's energy for humans.

CURRICULUM EXTENSIONS

Science:

Following the directions for the dissolved oxygen PROBE, determine the effect of temperature on dissolved oxygen.

TEKS:

6.1(A) (B), 6.2(B), 6.8 (B), 6.12 (B) (C)

RESOURCES

http://ecoplex.unt.edu/main

http://www.trms.ga.net/habitat/lessons/photosynthesis.html

http://wwwbrr.e\cr.usgs.gov/projects/SW_corrosion/diel-poster/abstract.html

http://www.acnatsci.org/erd/ea/pollnb2.html

7th Grade
Water Quality Lesson

Taxa-Rich and Taxa-Poor!

LEARNING OBJECTIVES

The student will be able to examine the quality of water by analyzing macroinvertibrates in the water.

STUDENT PERFORMANCE OBJECTIVES

* The student will demonstrate how energy flows through the environment.
* The student will identify an algae bloom and explain its effects on dissolved oxygen in water.
* The student will define macroinvertibrates and begin to understand that some macroinvertibrates are more pollution tolerant than others.

BACKGROUND

An ecosystem is a community of living and non-living components. Living things require the sun to provide energy needed to carry on life functions. Plants change light energy into a chemical energy through a process called photosynthesis.

The process of photosynthesis also provides oxygen for plants and animals to use. In a water ecosystem this oxygen is dissolved and is used by aquatic organisms. Different organisms require different amounts of dissolved oxygen. Nitrates and phosphates, which occur naturally and are found in fertilizers, are considered limiting factors of dissolved oxygen.

These nutrients can cause algae to bloom. Algae, classified as protist, are often mistaken for plants because they are green and utilize the process of photosynthesis. When nitrates and phosphates are added to a body of water algae can grow very quickly or "bloom". As the algae grow and spread across the water, they can block the sun and prevent photosynthesis by plants beneath the water. The algae bloom uses the oxygen in the water and when the demand exceeds the supply they die in large numbers. Bacteria that decomposes the algae also requires and uses the dissolved oxygen. This lowers the amount of oxygen available for other organisms.

Different organisms are able to tolerate different levels of dissolved oxygen. Different levels of pollution can affect the amount of dissolved oxygen. Macroinvertibrates are organisms that are visible to the naked eye and do not have backbones. In freshwater, they include aquatic insects, crustaceans, mollusk, aquatic snails and aquatic worms. These organisms are easy to gather and study as they are restricted to their environment and cannot escape changes in water quality.

Taxa is one of the hierarchical categories into which organisms are classified. Taxa-richness refers to the number of different organisms found in a particular body of water. The variety of species that live in and tolerate the water is an indicator of the water quality.

MATERIALS

* 3 Liter bottle
* 2 Liter bottle
* 1 Liter bottle
* Small bottle (to hold approx. 20 ml)
* Graduated cylinders (100 ml, 25 ml, 10 ml)
* Green food coloring mixed in 3 Liters of water (put in 3 L bottle)
* Construction paper symbols or magazine symbols of sun, plant, and 3 animals (best if symbols represent a true food chain[1 herbivore, 1 carnivore, 1 tertiary consumer])
* Baby food jars (one per group)
* Plant fertilizer pellets or plant food
* Algal culture (order from biology supplier)
* Hot tap water enough to fill baby food jars (aged for one day)
* Light source (florescent works best)
* Water sampling equipment (coffee cans at the end of a broom stick, nylon stockings over the bottom of a bleach bottle, half-gallon milk carton, etc)
* Data sheet [WQlty/7-1]
* Field guide (freshwater aquatic organisms)
* Data collection sheet [WQlty/7-2]

OPENING

Discuss with the class:
An ecosystem is a community of living and non-living components.

Ask the class:
What do plants and animals in an ecosystem need to survive? Does an aquatic ecosystem have the same needs as a terrestrial ecosystem?

PROCEDURE

1. Get the bottles and graduated cylinders.

2. Fill the 3L bottle with the green water and place the sun symbol on the bottle. Have a student volunteer to be the sun and stand in the front of the room with the 3L bottle of green water.

3. Have another student volunteer to be a plant and give that student the 2L bottle with a plant symbol on it. The plant volunteer will stand next to the sun.

4. Review photosynthesis with the students and have the sun give energy to the plant (pour green water into the two-liter bottle).

5. Explain that the plant uses that sunlight (water) to make food (glucose) for energy.

6. Ask another student volunteer to be a primary consumer that eats the plant (example: grasshopper). Give that student the 1L bottle with a herbivore on it.

7. Explain that the primary consumer gets its energy from the plant. Have the plant student pour 200 ml of green water into the 1L bottle (students need to use graduated cylinders to measure).

8. Have another student volunteer to be a secondary consumer that eats the primary consumer (example: frog). Give that student the smaller bottle with a carnivore/omnivore on it.

9. Explain that the secondary consumer gets its energy from the primary consumer. Have the plant student pour 20 ml of green water into the smaller bottle (students need to use graduated cylinders to measure).

10. Have another student volunteer to be a tertiary consumer that eats the secondary consumer (example: snake). Give that student the smaller bottle with a tertiary consumer on it.

11. Explain that the tertiary consumer gets energy from the secondary consumer. Have the plant student pour 2 ml of green water into the 10 ml graduated cylinder.

12. Discuss the flow of energy through an ecosystem. Explain that as the animals in the food chain consume organisms along the food chain they receive less of the sun's energy.

13. Explain that like plants, all animals need photosynthesis to survive. (You may want to review the lesson Water, O_2 and You to explain how oxygen dissolves in water).

14. Discuss with the class how nitrates and fertilizers can get into a water source through runoff and erosion.

15. Distribute baby food jars and explain how the students are to use the fertilizer (put pellets into jar, use eyedropper to put liquid fertilizer into jar).

16. Have students put fertilizer into jar (varying amounts are o.k. as long as jars are labeled with the amount of fertilizer used).

17. Have students fill the jar with warm tap water (aged for 1 day) up to 2 cm from the lid of the jar.

18. Have the students add one dropper full of algae to their jars. (Safety: students need to wash their hands after using fertilizer and algae)

19. Place all jars under the light source.

20. Have the students observe, draw and record their jars daily for one week.

21. Discuss the amount of algal growth with the students. Explain that when the algae grows this fast it is often referred to as an "algae bloom". Explain how the growth can prevent light from getting to the bottom of the water source. Explain that as the algae die (in large numbers) the bacteria uses more oxygen to decompose the algae.

22. Explain to the students that different organisms are able to tolerate different levels of nitrates, phosphates and dissolved oxygen.

23. Define macroinvertibrates as organisms that are visible to the naked eye and do not have backbones. Explain that these organisms are good sources to collect and study to determine the water quality of a water source.

24. Explain that certain macroinvertibrates are more tolerant or intolerant of pollution and by taking samples of these organisms we can generally determine the quality of the water.

25. Go to a local water source and have the students collect water samples and samples of macroinvertibrates.

26. At the site or in the classroom, have the students collect and count the numbers of macroinvertibrates they find. Students may use the field guides and the datasheet WQlty/7-1 to identify their organisms.

27. Have the students record the numbers of each macroinvertibrate on the data sheet [WQl/7-2].

28. Have the students use the datasheet WQlty/7-1 to evaluate the quality of the water.

29. Have the students use the ECOPLEX web site to look up the different levels of dissolved oxygen, nitrates and phosphates in Lake Lewisville.
    a) Go to Ecoplex web site.
    b) Click on Clams under Water Quality
    c) Click on Water Quality Data
    d) Click on Water Quality Sonde 1 : Scroll down to Dissolved Oxygen, Nitrates and Phosphates and observe and record the levels of the lake.
    e) Have the students discuss which level of macroinvertibrates they might find in Lake Lewisville.

SO WHAT?
(LIFE APPLICATION)

Have the students research different fertilizers to find out which are less likely to cause algae blooms in the water source. Have students also find out how people can use fertilizers safely and create a brochure for the safe use of fertilizers.

CURRICULUM EXTENSIONS

Science:

Schedule a field trip to the Elm Fork Education Center. Have the students complete the Pre-Visit and Post-Visit activities.

TEKS:

RESOURCES

Name_______________________________________

Product	Disposal Directions: recycle	Disposal Directions: trash	Disposal Directions: govt. regulations	No Directions

Name________________________________

Product	Phosphates/Phosphorous Contains	 Does Not Contain	Not Listed

WATER QUALITY DATASHEET

Enter test results in the grid below. Circle the results that are within safe drinking water guidelines. Parts per million will be noted as ppm.

List any living creatures visible at the water sample site? ______________________________

List any plant life visible at the sample site? ______________________________

Do you think the body of water appears healthy? __________ List your reasons ______________________

____

	pH	Temperature	Nitrates	Phosphorus	Copper	DO
Water Sample						
Healthy Water	5.0 – 8.5	>95	0.1ppm or less	0.1 ppm or less	>0.015 ppm	Depends on temp.
ECOPLEX			NA	NA	NA	

Can you tell if water is healthy by observation alone? Explain. ______________________________

____

Compare the ECOPLEX and class data. Are there differences? Explain. ______________________________

WATER QUALITY DATASHEET

Enter test results in the grid below. Circle the results that are within safe drinking water guidelines. Parts per million will be noted as ppm.

Do you see any signs of living creatures at the water sample site? If so, list them. ____

____

Is it possible to tell if the creatures are healthy, by looking at them? ____

____

Do you see plant life at the sample site? ____

	pH	Temperature	Nitrates	Phosphorus	Copper	DO	Cyanide
Water Sample							
Healthy Water	5.0-8.5	>95	0.1 ppm or less	0.1 ppm or less	>0.015ppm	Depends on temp.	0
ECOPLEX			NA	NA	NA		NA

Do any of the results seem unreasonable? ____

What pollutant source could be the cause of any unreasonable readings? ____

First Grade
Water Quality

Water---It's a Gas…Sometimes!

LEARNING OBJECTIVE

The students will understand that water can be a solid, liquid or a gas and will begin to understand some properties of water.

STUDENT PERFORMANCE OBJECTIVES

* The student will recognize the importance of water and how much of the Earth's water is available as fresh water.
* The student will understand that water can be found in three forms within the Earth's normal temperature range.
* The student will begin to understand the chemistry of water.
* The student will begin to understand surface tension and cohesion.
* The student will begin to identify the difference between a solution and a suspension.
* The student will begin to understand that water properties can affect water quality.
* The student will understand that methods of disposal of household chemicals can affect water quality.

BACKGROUND

Water is the most common substance on Earth. Every living organism needs water to survive. Although approximately 75% of the Earth's surface is covered with water, only about 1% is available freshwater for sustaining all life on Earth. (see water cycle lesson)

Water, like all matter, contains tiny particles called molecules. A drop of water contains millions of molecules. Each molecule contains smaller particles called atoms. Water molecules consist of two hydrogen atoms and one oxygen atom. The chemical symbol for water is H_2O.

Water can be a liquid, gas or solid. Water is the only substance on Earth that can naturally occur in three different forms. The form water takes depends on how fast the molecules are moving. As a solid (ice) the water molecules are far apart and move very slowly. As a liquid, the molecules are close together and move freely. When water is a gas, the molecules are very close. They move about violently and bump into each other. The rate of water molecule movement depends on the water temperature.

Surface tension is the force that causes the surface of water to appear as if a thin, elastic (almost skin-like) film covers it. The spherical shape of water drops is due to surface tension. Surface tension allows the surface of water to support objects. Cohesion refers to the attraction between the water molecules. Cohesion causes surface tension.

Water is an almost universal solvent. This makes it very easy for water to contain many dissolved substances. Some of those substances can adversely affect water quality. Toxic substances, hazardous chemicals, pesticides and minerals can all be polluters of water. When one substance mixes (dissolves) into water, a solution is formed. When particles of a substance do not dissolve, a suspension is formed. Gas and oil as well as solids do not mix with water and are water pollutants. Sewage, industry, and agriculture are all sources of water pollution. When people dispose of household products like paint, bug spray, nail polish and household chemicals by pouring them down drains or adding them to the landfills, these chemicals can seep into our groundwater or reservoirs and affect water quality. Water trapped beneath the ground is groundwater. Because water is a solvent, it can collect small amounts of whatever it comes in contact with. Rains that soak in, rivers that flow underground in certain areas, and melting snow are all sources of groundwater (for more information see watershed lesson). Due to its many sources, groundwater may contain many contaminants such as pesticides, insecticides, industrial wastes, as well as dissolved minerals. Scientists have developed tests to determine water quality. These tests measure foreign matter (microorganisms, chemicals, industrial or other wastes) as well as the physical/chemical condition of the water (temperature, dissolved oxygen, pH, etc.).

Several kinds of scientists study water. Hydrologists study water-related problems in society such as problems of quantity, quality and availability. Limnologists study water and aquatic life in freshwater. Oceanographers study water and aquatic life in saltwater.

<for more>

MATERIALS

* Waxpaper, approximately a 6 inch square per student
* Cup to hold small amount of water, one per student
* Powdered drink (Kool-Aid®, lemonade, etc.) enough to mix for each child to get a drink
* Pitcher of water to mix powdered drink mix
* Drinking cups, one per student

* Jar, one pint or larger
* Oil, vegetable or motor
* Four paper signs that say Hydrogen on one side and Water on the other side
* Two paper signs that say Oxygen on one side and Water on the other side
* Pepper
* Cups-one per group of students (procedure 7)
* Recording sheet [WQlty/1-1]
* Eyedropper
* www.ecoplex.unt.edu

OPENING

Ask the class:

What do you know about water?

PROCEDURE

1. The opening question should allow you to gauge the class's level of water knowledge. Lead the discussion to cover: how much of the Earth is water, how much of the Earth's water is usable fresh water, the water cycle, kinds of water, water sources, and uses of water. For more information and activities to introduce these concepts if they are unfamiliar to your class, see water cycle and watershed lessons**.** The procedures in this lesson are divided by the concepts: *states of water, chemistry of water, surface tension, water as a solvent*, and *water quality.*

   The states of water:

2. Explain that water is the most common and one of the most unusual substances in our lives. No other substance can be a liquid, solid or gas within the Earth's normal temperature range. Ask the students to identify the different states of water. (Examples: liquid--faucet water, rain, lakes, etc.; solid--ice, popsicles, etc.; gas--water vapor as seen in clouds, steam, during evaporation and transpiration.)

3. Show the students hand movements to show the three "states" of water. To demonstrate a solid, hold hands in front of you with palms facing each other approximately 24 inches apart and barely moving back and forth. To demonstrate a liquid, let your hands do a hand over hand rolling movement in front of your chest area. To show a gas, move your hands in a rolling motion in big sweeps in front of the torso area of your body. Explain that when water is a solid (ice) the molecules are far apart and almost still. In a liquid state (rain), the molecules are close together, but move more freely. As a gas, the molecules are close together. They move about violently and bump into

each other as they vaporize. Remind the students of boiling water as it turns to water vapor (gas).

4. Call out different items that contain water while the students demonstrate their understanding of water molecules with their hand movements. (*Solids*: ice, glacier, ice caps, icebergs, etc., *Liquids*: soda pop, rain, creek, soup, etc., *Gas*: steam, cloud, etc.)

The chemistry of water:

5. Explain to the students that water, like all matter, consists of tiny molecules. A drop of water contains millions of molecules. Each molecule consists of even smaller particles called atoms. One oxygen atom and two hydrogen atoms when combined make water. (Remind them that they are breathing oxygen right now.) A simple sketch might help the student visualize the two hydrogen atoms and one oxygen atom combining to form water. Choose six students to pick up a hydrogen or oxygen sign and challenge them to "join" to form a water molecule. When they think they've formed a water molecule, they will turn their signs over to show water. Repeat, allowing all students to have a turn.

Surface tension:

6. Give each student a square of waxpaper with a drop (or two) of water. Allow the students to watch the drop roll around. Be sure they observe that the water drop appears to have a skin around it that holds it in a sphere. This property of water is called surface tension. As they observe, remind them that each drop contains millions of molecules and inside each molecule there are tiny atoms of hydrogen and oxygen!

7. Divide the class into groups of 2 or 4. Give each group of students a small container or cup of water and pepper to shake on top of the water. (This could be demonstrated using the overhead projector before each group gets their own supplies.) When pepper is shaken on the water, most of the pepper floats on top due to surface tension. Add one drop of liquid soap to the water. The pepper scatters to the side of the container because the soap causes a break in the surface tension.

8. Ask the students if they have ever seen water striders or other insects move or rest on the surface of a pond or other body of water. Surface tension allows the insects to stay on top of the

water because their legs don’t break the surface tension.

Water as a solvent:

9. Take out the pitcher of water, powdered drink mix and cups for each child. Show the drink powder. Mix it in the pitcher. Pour each child a drink. Ask the students what happened to the powder when you mixed it with water. Remind them of the molecules of water. The molecules of powder mixed completely with the molecules of water. Explain that when one substance dissolves (mixes) in another one we call it a solution. Think of other solutions (other drinks made with powder, cheese sauces made with powdered cheese, etc.). Another interesting property of water is that in it’s liquid state, water is an almost universal solvent. This means many things dissolve in water. Ask if the students can think of other things that dissolve in water.

10. Ask if all liquids dissolve in water. Encourage the students to give examples. Fill a jar ½ full of water. Add vegetable oil, motor oil, or other type of oil. Shake the jar and ask students to describe what they see. Explain that when two substances don’t mix, it’s called a suspension. They may have seen this in oil and vinegar dressing, tomato juice or other unstrained liquids. Ask what they think is happening to the molecules of oil and water.

Water quality:

11. Explain that sometimes chemicals, oils and other substances get into water that make it dirty or polluted. Sometimes we can see or smell when water is polluted, but not always. Some chemicals dissolve in water—like the powdered drink mix. These could be pesticides and fertilizers that we use on our lawns and that farmers use on croplands. (Share background information.) Other substances like oil and grease don’t dissolve in water. They stay on the surface.

12. Our drinking water and natural water (lakes, reservoirs, ponds, etc.) are tested to be sure they are “clean” for their intended use. Water quality is based on not having too many “bad” things (pollutants) and enough “good” things such as oxygen. These “things” vary depending on the use of the water.

13. Locate www.ecoplex.unt.edu. Show the students the various information available. Explain that the water quality section allows us to see the test results for Lake Lewisville. Help the children realize that water quality is very important, and that scientists test water to monitor water quality. Look at some of the data available. Encourage the students to notice the different tests that are ongoing.

14. Since many things that go down our drains or into the ground eventually enter our water supply, it is important for each of us to monitor what we put down our drains or throw away in our trash. The way our families and industries dispose of wastes may damage our water supply. (see watershed lesson)

15. When we dispose of household chemicals according to the directions on the containers, we are protecting both our drinking water supply and the natural waters in our watershed.

SO WHAT?
(LIFE APPLICATION)

Students will discuss with their families how to dispose of household chemicals. Using recording sheet [WQlty/1-1], families will list a few products found in their homes, read disposal guidelines, record, and return the sheet to school.

CURRICULUM EXTENSIONS

Science

Sink and Float-set up a sink and float discovery center. Try the objects in saltwater and freshwater. Are there any differences?

In the science center, set up several things that could be mixed with water to see if a solution is formed (salt, sugar, sand, etc.)

Surface Tension-Fill a clear plastic cup completely full of water. Ask if the students think the cup will spill over if you add a penny to the cup. Gently slide a penny down the side of the cup. Let children help you continue sliding pennies in until it spills over. (This will take about 50 pennies)

Math

Predict how many pennies will be added to the cup in the above activity before the water spills over.

Give each child a penny, a cup of water and an eyedropper. Ask them to predict how many drops of water they think their penny will hold (as a result of surface tension). Record the predictions. Record the results. Will “heads” or “tails” hold more water?

Social Studies

Invite a classroom speaker from the water quality office in your community.

Schedule a field trip to the wastewater or water treatment plant.

Try to arrange a field trip to a creek, pond or other natural body of water to observe the habitat. City parks often have ponds or creeks.

Art

Ice Sculptures-Freeze ice in many different containers. Using big blocks of ice as a base, attach other ice shapes to the big blocks. This can be accomplished by using table salt as a glue (do not use rock salt). Drip food coloring on the sculpture to add color.

Language Arts

Allow the children to gather clean, empty product containers that the contents have been disposed of properly. Share disposal information with other classes.

TEKS

Science: 1.1A,B, 1.2A,C,D,E, 1.3A,B,C, 1.4B, 1.9A,B

RESOURCES

FAQ’s

Related Children’s Literature:

Solid, Liquid, or Gas by Sally Hewitt

Water by Frank Asch

A Drop Around the World by Barbara McKinny

Follow a Raindrop by Elsie Ward

What Will Float? by Fred and Jeanne Biddulph

What Makes It Rain? by Keith Brandt

The Magic School Bus at the Waterworks by J. Cole and B. Degan

Kindergarten
Water Quality

Water in Me

LEARNING OBJECTIVE

The students will begin to understand the importance of the quality and availability of water to life on Earth.

STUDENT PERFORMANCE OBJECTIVES

*The student will locate water globally and locally.
* The student will begin to understand the importance of water to life on Earth.
* The student will identify different kinds of water.
* The student will identify various purposes of water and understand that water quality can affect its intended use.
* The student will begin to recognize that human actions affect water quality.
* The student will use the five senses to describe water.

BACKGROUND

Water is a fundamental requirement of all living things. Although seventy-five percent of the Earth is covered by water, the amount of freshwater available to sustain life is limited. Approximately ninety-seven percent of all water on Earth is saltwater and cannot be used for drinking or for terrestrial plant growth. The remaining 3% is freshwater, but 2/3 of that is unavailable for use because it is frozen in glaciers or ice caps. This leaves only 1% of the Earth's water as usable fresh water. (see <u>water cycle</u> lesson)

Essentially, the amount of water on Earth has not changed since the beginning of time. Although we drink, spill and throwaway water every day, The Earth has a natural system, the hydrologic (water) cycle, which produces fresh rainwater over and over. The water we use today is the same water used by the dinosaurs and our great great grandparents. Because our water has been used so many times and due to the population growth and wide use of chemicals in our daily lives, water quality is a concern for all of us.

Wastes such as chemicals, metals and oils cause pollution of our water supply. Some polluted water can be identified by sight (shiny oil films, suds, color, etc.) and smell (sewage odor, sulfur smell, etc.). However, it is difficult to identify all polluted water by appearance because sometimes contaminated water shows no noticeable signs. Some common sources of pollution are sewage, industry and agriculture.

Water quality is important and monitored for both our drinking water and our natural waters. Changing the condition of our natural waters in ways, which harm or exclude normally occurring aquatic life is an act of pollution. When natural waters (reservoirs, lakes, streams, ponds, bays, rivers and estuaries) are free of foreign matter and support a wide variety of aquatic or marine life, they are said to be of good quality. When our drinking water passes federal and state testing standards, it is also considered to be of good quality. Standards for drinking water and natural water are different. Drinking water would not make a good pond or other natural water body because it would be low in the nutrients (nitrogen and phosphorous) for algal growth. Without algae, baby fish could not survive and the food chain of the pond would be altered.

Several kinds of scientists study water. Hydrologists study water-related problems in society such as problems of quantity, quality and availability. Some chemists specialize in the study of water. Aquatic toxicologists study the effects of chemicals found in water on the health of aquatic organisms. Limnologists study water and aquatic life in freshwater. Oceanographers study water and aquatic life in saltwater.

Every living organism has water in it. Flowers, trees, birds, snakes, whales and insects all contain water. The human body is approximately 70% water. Adults need more than 2 quarts of water each day to stay healthy. We get water from things we eat as well as things we drink. A person can live without food for one month. A person can only live for about one week without water. When people or other living organisms lose water and it is not replaced, dehydration occurs. Dehydration is a serious health concern for humans and animals.

The process of dehydration is used often in the food industry to help preserve foods by drying them. Dehydrated foods are lightweight and compact, which has many advantages over fresh, frozen and canned foods. Exposing fish and meat to the sun's rays for drying has been used for thousands of years.

<for more>

MATERIALS

* Clear 2 quart pitcher of water

* Clear container of water, 1 quart size or larger
* 8 oz. cups (one per student)
* Four 6-8 oz. clear plastic cups
* Yellow (or any color) food coloring, a few drops
* 1/3 cup vinegar
* 1/8 cup of liquid detergent (clear, if possible)
* Blank paper
* Crayons
* Wax paper
* Eye droppers (straws or small squeeze bottles can be substituted)
* Drinking straws
* Toothpicks
* A few grapes
* A slice of apple
* A stack of 10 unifix cubes for each student (or other set of 10 objects)
* Eyedroppers, 1 per child or pair of children.
* www.ecoplex.unt.edu
* **TEACHER PREPARATION:** Using the four clear plastic cups, put about ½ cup of water in each cup. In one cup, add yellow food coloring. In a second cup, add vinegar (enough to detect the odor). In the third cup, put in some clear liquid detergent (enough to give the water a slick, soapy feel, but no suds). The fourth cup will be tap water. Put these cups where the class can't see them until you are ready to use them.

OPENING

Ask the class:

What is water?

PROCEDURE

1. Listen to a few of the students' ideas, then ask, "Where is water?" Use a globe to show various locations of water. Continue asking questions such as: Is all water the same? Who/what uses water? Is there lots of water for us to use? Each time listen to a few ideas and keep the discussion lively as you ask the students to tell why they think as they do. (Use the water cycle lesson activities if the students don't realize how little of the water on Earth is usable fresh water.)

2. Show the pitcher and other container of water. Tell the students that the water came from the faucet. Is it safe to drink? (Yes) Ask the class to tell you other places where water can be found (lakes, reservoirs, rivers, ponds, puddles, etc.). Ask how drinking water is different from water in the other locations.

3. Explain that the students will describe water using their five

senses. Since all water is not the same, they will have two lists. Write two headings: "Drinking Water" and "Other Water". Beginning with eyes, list characteristics of water (clarity, color, etc.). Continue with nose (different odors); skin - allow the children to touch the water that is not in the pitcher to stimulate descriptive words, (temperature, etc.); ears (include sounds of a river, waterfall, brook, ocean-use shells, etc.); and taste - give each child a taste of the water from the pitcher to help stimulate vocabulary. Although we do not drink lake water, some of the children may have gulped a small amount, in a pool, lake or ocean, and can remember the taste to add to the list.

4. Review the lists with the class and help them notice that drinking water and other types of water have different characteristics. Ask if the students would drink pond water. Is pond water okay for fish, frogs and other animals? Review the same idea with reservoirs and lakes.

5. Introduce the term, water quality. Water quality refers to the "cleanliness" or "naturalness" of water. Water quality means different things to different organisms. Good water quality for a frog is different from good water quality for our drinking water. Why? Why wouldn't our drinking water be good pond or lake water? (Drinking water treatment reduces the concentration of necessary nutrients to support fish and aquatic life, and chlorinated water is toxic to aquatic life.)

6. Water quality is measured by special tests. Scientists who study freshwater are hydrologists and limnologists. Many people work to make sure our drinking water is safe. Ask what the students think makes "safe drinking water". Show the four cups of water you prepared before the lesson. Ask what they think is in the cups (water). Why? Is it safe to drink unknown liquids? (No) Let's use our five senses again to discover what might be in the cups. Remind the students that we can not trust our five senses to tell us that water is clean and safe to drink. Name the senses, and establish that taste can't be used. Start with eyes. Encourage students to describe what they see. Next, use ears and describe what they hear. Allow students to touch the water and describe what they feel. The students might be able to identify the soapy water. Last, use the sense of smell and describe. Make a list of the guesses to identify the unknown liquids. Check the guesses with the actual contents of the cups. Although our five senses give us clues to water quality, testing water is how our government and local officials determine if water is clean and safe to drink. This testing

measures substances or properties that humans can not sense directly. Scientists test reservoir water as well as drinking water. Why? (Even though we don't drink this water, we want it unpolluted for aquatic life and for our recreational uses. The water in our lakes and reservoirs also becomes drinking water after further treatment.)

7. Water is very important to us. Our bodies have lots of water. Give each child a stack of 10 unifix cubes. Ask the class to imagine that the unifix stack is their body. Ask them to take off the number of cubes that they think would represent how much of their body is made of water. As the children guess, put the different number of cubes in different areas (ex: all the stacks of 2 in one area). Review the guesses. The correct answer is that approximately 70% of our bodies are water. Seven cubes would represent the amount of water in their bodies. Allow children time to discuss and process the information. Gather the cubes.

8. We need to drink eight cups (8 oz) of water every day to stay healthy! To help us get in this good health practice, we will keep a log of the water we drink each day. Give each child an 8 oz. cup with initials or name clearly marked. Give each child a piece of plain white paper, and tell them fold it into fourths. Open the paper and draw a line on the fold lines on both sides. This will give a total of 8 squares. Each student will put his/her name in one square and the name or initial for the days of the week in each of the seven remaining squares. (One day in each square.) Give each child a cup of water to drink while working on the paper "water log". They will begin the log by placing a tally mark for the cup of water they are currently drinking in the correct day square. Students will keep their log in desk/cubby and mark it each time they drink a cup of water or other liquid. They will take the log home daily for one week.

9. Explain that when people or other living organisms lose water and it is not replaced, dehydration occurs. Dehydration in humans and animals is very dangerous. Ask the students if they remember being sick and the doctor or parents reminded them to drink lots of liquids. Do they think their pets need fresh water daily? Why? (Same reasons as humans.)

10. Explain that there is lots of water in other living things. Show the grapes and apple slice. Both of these fruits have lots of water. Ask the class what will happen to the water inside the fruits if we leave them on the shelf for a few days. Start the

Grape and Apple Experiment by setting the fruit in a sunny area of the classroom. Later, the students will begin their entries in either a class or individual science journals to record daily observations. (See water cycle lesson if students don't understand evaporation.)

11. To help students understand the importance of water quality, locate www.ecoplex.unt.edu. List the types of tests that are found. Show the students that the water tests are ongoing. Remind the students that these tests help monitor the water quality to benefit humans and aquatic life in the reservoir. (Half of the class could be involved in the following activity to allow a small group to view and discuss ECOPLEX.)

12. Allow the students some time for free exploration of water. Give each child (or pair of children) a piece of waxpaper, a cup with a small amount of water, an eyedropper, and a toothpick. Students should observe how water moves on the waxpaper. Can they move water by blowing on it? Can the toothpick separate a drop?

SO WHAT?
(LIFE APPLICATION)

Understanding that students use water for many different purposes, instruct each child to draw or cut out pictures of ways they use water. Sort the pictures based on the use or purpose of the water (water we use in our homes, water we use for recreation, water for aquatic animals and plants). Help the students understand how important water quality is, and how it relates to the intended use of the water. Brainstorm ways the students can help maintain good water quality.

CURRICULUM EXTENSIONS

Social Studies

Ask the students to generate a list of all the ways their family uses water at home. Parents can help write this list or students can draw the list.

Generate a list of ways water is used at school. Be sure to visit all areas of the school, not just the classroom.

Science

Explore the dehydration process in foods. Obtain a small food dehydrator and try drying different fruits and vegetables.

Obtain and install a classroom aquarium. Have classroom helpers do the water testing to keep the fish healthy.

Math

Using the stacks of 10 unifix cubes, allow students to predict what percentage of water is in other food (apple-80%, corn-70%, watermelon and tomatoes-90%).

Weigh foods before and after dehydration.

Language Arts

Collect books for the classroom reading library on the food chain in water habitats. Read the books. As a follow-up activity ask the children draw and develop a pond (or other location) food chain. Brainstorm what human behaviors might interrupt or protect the food chain.

Art

Create a classroom mural of a natural, healthy lake with children and animals. Create another mural of a polluted lake with unhealthy conditions for children and animals. Compare the two. Children can write or dictate their feelings and ideas about the two murals. Display the murals in the school.

TEKS

Science: K.1A,B, K.2A,B,C,D,E, K.3A,B,C, K.4A,B, K.5A, K.7A,B, K.9B,C,K.10A,B,

RESOURCES

FAQs

Related Children's Literature:

In the Small, Small Pond by Denise Fleming

All Eyes on the Pond by Michael Rosen

Out of the Ocean by Debra Frasier

The Freshwater Alphabet by Jerry Pallotta

Wonderful Nature, Wonderful You by Karin Ireland

What Are Food Chains and Webs by Bobbie Kalman

Food Chains by Peter Riley

Second Grade
Water Quality

Amazing Water

LEARNING OBJECTIVE

The students will begin to understand that human actions, as well as nature, affect water quality.

STUDENT PERFORMANCE OBJECTIVES

* The student will identify characteristics of healthy and unhealthy (polluted) ponds.
* The student will begin to understand the importance of dissolved oxygen as it relates to water quality.
* The student will begin to understand that a balance of nutrients is necessary for healthy natural waters.
* The student will begin to understand the role of temperature as it relates to water quality.

BACKGROUND

Water quality refers to the condition of water based on its intended use. We use water for many different purposes (drinking, washing, recreation, manufacturing, etc.). Drinking water and pond water have different quality standards. Many substances are added to water sources naturally through the water cycle and unnaturally by actions of man. Scientists have developed different tests to determine the presence of harmful, beneficial, natural and unnatural substances.

People often pollute water with wastes such as chemicals, metals and oils. Sight, smell, and taste can help identify some polluted water. However, testing is required to measure substances that humans cannot sense directly. Water is polluted primarily by sewage, industry and agriculture. Sewage is human waste and water from bathing and cleaning. Industrial wastes include metals from mining, organic chemicals from petrochemical plants, and heated water from power plants, among others. Agricultural wastes result from pesticides and fertilizers used for farmlands, as well as animal wastes. Rain and runoff carry these chemicals into streams. Hazardous wastes are leftover or unwanted materials (motor oil, paint, unused pesticides and herbicides, old batteries, electronic devices, etc.) that are harmful to living organisms if not disposed of properly.

Traces of nutrient materials such as nitrates, ammonia and phosphates are necessary in natural water for the growth of algae and other aquatic plants. However, in large quantities these nutrients can cause an explosion of aquatic plant growth. This heavy growth often interferes with recreational uses of water (boating, fishing, skiing, swimming, etc.) as well as causing a bad taste, foul odors, and degradation of aquatic life. Phosphates are chemicals that are sometimes added to detergents to enhance their sudsing and cleaning. When people develop the land around a lake, pond or reservoir, septic tanks can leak too many nutrients into the water. Agricultural fertilizers, sewage wastes, and industrial wastes can all cause high nutrients which can result in an explosion of algal growth. When algae thrive this way, they can block out sunlight and use up oxygen. When algae die, oxygen is used as they decompose. This depletion of oxygen can leave plants and animals without the oxygen they need to survive.

Dissolved oxygen (DO) in water is necessary for sustaining aquatic life. One measure of water quality is the amount of dissolved oxygen. Oxygen is dissolved in water for aquatic life to "breathe". Normally a pond has enough oxygen to sustain the plant and animal life. Algae and other aquatic plants produce oxygen all the time (photosynthesis), but at night and on cloudy days they use (consume) more oxygen than they make (produce). The nutrients in natural water which allow algae and other plants to grow are phosphorous and nitrogen. The availability of those nutrients is one of the ways healthy lakes or ponds keep algae and other plant growth under control. The result is that water has the plant growth necessary to sustain aquatic life. Excessive growth of algae and other plants can imbalance the rates of oxygen consumption and production. Different types of fish require different amounts of DO (carp - 3ppm, largemouth bass -5-8ppm). Flowing streams can recover oxygen just by movement. The more riffles and rapids present, the quicker streams recover lost oxygen.

Temperature is also a factor in determining water quality. Temperatures of water sources are often altered by wastewater from power and manufacturing industries. Water used by the power industry is capable of raising the surface temperature of water to a point at which fish and other aquatic life cannot exist. This requires the animals to avoid the heated areas or risk death. In addition, increased temperature reduces the amount of oxygen the water can contain, increases the rate of chemical reaction of other pollutants, and increases toxicity of many poisonous substances. The maximum temperature acceptable for some aquatic life is about 95?F (35?C). Almost one-half of all water used in the United States is used for cooling and condensing by power and manufacturing industries. Increased temperature reduces the amount of dissolved oxygen in the water. Large areas of heated water block fish from moving upstream. Oysters close their shells when the water temperature is 95? F (35?C) for prolonged periods. When their shells are closed, they cannot feed properly. Since they can't move, long periods of closed shells cause death by starvation. When temperatures get too high, the food chain of a body of water can be disturbed.

In lakes that are sufficiently large and deep, thermal (heated) discharges may not harm warm water fishes such as channel catfish and largemouth bass. In winter, the heated water can even provide excellent fishing since fish tend to move to warmer water. However, cold water fish (such as rainbow trout and salmon) may be completely eliminated by increased water temperature.

MATERIALS

* Around the Pond, Who's Been Here? By Lindsay Barrett George
* Containers (empty and clean) of possible pollutants such as: motor oil, gasoline can, aluminum can, plastic bottle - any kind that might be left by campers, toy tire - to represent a real one, other objects of possible pollution based on your experience or location
* 12"x18" manila paper, one per student
* Pond water, 2 cups or more
* Aquarium water, ½ cup
* Tap water, 2 cups
* Dissolved oxygen test tablets (available from Pond Water Tour, LaMotte Company, PO Box 329, Chestertown, Maryland, 21620 800-344-3100)
* Three sandwich size Ziploc® bags
* Three clear containers with three different temperatures of tap water (cold, warm, hot)
* Two identical juice glasses or baby food jars
* Four 3x5 size index cards
* Water Quality Record Sheet [WQlty/2-1], one per student
* www.ecoplex.unt.edu

OPENING

Ask the class:

Have you ever been to a pond? Tell me about it. (What did you see, hear, smell? Why did you go? What did you do there? Who went with you?)

Tell the class:

Today we will read a story, Around the Pond Who's Been Here? by Lindsay Barrett George. The story is about a visit to a pond by some children about your age. They make discoveries along the way…maybe you can make the discoveries, too.

Read the story, pausing after each question, "Who's been here?" for the students to give ideas. Use the last page of the book to extend the students knowledge about each pond animal as it is discovered.

PROCEDURE

1. Ask: Was the story about a healthy pond or a polluted pond? Why do you think that? Review the healthy and diverse terrestrial and aquatic life in and around the pond. Also, remind the students that the pond was a good place for the family to swim.

2. Water quality refers to the condition of water based its intended use. Would the water in this pond have the same water quality as water we drink? (No) Why? (Drinking water has a reduced number of the nutrients needed for sustaining pond life, and chlorine in drinking water makes it toxic for aquatic animals.) Sometimes actions of people affect the water quality of ponds and other water sources.

3. Explain that you have a collection of objects which might affect the quality of the pond. Write these headings: *Product*, *Pollution*, *How It Got There*, *Affect to Pond Life.* As you show each item, you or a student can record the students' ideas.

4. Discuss each item as you show it. Fill in the list as you go. For example:
   Product: motor oil
   Affect to the Water: oily water, floats on top,
   How It Got There: leak from a boat, trash from a boater storm drains, runoff from parking lots
   Affect to Pond Life: gets into feathers and fur of animals, smells bad, reduces the amount of sunlight that can enter the water, not healthy for the family to swim.

5. Divide the class into groups of 2-4 to begin a rewriting of the story with text and illustrations to reflect a very different pond. It would begin as the original book, but the first discovery could be oily water—Who's been here? The next page would

show a person tossing a motor oil bottle into the water or a boat leaking. Continue for all the objects. (You and your class might think of other objects for pollution based on personal experience or your location.)

6. When the students are finished, compile the pages into a big book and read to the class. Would the family want to swim in the pond now?

7. Sometimes other factors can cause a pond or other water sources to become unhealthy. Scientists have developed tests to measure indicators of the general health of water and aquatic systems. Remind the children that when they go to a doctor, their vital signs (temperature, blood pressure, reflexes, etc.) are measured to indicate their general health. Two measurements scientists use to test for water quality are: the amount of dissolved oxygen available in the water and the temperature of the water.

Dissolved oxygen:

8. Explain the background information on dissolved oxygen (DO) to the class.

9. DO is measured to determine whether or not there is enough oxygen dissolved in the water for aquatic life. Using pond water, aquarium water and tap water samples that you've collected, follow the directions on the DO test to check the amount DO in each sample. Ask the students why the amount of DO is important.

Temperature:

10. Explain the background information on temperature to the class. Fish and other aquatic life have no control over their body temperatures. Allow the students to touch water that is approximately 95°F (the maximum temperature for some aquatic life).

11. Heated water behaves differently than cold water. Use the three containers of varying temperature of water. Add a few drops of food color to each container. Observe and record how the food coloring reacts at different temperatures. The warm water has molecules that are moving faster. How is mixing affected by temperature? How might water temperature affect pollutants? Why? (see amazing water

lesson)

12. (Do this as a demonstration! Practice ahead of time, and use a pan in case of spilling.) Using two *identical* juice glasses (or baby food jars), fill one with very hot tap water and a few drops of red food coloring. Watch as the color disperses. Fill the other glass with cold tap water and add a few drops of blue food coloring. Did the food coloring behave differently in the hot and cold water? Slowly add more water to the blue glass until you can see a bulge over the rim. Lay an index card over the glass and tap it lightly to form a seal. (You can tell when the seal is formed.) Ask the students what they think will happen when you put the glasses on top of each other. Flip the blue glass over in one swift movement and place it on the red glass. Carefully hold both glasses together as you slip out the index card. Student will observe and record what happened in their science journals while you prepare the two glasses of water again. This time the red (warm water) glass will go on top. Ask student to describe what happened (colors did not mix). Red water stayed on top because the higher temperature makes it less dense (lighter-molecules moving faster) than the cold water. Relate this to the water temperature in a lake or other natural body of water. How might pollutants be affected by water temperature?

13. Locate www.ecoplex.unt.edu. Choose the Clam and Water Quality Data. Read about the clam study (some pollutants cause the clams to close). By monitoring the clams, scientists at UNT gather important water quality data. Also click on Water Quality Sonde 1 to read current temperature and DO data for Lake Lewisville.

SO WHAT?
(LIFE APPLICATION)

Since phosphates are one chemical which can affect water quality, students will use [WQlty/2-1] to check labels on detergent and cleaners at home. After listing the products and recording whether or not they contain phosphate/phosphorous, students will return the record sheet to class. Compile the information on products. Could personal decisions regarding buying cleaning products affect water quality in your watershed?

CURRICULUM EXTENSIONS

Science

Set up an aquarium in the classroom. Students will take turns being the limnologist that checks the water temperature and DO.

Check with a local water testing lab, university, or pet store for *Daphnia* (water fleas). Put the *Daphnia* in four containers and set up an experiment adding oil to one, acid (vinegar) to another, raising the temperature of another (very sunny location might work), and leaving one as the control (no change in water). Students will record the effect of each pollutant on the *Daphnia*.

Arrange a field trip (if you're lucky you can walk) to a local pond or creek to observe the natural life in and around it. Also look for signs of pollution and determine if there is a need for the students to take action.

Social Studies

Invite a local water chemist or water quality employee from your community to visit and discuss water quality jobs as careers.

Read A River Ran Wild by Lynn Cherry. This is a story of a 7000-year-old river that becomes very polluted and then is cleaned up. Students will create a timeline for the river's history and add in other historical happenings along the way.

Language Arts

Students will research the oil spill of the Exxon *Valdez* near Valdez, Alaska on March 24, 1989. (More than ten million gallons of oil spilled into Prince William Sound.) Students will gather information on the effects of the spill to the marine and wildlife, and present the information to the class as well as other classes.

Math

Set up the water temperature and food coloring activity from Procedure 12 in the science center. Students will measure and record different temperatures of water, discovering how the different temperatures affect the color disbursement. The students can also record the time it takes for the colors to mix at different temperatures.

TEKS
Science: 2.1A,B, 2.2A,B,C,D,E,F, 2.3A,B,C, 2.4A,B, 2.6A.C.D. 2.7A.B. 2.9A,B, 2.10 A,B

RESOURCES

FAQ'S
Related Children's Literature:
A River Ran Wild by Lynn Cherry
Oil Spill by Melvin Berger
Prince William by Rand
A River Story by Meredith Hooper
Sea Otter Rescue by Roland Smith
Beaver At Long Pond by William and Lindsay B. George

8th Grade
Water Quantity

Water To Supply an Ever-growing Population

LEARNING OBJECTIVES

The student will begin to understand that although water cycles through our environment, the amount of available freshwater is limited. The student will begin to understand the need for alternative solutions for future freshwater supplies.

STUDENT PERFORMANCE OBJECTIVES

* The students will recognize that water is an essential element of the natural environment.
* The students will model the hydrologic cycle.
* The students will evaluate the changes in population over time and evaluate the present and future demands for freshwater.
* The students will research and identify known ways to conserve freshwater.
* The students will investigate the control and distribution of freshwater locally and globally
* The students will devise alternative solutions for conserving freshwater for the growing population.

BACKGROUND

The United States abundance of water leads many people to believe that there will never be a shortage of water. Water constantly cycles through the environment; however, water does not fall evenly on the Earth. Water is carried by tradewinds and weather patterns to different parts of the world, and only a small portion of water falls down into our freshwater supplies. Most of the water returns to the oceans. While the United States has an abundance of freshwater with its rivers, lakes, aquifers, and streams, other countries and continents struggle for survival due to their limited supply. As water knows no boundaries, many states and countries share water resources, which creates a need for cooperation and planning.

Due to the natural cycle of water, it is impossible to calculate an exact volume of total water that exists in the world. The world's water is found in the oceans, lakes, rivers and streams, as well as glaciers, groundwater and the atmosphere. The volume of the Earth's water can be estimated by utilizing known resources and unknown or inferred resources. Many of our estimates of unknown resources are made through indirect evidence and therefore are uncertain.

An inventory of this valuable resource we need to live, grow food and raise animals is taken providing us with information that three-fourths of the world is made of water. This number is misleading as 97 percent of that water is in the oceans, full of salt and unusable for our needs. Two percent is tied up in glaciers or in the atmosphere leaving less than one percent as available fresh water. This makes water a concern for all. Understanding the little water that is available, conserving this valuable resource and cooperating with other nations will help us to develop and make wise choices about our resources.

Although each person needs only one gallon of water a day to sustain life per person, the average United States household uses 150 gallons. This is more than most other nations around the world. However, freshwater sources are becoming scarce for many countries, especially those experiencing high population growth.

The amount of water on Earth has remained approximately the same since the beginning. However, the number of people using this water has grown considerably. As we continue to use this limited, valuable resource some of the water becomes unusable and therefore further limits the supply even more. The future of the available freshwater may depend on innovative and currently unknown solutions.

See other lessons on the watercycle, watersheds, wastewater, surface water, groundwater, local watersheds, available freshwater and conservation.

<for more>

MATERIALS

* World maps or globes for each group of students
* Datasheet [WQty/8-1]
* Glass aquarium
* Plexiglass?
* Soil
* Fast growing plants (such as: moss and liverworts)
* Water sprayer
* Salt water
* Distilling apparatus

OPENING

Ask the class:

How much water is in the world today? Is water a limited resource? How is water redistributed around the globe in the watercycle?

Discuss with the class:

What is the hydrologic cycle? How does it redistribute the world's water? How is the water used and/or misused?

PROCEDURE

The activity (as listed in step #4) has been adapted from EPA's The Water Source Book; *The Hydrologic Cycle*. To order copies of The Water Sourcebook, contact the Water Environment Federation, http://www.wef.org

1. Using globes or maps, have students identify water sources around the world.
2. Using the datasheet [WQty/8-1] have the students draw and label the water resources around the world and answer the questions on the datasheet.
3. Discuss the countries with high populations and review their water sources. Are their water supplies limited?
4. Create a water cycle.
   a) In the aquarium place a soil mixture in one end so that it slopes down from one side of the aquarium to the other.
   b) Tilt the aquarium so that one side is slightly higher than the other.
   c) Pour water in the other end of the aquarium so that it creates a pool.
   d) Plant the moss and/or liverworts in the soil and mist well with a sprayer to dampen the plants and the soil, but not enough to make mud.
   e) Place the Plexiglass ? in the aquarium so that one end sits in the lower end of the aquarium and the other end is flush with the top of the higher end of the aquarium.
   f) Set the aquarium in a window so that it gets indirect or partial light through out the day.
5. Have the students observe the aquarium for a few days. Discuss and review the stages of the hydrologic cycle.
6. Ask the class how they could tell that evaporation and transpiration were taking place.
7. Discuss how water is essential for life on Earth.
8. Identify your city's water source (for Denton Lake Lewisville and Lake Ray Roberts) and how water is collected and distributed to the residents.
9. Have the students open the Ecoplex web site (http://www.ecoplex.unt.edu/main.html) to compare the water levels of Lake Lewisville over time (for the last year or two to observe times of drought and times of rain. Best example rainfall between 1998-1999). (See lesson H_2O is Underground Too).
10. After identifying periods of drought or low rainfall, discuss what

management techniques, if any, cities used to conserve water (such as water rationing, encouraging xeroscaping and contingency plans).

11. Discuss the population growth of your city and determine the effect population has on the water supplies for your area.
12. Ask the class if the hydrologic cycle distributes water to all parts of the world equally.
13. Ask the class how the population growth of the world affects the water supply.
14. Have the class discuss the short term and long term conservation methods we can use to protect water sources.
15. Ask the class if there is any other way to provide water to the world. Are there any other alternative solutions to collect and store water?
16. Have the students brainstorm their ideas.
17. Inform the students that their role as scientists is to invent alternative solutions to address the Earth's Water issues.
18. Have an Invention Conference for the students to present their ideas

SO WHAT?
(LIFE APPLICATION)

Have the students create a brochure to discuss global water issues and explain their invention or solution.

CURRICULUM EXTENSIONS

Math:

Have the students research the population of their city and calculate the amount of water that their residents use.

Language Arts:

Have the students create a water trivia game to inform others of the value of water as a limited resource.

Have the students write the Congress person from their district requesting the Water Rights of their city and state.

Science:

Have the students discuss some things that water is capable of doing such as: Water as the universal solvent, surface tension and capillary action. Have the students create test and experiments to demonstrate these characteristics.

Investigate water's role in providing the world's energy (hydropower, hydroelectric and tidal power).

Social Studies:

Locate areas around the world that have had recent water shortages. Research and discover if these areas have large industries, agricultural areas, economic center or deserts. How do these activities affect the water supply?

TEKS:

RESOURCES

Ecoplex web site http://www.ecoplex.unt.edu/main.html

The Water Sourcebook

http://www.stark.k12.oh.us/Docs/units/1996/water.mr/

http://wwwga.usgs.gov/edu/earthriverslandscape.html

http://www.und.nodak.edu/instrudt/eng/fkarner/pages/hands.htm

http://www.ncsa.uiuc.edu/Edu/RSE/RSEred/lesson3Activity3.html

http://www.cityofdenton.com/utilities/waterquality.1999.html

3rd Grade
Water Quantity

Name That Surface Water

LEARNING OBJECTIVES

The student will be able to explain how reservoirs and lakes form and why they are important. The student will begin to understand the importance of wetlands as natural filters.

STUDENT PERFORMANCE OBJECTIVES

* The student will be able to identify types of surface water.
* The student will be able to give reasons for building a reservoir.
* The student will use the Ecoplex Web site to discover elevation levels for Denton area lakes.
* The student will map Denton area surface water.
* The student will identify reasons for conserving water.
* The student will recognize and reflect on their personal use of water.

BACKGROUND

Surface water is water that is not absorbed into the earth or returned to the atmosphere by evaporation or transpiration, instead it is stored in lakes, reservoirs, wetlands, streams, rivers, creeks, marshes, bogs, oceans etc. Water that flows across surfaces rather than being absorbed by the earth is called runoff. Runoff adds to surface water amounts and occasionally causes floods. As buildings and concrete are constructed appear in what was once a field or creek, runoff patterns are altered. A lake is water that has collected in a low area. The water is not trapped but enters faster than it can escape. A reservoir is a man-made lake. Reservoirs are created by using a dam to trap water. There are 78 reservoirs in Texas. The 79th is Caddo Lake. Some consider Caddo Lake the only natural lake in Texas while others disagree.

A reservoir is built for a variety of reasons: an additional drinking water supply, flood control, maintain water levels in canals that are travel ways, water for hydroelectric plants, irrigation, and recreation.

Land that remains wet at least part of the year is considered a wetland. A wetland is the land between dry land and a body of water. Wetlands are one of the Earth’s natural ways to clean water. Because water slowly seeps through the wetland, chemicals or organic wastes can be filtered naturally. Occasionally, wetlands are used to treat agricultural, industrial or mining wastewater. This method usually costs less, is more pleasing aesthetically, and attracts wildlife.

Conservation is the act of keeping, protecting, or preserving our natural resources. Examples of conserving water are: using low flow shower heads, turning off water while brushing teeth or soaping hands, adding an object to the toilet tank to displace water, and collecting water, which usually goes down the drain, while you wait for the water to warm. Planting vegetation that is drought tolerant (naturescaping) and watering in the morning are also helpful ways to conserve water.

We need to conserve water for a variety of reasons. There is a finite amount of water on Earth. Only 3% of the Earth's water is fresh, of this 1% can be used to meet our freshwater needs. While the amount of usable water is virtually unchanged, our population continues to increase. Water conservation saves money on the chemicals used to treat water and energy to pump it and heat it in your home. Drought (very little rain falls and there is a long period of dry weather) is another reason for conserving water.

See other lessons on water cycle, watershed, and water treatment.
<for more>

MATERIALS

* Salt dough relief map **TEACHER PREPARATION – *Several days prior*** to the opening activity create a salt dough map. Make 3 batches for the relief map. (For the best results, do not double the recipe. This map can be used for the 3rd water quality lesson.)
  - Foil lasagna pan
  - Food coloring
  - 1 and ¾ cups of flour
  - ½ cup salt
  - 1 cup water
  - 1 tablespoon cooking oil
  - 2 teaspoons cream of tartar
  - Paintbrush
  - Waterproof paint

Mix ingredients until a ball forms. Food coloring may be added. Place dough into a foil lasagna pan. Press dough out to the edges of the pan. On one end create 2 depressions that will join in the middle of the pan in the shape of a "V". On the opposite end of the pan create another depression that will join the "V" creating a "Y". These depressions will serve as rivers. Create a depression where all the rivers join. This will create a lake. Use a paintbrush to "paint" the model with food coloring (land green, rivers blue). Allow the model to dry for 3 days. Paint the dough with waterproof paint so that it can be used again.

* Pitcher of water
* 3 to 5 3x9 indoor/outdoor carpet samples
* 3 to 5 clear 9x13 dishes
* 3 to 5 packages of clay
* 3 to 5 Stop watches
* Post It Notes?
* www.ecoplex.unt.edu
* Stop watch
* Class set of Personal Water Surveys [WQty/3-1]
* Class set of Ecoplex maps **TEACHER PREPARATION**- The day before teaching this lesson, download the surface water map from the Ecoplex site. White out the names of the surface water. Make a class set of the altered maps. Students will label the maps using the map on the Ecoplex.

OPENING

Demonstrate one of the ways a lake can be formed by pouring water (add food coloring to really make the water obvious) down the salt dough relief map rivers. The rivers should all merge into a low-lying area thus forming a lake. Allow the students to observe and describe how rivers can form lakes.

PROCEDURE

1. Define lake, reservoir, and surface water.

2. Ask students to guess how many reservoirs and lakes there are in Texas. After a few guesses, share the correct number with the class and discuss why Texas may have so many reservoirs (TX doesn't have much rain, TX is a large state etc.).

3. Brainstorm uses for a lake or reservoir. Record the ideas on Post It Notes? . Ask the students to think of category headings for the uses of reservoirs (survival, recreation, agriculture, etc.). Record the heading titles in a row on the chalkboard. Ask the students to sort the Post It Notes? below the appropriate category.

4. Ask students to name lakes they have visited. Ask them which lakes/reservoirs they think our drinking water comes from.

5. Explain that Lake Lewisville is the main source for Denton, but water can be removed from Lake Ray Roberts.

6. Distribute the student set of Ecoplex maps. Using the Ecoplex Web site map, label as many surface water bodies as possible including: Elm Fork, Pecan Creek of the Trinity, Lake Lewisville and Lake Ray Roberts.

7. Explain that not only is it important to know where our water comes from, but also to educate ourselves about how much water we have. We can begin by paying attention to rainfall. Rainfall or lack of rain is important to communities because that data warns of floods or droughts.

8. Direct students to click on the lake rainfall button at the bottom of the Ecoplex main menu, students will scroll to Lake Lewisville. In the year field, ask groups of students to enter different years within the last 10 years. Print data.

9. Compare the rainfall data results. Students should notice the drop in rainfall during 1999.

10. Explain that next we will observe lake elevation (depth) data. Elevation is an important part of the decision to empty water from Lake Ray Roberts into Lake Lewisville. Evaporation, runoff, and rainfall also play a part in the decision.

11. Direct students to the main menu of Ecoplex. Click on lake data. On the Ft. Worth District Reservoir Control Office data page, scroll to Lewisville. Enter a start date of 1-01-98 and span through your current date. Click on “Lake elevation” and “Tabular text” format, everything else should be blank or click “No”. Print data.

12. Ask students to share their elevation data from various years. What does elevation tell them about their water source? Do they notice any correlation to the rainfall data?

13. Go back to the Hydrologic Data page and click on the “maximum and minimum elevation” line (just below the paragraph about the site).

14. Ask the students, “If you knew the lake was getting low, would you do something at home to conserve water? If yes, would you be willing to do something all the time to conserve water? Remind students that we never know when a drought may

occur.

15. Brainstorm all the ways the students use water. Distribute worksheet [WQty/3-1]. Record the water use ideas in the first column. Next to each idea write a water conservation suggestion.

16. Ask the students to keep track of their water use for 48 hours. The student will place a zero (0) or a plus (+) will be placed in the Data Column. The 0 indicates that the student uses water as listed, and + indicates that the student practiced the conservation idea.

17. Explain to students that there is another type of surface water called a wetland.

18. Define wetland and instruct students to create a wetland simulation per instructions below.

19. Divide students into small groups.

20. Give each group a clear rectangular dish or clear, plastic sweater box, package of modeling clay, 3x2 inch section of indoor/outdoor carpeting, and access to water.

21. Students will smooth the clay from the bottom center of the dish slanting upwards to the top edge of the dish.

22. Ask the students to pour 2 cups of water down the clay into the dish and time how long it takes the water to reach the other side. Empty the dish of water.

23. Place the indoor/outdoor carpet strip, which represents the wetland, against the clay. Pour another 2 cups of water down the clay and time how long it takes for the water to reach the other side of the dish. Students will observe that the water will move slowly through the "wetland".

24. Explain that not only does a wetland filter or clean the water, it also provides a natural flood control.

SO WHAT?
(LIFE APPLICATION)

Ask the students to think about what life would be like if our water supply were rationed (limited). This might mean that watering yards, washing cars etc. were activities that could only be done on certain days. Some states allow only a certain number of gallons of water to be used each day per family. If a family exceeds their allotment, they must pay a higher price for the water. Discuss what each child could do to help conserve water. Suggest that the class educate others on ways to conserve so that we are all working together. Ask each student to create a page for a class book that illustrates a conservation idea. Display the book in the office or library.

CURRICULUM EXTENSIONS

Science

In small groups, students create their own salt dough relief maps that reflect their watershed.

Art

Create a mural of the different types of surface water. Include how we use surface water in the mural. Ex: someone fishing, a dam.

Math

Using the Ecoplex precipitation data from various years, ask students to find averages for different months.

TEKS: Science: 3.1A,B, 3.2B,C,D, 3.3A,C, 3.4A, 3.7A, 3.11A

RESOURCES

http://www.ecoplex.unt.edu
http://wwwga.usgs.gov/edu/mearthsw.html
http://www.rgs.edu.sg/virtual/bio/flylab/Wetlands.html

4th Grade
Water Quantity

H_2O is Underground Too!

LEARNING OBJECTIVE

The student will begin to understand groundwater, recharge, and the importance of conservation.

STUDENT PERFORMANCE OBJECTIVES

* The student will create a model of an aquifer.
* The student will simulate the over use of a fossil aquifer.
* The student will identify local aquifer.

BACKGROUND

Groundwater is water beneath the surface of the earth. An aquifer is an underground layer of unconsolidated rock or soil that is saturated with usable amounts of water (a zone of saturation). Another way to think of an aquifer is as an underground reservoir. Two types of aquifers are Alluvial and Fossil. Aquifers provide 40% of the public water supplies (UNICEF suggests 60%) and 38% of agricultural water needs. In arid, desert environments aquifers are usually the major water source.

When aquifers receive water (possibly from a reservoir, precipitation, or stream), it is being recharged. Permeability is a factor in recharge. Gravel has a greater permeability than sand because water will flow much faster through gravel than sand. Clay has the slowest rate of permeability. Discharge occurs when groundwater escapes to the Earth’s surface, such as a creek, freshwater spring, or pumped by a well.

Over use, especially in arid areas has caused groundwater sources to be depleted at a faster rate than it can be recharged. In coastal zones, there is concern of seawater encroaching into the fresh groundwater. Pollution from sewers and agriculture may also make groundwater unusable. Clean up of groundwater can be difficult and expensive. On occasion, an alternate water source must be found.

See other lessons on the following subjects: water cycle, watershed, water treatment, and surface water

<for more>

MATERIALS

* 1 clear plastic cup 2 ¾ deep x 3 ¼ per small group or per student (ex. Solo?   6 oz.)
* 1 ¼ inch cube per cup
* 2 bowls – 1 must be clear
* White play sand
* Aquarium gravel or small pebbles of natural color
* Dropper for each cup
* M&M?   candy or another small candy
* www.ecoplex.unt.edu
* Class set of Ecoplex maps **TEACHER PREPERATION**: The ***day before teaching this lesson***, download the surface water map from the Ecoplex Web site. White out the names of the surface water and aquifers. Make a class set of the altered maps. Students will label the maps using the map on the Ecoplex web site.

OPENING

Ask the class:

Where is water found? Record their answers. (If students do not mention underground, be prepared to lead them in this direction.)

PROCEDURE

1. Define aquifer and groundwater.

2. Ask students to create a simulation of an aquifer. (The following simulation is adapted from an EPA lesson, *Aquifer in a Cup*.)

3. First pour approximately ¼ inch of sand in the bottom of a clear cup.

4. Using droppers, drop water onto the sand allowing the students to watch the sand absorb the water. Continue dropping water on the sand until it is saturated, but not standing. (This simulates how water is stored in the ground.)

5. Students should flatten the clay into a disk that covers half of the cup. Place the clay on top of the sand. Attach the clay to one side of the cup. Drop water onto the clay in the same spot. Water will collect and slide onto the section of sand that is not covered by the clay. The clay simulates an area where water cannot permeate (confining area). Note: In nature, water can permeate some clay at an extremely slow rate of speed.

6. The students will spread aquarium rocks or pebbles across the clay and sand (the full diameter of the cup) creating the next layer of earth. Form a small hill with the pebbles against one

side of the cup. Pour a small amount of water slowly down the rock hill, filling the valley. Students will observe how the water is stored around the rocks. A small puddle may stand and can be identified as surface water (lake).

7. Ask students to describe what has happened in their aquifer (cup).

8. To simulate an aquifer that is overused, fill a clear bowl with enough M&M's? (or some other small candy) for each child to have 5 pieces. Additional candy should be available in a separate bowl. The additional candy will be used to represent the recharge.

9. Ask a student to discharge the aquifer by taking 5 candies.

10. Place one of the additional candies back into the bowl as recharge.

11. Continue the process until each child has taken a turn. Ask the students if there is enough water (candy) for everyone to take a second turn.

12. Explain to students that when water is added to the aquifer it is called recharge. Removing more water than is being recharged could deplete the aquifer.

13. Explain that Denton's water source is Lake Lewisville and Lake Ray Roberts; however, many surrounding communities use aquifers as their water source. Ask the students: "What do you think would happen if a surrounding community depleted their local aquifer?"

14. Discuss what would happen if this were a country instead of a classroom and the candy bowl was a real aquifer.

15. Ask students if they think we receive water from an aquifer. Ask if they think there are aquifers in Texas.

16. Using the Ecoplex Web site, identify where our drinking water comes from and locate any area aquifers.

17. Distribute the student set of Ecoplex maps. Ask students to label the student map with water sources (surface and aquifers) using the Ecoplex Web site.

SO WHAT? (LIFE APPLICATION)	Ask the students what would happen if many people wasted water from an aquifer (for examples of wasteful situations see the lesson on conservation). Understanding how slowly groundwater may recharge, ask the students to think about how this would affect their local reservoir.
CURRICULUM EXTENSIONS	**Math** Repeat the M&M? aquifer depletion activity. Assign each M&M? a value of 5 gallons of water. Before removing any of the M&M's? , ask the students to calculate the amount of "water" in the bowl. After each student has removed "water", calculate the amount of "water" remaining in the bowl. **Social Studies** Using the http://sr6capp.er.usgs.gov/gwa/index.html Web site, locate and map Texas aquifers. **Language Arts** Write a creative story from the perspective of a raindrop as it moves from a cloud to an aquifer. **TEKS:** Science: 4.1A,B, 4.2B,C,D, 4.3C, 4.4A, 4.11C
RESOURCES	http://ecoplex.unt.edu http://sr6capp.er.usgs.gov/gwa/index.html

5th Grade
Water Quantity

What-A-Shed

LEARNING OBJECTIVES

The student will begin to understand the concept of a local watershed and its place in a global watershed. The student will begin to understand how to conserve water.

STUDENT PERFORMANCE OBJECTIVES

* The student will identify the local watershed.
* The student will identify ways to conserve water.

BACKGROUND

A watershed is a land area that drains water to a stream, river, lake or ocean. Each watershed is determined by connecting the tallest topographic points on a map between two adjacent areas. Each small watershed is part of a larger regional watershed, which is part of a larger watershed ultimately a global watershed is formed.

Watersheds are refilled (recharged) by rain, snow, sleet, or hail. Water does not fall evenly across the Earth. Because a community does not know when a drought may occur or when population increases will strain the water supply, we should each act responsibly when using water.

Conservation is the act of keeping, protecting, or preserving our natural resources. Examples of conserving water are: using low flow shower heads, turning off water while brushing teeth or soaping hands, adding an object to the toilet tank to displace water, and collecting water, which usually goes down the drain, while you wait for the water to warm. Planting vegetation that is drought tolerant (naturescaping) and watering in the morning are also helpful ways to conserve water.

See other lessons on the following subjects: water cycle, watershed, water treatment, surface water, and groundwater.
<for more>

MATERIALS

* 3 buckets – must contain a minimum of 2 gallons
* 1 set of water cards [WQty/5-1]
* www.ecoplex.unt.edu
* 1 set of measuring cups

* Ruler

OPENING

Ask the class:

What is a watershed?

PROCEDURE

1. Define watershed.

2. Explain to students that we are part of a watershed. A smaller watershed would be the school neighborhood, which is part of a larger watershed that would be your city.

3. Using the Ecoplex Web site, locate the map of the local watershed. Point out the school's watershed and then the city's watershed.

4. Ask the students to think about the importance of water and the many ways we use water.

5. (The following activity is adapted from *Waste Not, Want Not* http://www.epa.gov/region7/kids/tvaact.htm .)Explain that the class will be simulating 2 different families in 2 different neighborhoods. Family A is the Andrews family. The family includes Mr. and Mrs. Andrews and their daughter, Ann. Family B is the Brewer family. The family includes Mr. and Mrs. Brewer and their son, Bob. Each family gets their water from a different reservoir (reservoir bucket A and B). Print a set of cards that are on worksheet [WQty/5–1].

6. Place 3 buckets at the front of the classroom. Label one bucket A and the other B. Bucket A is the Andrews' reservoir; B is the Brewers. Fill bucket A and B with with 2 gallons of water. The third bucket (catch bucket) is for water that will be removed from the "reservoirs" and "used".

7. Cut out the cards on [WQty/5–1]. At the top of each card is an A or B. Shuffle the cards and turn them face down between the A and B buckets.

8. Place the measuring cups by the buckets.

9. Using a ruler, ask the students to find the elevation of each reservoir bucket by measuring the depth of the water in each bucket. Record the elevation on the chalkboard. Each child will draw from the card pile. A scenario is written on each card with an amount of water to be removed from the reservoir buckets.

Using a measuring cup, the student will remove the indicated amount of water. If the card has an A at the top, they will remove the amount of water from the A (Andrews) reservoir bucket. If the card has a B at the top, repeat the procedure using B (Brewer) reservoir. The water that is removed will be poured into the third bucket (catch bucket).

10. When all the cards have been used, ask a student to measure the elevation of the reservoirs. Record this amount on the chalkboard below the original elevation.

11. Review the cards. Ask the students to explain ways that the Brewer family could have conserved water.

12. Ask the students in which neighborhood they would prefer to live considering the reservoir levels.

SO WHAT?
(LIFE APPLICATION)

Remind students of the importance of the water in the local watershed. What will happen if we choose no to conserve water? Ask the students to write senators, representatives, city councilmen, or the newspaper editor to share their knowledge and request that the city put up signs marking the watershed boundaries and providing conservation alerts.

CURRICULUM EXTENSIONS

Math

Repeat the reservoir simulation but ask the students to measure their water removals using 1/3 and 1/4 cups.

Art

Create a collage showing water uses and bodies of water.

Create a water conservation superhero.

Language Arts

Create a comic strip include speech bubbles. Incorporate the water conservation superhero.

TEKS: Science: 5.1A,B, 5.2B,C,D, 5.3C, 5.4A

RESOURCES

www.ecoplex.unt.edu
http://www.epa.gov/region7/kids/tvaact.htm

Name:___________________
Date:___________________
Class:___________________

WQT/6-1

WATER vs. LAND and SEA

Record the results of the "Globe Toss" below. Make sure to mark the Total water section with each tally in the columns for Ocean Water, Frozen Water, and available Freshwater (all water is marked twice, once for Total water, and once for the type of water).

	LAND	TOTAL WATER	OCEAN WATER	FROZEN WATER	AVAILABLE FRESHWATER
Tally Marks indicate # of times landed on					
Total					
Percent of Globe (record from questions below)					

1: What is the total amount of Land? ____________
2: What is the total amount of Land and Total Water? ______________
3: Divide the total amount of Land by the total amount of Land and Total water. ____
4: Change the decimal to a percent. ______________ This gives you the % of Land.
(For example: if Land = 10 and the total amount of Land and water = 30, 10 Divided by 30 = 0.33 = 33%)
5: What is the total amount of Ocean Water? ______ Frozen? _______ Fresh? ______
6: Divide the total amount of Ocean Water by the total amount of Land and Total Water. ________________ Change the decimal to a percent for the % of Ocean Water. __________
7: Divide the total amount of Frozen Water by the total amount of Land and Total Water. ______________ Change the decimal to a percent for the % of Frozen. _________
8: Divide the total amount of Available Freshwater by the total amount of Land and Total Water. _________________ Change the decimal to a percent for the % of Fresh Available Water. _________
9: Divide the Total Water by the total amount of Land and Total Water. ___________ Change the decimal to a percent for the % of Total Water. __________________

Name:___________________
Date:___________________
Class:___________________

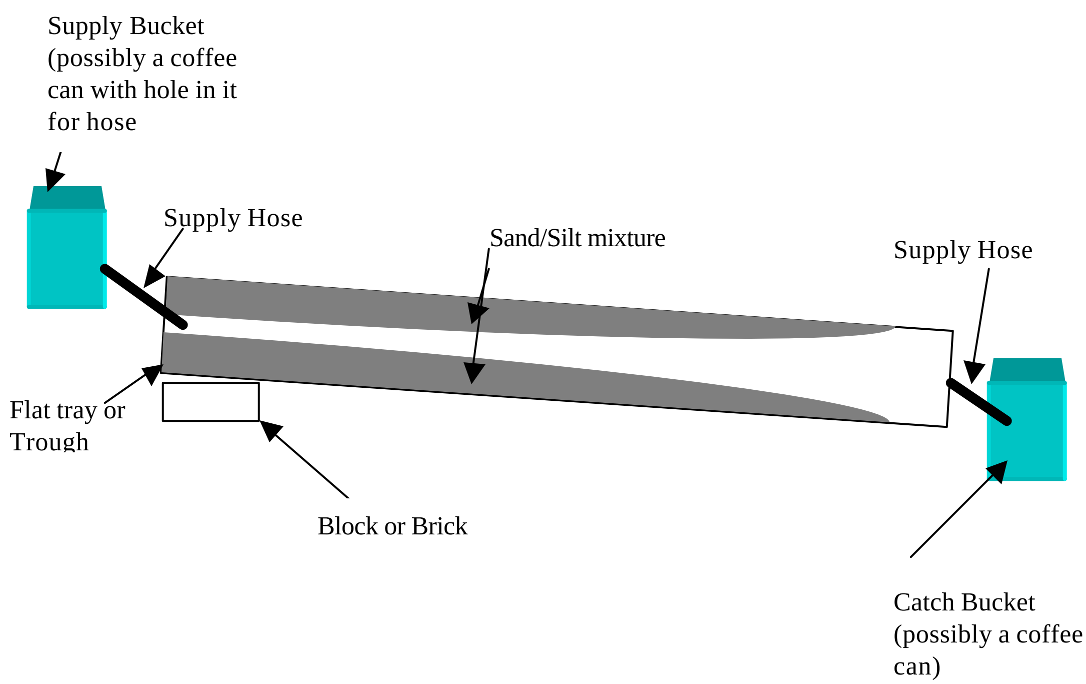
WQT/6-1

WATER vs. LAND and SEA

Record the results of the "Globe Toss" below. Make sure to mark the Total water section with each tally in the columns for Ocean Water, Frozen Water, and available Freshwater (all water is marked twice, once for Total water, and once for the type of water).

10: Create a Pie Graph to display your data. Color the percent of Land **brown**. Color the percent of Ocean Water **green**. Color the percent of Ice Cap Water **yellow**. Color the percent of Available Freshwater **blue**.

WQty/6-2
Diagram for Stream Table



a) Set tray or trough on table
b) Add sand/silt mixture to one side of the tray (it may cover up to ¾ of the tray).
c) Create a stream in the sand/silt mixture.
d) Elevate the sand and stream side of the tray on a brick or block of wood.
e) Place a supply bucket on the sand side of the tray so that it is elevated above the stream table.
f) Place the supply hose at the beginning of the stream.
g) Place the catch bucket at the bottom and below the reservoir end of the stream table.
h) Place the catch hose with one end in the reservoir of the stream table and the other end in the catch bucket to siphon out the water.

(Optional: Use the pinch clamps to control the flow of water into the stream)

6th Grade
Water Quantity

The Ups and Downs of Your Watershed

LEARNING OBJECTIVE

The student will be able to determine that the amount of fresh water is a limited resource, which is managed through the use of reservoirs.

STUDENT PERFORMANCE OBJECTIVES

* The student will determine the percent of water present on Earth and the percent of water, which is available for use by plants and living organisms.
* The student will define a reservoir and other points where water is collected such as aquifers and wetlands.
* The student will discuss ways in which water is managed and the importance of reservoir management.
* The student will graph their watershed using both a landsat map and [Arcview?] or a topographic map.
* The student will discuss water ownership and cost of water usage.

BACKGROUND

Water is a perpetual resource, which constantly cycles in our environment. The water we use today is the same water, which has been used for thousands of years and hundreds of generations. Due to this cycle students as well as adults often believe that the supply of water is unlimited. This is true to the extent that water is continuously present and always will be. However, the amount of water which is usable for drinking, household use and irrigation, is limited.

The Earth is covered with water, 97 percent of which is salt water. Only three percent of the water is available as freshwater and with two percent tied up in glaciers and polar ice caps that leaves only one percent in lakes, rivers, streams or groundwater.

Water evaporates into the atmosphere and is deposited back on the Earth through the hydrologic cycle. Some of this water is deposited in rivers and streams and still more is absorbed into the ground as groundwater. As water runs, underground or downstream, it is deposited in lakes, wetlands, aquifers and oceans.

Reservoirs, usually an artificial lake used to collect and store water, are filled by rain and rivers or streams that flow into them.

Wetlands are the areas between dry land and water. Usually low-lying areas of land that are wet during extended periods of time. These areas occur naturally and have been significantly shaped by the presence of water over time. Left alone these areas often serve to clean and purify many contaminants from the fresh water.

Aquifers begin below the land surface where the water collects in large quantities. Aquifers sometimes provide water to lakes and reservoirs.

All water sources and the land that supplies them are part of a watershed. A watershed is the land area from which water drains into lakes, rivers, streams and reservoirs. Each local watershed is part of a larger watershed which is a part of the global watershed. The activities that we do as well as the components within such as the soil type affect our local watershed.

See other lessons on water, watersheds, where water goes, reservoirs, groundwater and aquifers, and watershed conservation.

<for more>

* Globe beach ball (If rivers are not present on the ball, you may wish to draw them; otherwise, the lake areas will serve as the freshwater in the activity).
* Datasheet [Wqty/6-1]
* Diagram [Wqty/6-2]
* Stream table materials
  - Flat trough or tray (foil baking pans work great)
  - Sand/silt mixture
  - Supply hoses
  - Supply bucket (bucket with hose coming out of the bottom
  - Catch bucket
  - Pinch clamps (optional)
  - Brick or block of wood to elevate one end of stream table
* Alternative materials for stream table
  - squeeze bottle
  - tray (such as foil baking tray)
  - sand
* Map of Denton's watershed from Ecoplex (download Ecoplex map).
* [Landsat map] or Topographical
* [Arcview? software download] *web address to their homepage for this? *
* Protractor (optional)

OPENING

Ask the class:

Where does the water in your homes come from? How do you get that water? Is the water free?

Discuss with the class:

Water covers the majority of our planet; however, freshwater is a precious resource, which is limited.

PROCEDURE

1. Using a globe beach ball to toss around the room, have the students record where their right index finger lands on the ball. Toss the ball 25, 50 or 100 times to get a good sample and to make calculations easier. Students will record in appropriate columns on the datasheet [Wqty/6-1].
2. Students will then answer the questions on the data sheet to calculate the percent of times they recorded Land, Total water, Ocean Water, Ice Cap Water and Available Fresh Water.

(Approximately 75% of the Earth is covered in water. Ocean water makes up approximately 97% of all water, Ice caps 2% and Available Fresh Water makes up approximately 1%)

3. Students will create a pie graph to display their data according to the directions on the data sheet. You may want to have them use a protractor to accurately display their percents on the graph.
4. Have the students compare the amount of Land with the amount of Total water on the Earth. Discuss with the students that Ocean Water contains too much salt to drink or use for our plants and animals on land.
5. Discuss with the class that fresh water is a limited resource and must be conserved and managed.
6. Ask the students where do we find our Fresh Water? Have the students brainstorm where our water comes from.
7. Review the water cycle with the students and discuss how water cycles in the environment.
8. Discuss the path of freshwater from the beginning of a stream into a reservoir. Have the students draw and label the path of a stream using the topographical map of Denton (download Ecoplex map).
9. Have the students work in groups to create a stream table to demonstrate the path of the stream (see diagram [Wqty/6-2]).
   a) Set tray or trough on table
   b) Add sand/silt mixture to one side of the tray (it may cover up to ¾ of the tray).
   c) Create a stream in the sand/silt mixture.
   d) Elevate the sand and stream side of the tray on a brick or block of wood.
   e) Place a supply bucket on the sand side of the tray so that it is elevated above the stream table.
   f) Place the supply hose at the beginning of the stream.
   g) Place the catch bucket at the bottom and below the reservoir end of the stream table.
   h) Place the catch hose with one end in the reservoir of the stream table and the other end in the catch bucket to siphon out the water.

   (Optional: Use the pinch clamps to control the flow of water into the stream)

10. Have the students observe how the flow of the stream affects the reservoir and the land forms.
11. Discuss how water gets into the streams (rain, drainage, etc.).
12. Discuss how the amount of water in a stream affects how much water goes into the reservoir.
13. Define a watershed as an area of land that drains into a reservoir or water basin. The watershed is the land area from which water

drains into lakes, rivers, streams and reservoirs. Show the students a map of Denton's watershed (download Ecoplex map). Explain that most of Denton is in the Pecan Creek watershed which is a part of the larger watershed known as Elm Fork.

14. Have the students graph their watershed using a landsat map or topographic download map and determine the water areas using Arcview? software.
15. Discuss the characteristics and uses of a reservoir and other components within their watershed.
16. Define and discuss other areas where water is collected naturally in the environment such as aquifers and wetlands.
17. Discuss the importance of the management of reservoirs, aquifers, wetlands, streams and other components of their watershed.
18. Have the students determine that the watershed and reservoir must be managed and discuss who manages it and why.
19. Discuss that different cities own different parts of the water and we buy our water in order to pay for the management of this resource.

SO WHAT? (LIFE APPLICATION)

Have the students come up with a law to assist in the management of Denton's watershed.

CURRICULUM EXTENSIONS

Math:
Have the students calculate the rate at which water flows through the stream table (example: depth in centimeters per second)

Language Arts:
Have the students write a letter telling a friend how the water that they see going through the storm drains gets into the streams (like Pecan Creek) which end up in our reservoir.

Technology:
Have the students create a database to chart the flow (depth in feet or inches per second) of the creek in their watershed over a period of time.
Have them create a section for rainfall and compare the rate of flow to the amount of rain in the same time period.
Compare the water in the creeks and the rainfall to the water levels at Lake Lewisville from the Ecoplex web site.

Art/Music:
Have the students draw and label the different parts of their watershed.

Science:
Have the students play a water rationing game to determine the

importance of reservoir management. (A good example would be AIMS: Water Island; Water Precious Water, Book A pp 74)

Social Studies:
Have the students look up all of the streams and creeks that drain water into our reservoir Lake Lewisville. Have the students discuss who which city or cities use the water in Lake Lewisville and how managing that lake is a big responsibility to make sure that all cities can have access to the water they need.

TEKS: 6.1(B), 6.6(C)

Denton ISD SPO: S7.2, S6.1, S5.3S1.3

RESOURCES

ECOPLEX WEB SITE
http://www.ias.unt.edu/projects/pecancreek/pc.jpg
http://www.ias.unt.edu/projects/elmshed/ef.gif
http://www.epa.gov/surf3/counties/48121
http://www.4j.lane.edu/partners/eweb/ttr/curriculum/watershd.html
http://water.usgs.gov/outreach/poster4/middle_school/Page1.html
http://www.und.nodak.edu/instruct/eng/fkarner/pages/hands.htm

7th Grade
Water Quantity

Water Use and Abuse

LEARNING OBJECTIVES

The student will be able to determine the quantity of water by individual, family and city. The student will be able to determine where their water comes from and the quantity of water used by individuals, families and cities.

STUDENT PERFORMANCE OBJECTIVES

* The student will determine the amount of water he/she uses daily.
* The student will calculate the amount of water he/she uses weekly and monthly.
* The student will determine the amount of water used in their household monthly.
* The student will determine the amount of water used in their city monthly.
* The student will access the Ecoplex website to identify their watershed and observe the creeks and streams flowing into their reservoir.
* The student will identify ways to conserve water.

BACKGROUND

We live on a planet that is primarily made of water. Approximately seventy-five percent of the Earth is covered in water, most of which is in the ocean. Ocean water contains too much salt for people to use for drinking, cooking, cleaning or bathing. This water is also too salty for agricultural or ranching purposes. Approximately ninety-seven percent of all water on Earth is salt water. Three percent of the Earth's water is freshwater; however, two percent of that is frozen in glaciers and ice caps. That leaves only one percent of all water available for use by an ever-growing population.

Sources of freshwater include rivers, streams, aquifers, reservoirs, groundwater and water in the atmosphere. An unknown quantity of water travels through the air and beneath the Earth's surface as part of the hydrologic cycle. The known sources are spread out across the Earth unevenly

Due to the distribution of this valuable resource, water rights have continued to be a political and social issue. As new cities develop and grow, water needs are constantly being evaluated. These decisions include where the water is obtained and how to pay for it.

The reservoirs that serve the Denton area are Lake Lewisville and Lake Ray Roberts. Denton has water rights from these lakes to obtain 24.6 million gallons per day to serve its residents..

This water needs to be managed. Denton has created several divisions to manage the water in the reservoirs. A great reference for finding out more information about the divisions within reservoir management is the City of Denton: Utilities.

Throughout history people of all nations have settled around water sources. As populations increase the need to transfer water also increases. Dams, wells and reservoirs have allowed development in areas where water is not readily available. Countries, states and even cities that share boundaries often share water resources. As populations in these areas grow the demand for fresh water increases. Fresh water quantities remain relatively constant; therefore, the need for conservation and management of this resource becomes essential.

Conservation is the act of keeping, protecting, or preserving our natural resources. Examples of conserving water are: using low flow shower heads, turning off water while brushing teeth or soaping hands, adding an object to the toilet tank to displace water and collecting water, which normally goes down the drain, while you wait for the water to warm. Naturescaping or xeroscaping land areas, as well as watering in the morning are also helpful ways to conserve water.

See other lessons on the water cycle, watersheds, water treatment, surface water, groundwater, conservation and available water.
<for more>

MATERIALS

* Data chart [WQty/7-1]
* Data sheet [WQth/7-2] {The Water Sourcebook p 1-101 *Permission needed from Water Sourcebook for this part.*}
* Butcher paper for mural
* Download Ecoplex map

OPENING

Ask the class:
How much water do you think you use in a day? How much water

do you use in a week?

Discuss with the class:

Discuss the importance of reservoir management by leading the students to determine that the reservoir must be managed. Discuss who manages it and why.
Discuss that different cities have different rights to the water in the reservoir and we buy our water in order to pay for the management of this resource.

PROCEDURE

1. Distribute the Water Use Datachart [WQty/7-1].
2. Ask the students to collect and record data on the Water Use Chart for a 24-hour period.
3. Have the students bring their water utility bill to school (parents may want to mark out account numbers and addresses). (This is an ongoing activity which students will revisit on procedure #12)
4. Ask the students where the water comes from in their homes.
5. Ask the students "Do you have to pay for the water that comes into your home?"
6. Explain to the students that two local water sources, for the Denton area, are Lake Ray Roberts and Lake Lewisville. Ask the students how the water enters these reservoirs.
7. Have the students chart the path of water from a local creek (Pecan Creek, Hickory Creek and Elm of the Trinity River) to Lake Lewisville or Lake Ray Roberts
8. Have the students access the Ecoplex website to identify the boundaries of their watershed and observe the creeks and streams flowing into a reservoir.
9. Discuss the fact that a variety of creeks, streams and tributaries cross the borders of different cities. Ask the students how crossing borders affects who controls the water supply and who has rights to their water supply.
10. Discuss that the water in the reservoir is owned by the cities who then charge the residents for water use.
11. Ask the students how governments determine who owns and controls the water supply in their area.
12. Students may research this information by calling their local water department or the Corps of Engineers (see resources for phone numbers).
13. The next day: Have the students use their data chart to estimate their weekly water use (multiply daily use by 7).
14. Have the students estimate their monthly water use.
15. Have the students use their utility bill to determine the amount of water their family uses in a month.
16. Have the students compare household and domestic use with

commercial and agricultural use using the data sheet [WQty/7-2]. *Permission needed from Water Sourcebook for this part.*

17. Discuss with the students that water is a limited resource we need to conserve.
18. Have the students set goals on how they and their families will work to reduce the amount of water used in their homes.

SO WHAT? (LIFE APPLICATION)

Have the students create brochures for families and friends explaining the need for conservation and providing examples of ways to conserve water.

CURRICULUM EXTENSIONS

Math:
Have the students research the population of Denton and calculate the amount of water that Denton residents use.

Language Arts:
Write a summary explaining the need for conserving water.

Technology:
Use the Ecoplex web site to chart information on Lake Lewisville (elevations, evaporations, precipitation, inflow, etc)

Art/Music:
Have the students draw two cartoons. One showing people conserving water and the other showing people wasting water.

Social Studies:
Have the students research the history of lakes and reservoirs in Texas. Have the students determine which lakes are natural and which are man-made.

TEKS: 7.14(C), 7.1 (B),

RESOURCES

http://www.ecoplex.unt.edu/main.html
Lewisville Corps of Engineers (972) 434-1666
The Water Sourcebook http://www.wef.org
http://www.ci.denton.tx.us/utilities/water.html
http://www.stark.k12.oh.us/Docs/units/1996/water.mr/
http://wwwga.usgs.gov/edu/earthriverslandscape.html
http://www.und.nodak.edu/instrudt/eng/fkarner/pages/hands.htm
http://www.ncsa.uiuc.edu/Edu/RSE/RSEred/lesson3Activity3.html
http://www.cityofdenton.com/utilities/waterquality.1999.html
http://www.ias.unt.edu/projects/pecancreek/pc.jpg
http://www.ias.unt.edu/projects/elmshed/ef.gif
http://www.epa.gov/surf3/counties/48121

First Grade
Water Quantity Lesson

Here I Go 'Round My Watershed!

LEARNING OBJECTIVE

Students will review the hydrologic (water) cycle and begin to understand the components and importance of a watershed.

STUDENT PERFORMANCE OBJECTIVES

* The student will become aware of the usable water on Earth.
* The student will review the hydrologic (water) cycle, including transpiration.
* The student will begin to understand that the water available for his/her use comes from the local watershed.
* The student will learn that a watershed is composed of reservoirs, rivers, streams, lakes, creeks, groundwater, wetlands, and bogs.
* The student will understand that rainfall, drought and the water use of the population that lives within that watershed affect the water quantity in the local watershed.

BACKGROUND

Every living thing on Earth depends on water to survive. Although water covers 75% of the Earth's surface, much of it is not available to sustain life. Ninety-seven percent of the Earth's water is salt water found in oceans and seas. Three percent of the total water on Earth is fresh water. Two-thirds of it is frozen in glaciers, ice caps and snow which leaves it unavailable for use. The remaining one-percent is fresh water that is available for use by *all* living things on Earth!

Essentially, the same water has been moving in the hydrologic cycle since the beginning of time. The most familiar parts of the water cycle are: evaporation, condensation and precipitation. Evaporation is the process in which the sun's energy causes the water on Earth to change from a liquid into a vapor (gas). Condensation is the process of changing from a vapor (gas) to a liquid. Precipitation occurs when water droplets or ice particles condense from water vapor in the atmosphere and achieve sufficient size to fall to Earth as rain, sleet (transparent frozen or partially frozen raindrops), snow (solid precipitation of ice crystals of various shapes) or hail (hard pellets of ice or hard snow). Another step in the water cycle is transpiration. Transpiration is the process of water moving through the root systems of plants up to the leaves, passing through pores (stomata) in the leaves and then evaporating into the atmosphere. Groundwater, water that is absorbed into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface, is another component of the water cycle.

A watershed is the land area from which water drains to a surface body of water. It is from watersheds that we get our water supply. Every urban and rural area is part of a local watershed. Each local watershed is part of a larger regional watershed and so on to make us all part of our global watershed. There are several possible components of a watershed: lakes, reservoirs (man-made areas where water is collected and stored for use), rivers (a large body of flowing water that receives water from other streams or rivers), streams (a body of flowing water), creeks, wetlands (areas that are sometimes waterlogged or covered with a shallow layer of water with reduced soil), bogs (fresh water marsh with a build-up of peat and high acidity), aquifers (reservoirs for groundwater), bay (a body of water partially enclosed by land, but with a wide outlet to the sea), and ponds (still body of water smaller than a lake where mixing occurs primarily due to wind).

Drought is a long, dry period of little or no rain. Drought conditions exist in many areas around the world and in several regions of the United States, including parts of Texas. The Ecoplex Web site water quantity information will allow you to view the current water level data as well as historical data for the Elm Fork Watershed.

Everyone and everything affects what happens in a watershed. Precipitation, construction, farming, logging and water use by the population can affect the quantity of water flowing from a watershed.

MATERIALS

* Globe
* Water Grid paper [WQty/1-1]
* One cup for each student
* Three self-sealing plastic bags (Ziplock® type)
* Materials for water cycle bracelets: beads for stringing in the following colors: yellow, clear, dark blue, light blue, brown, and green. Elastic string for each child (long enough to go around a wrist and suitable for bead stringing). These are available at hobby stores.
* Optional: celery stalk, red and blue food coloring (see Procedures Step 4)

OPENING

Ask the class:

What do you do when you are thirsty? Where does the water you drink come from?

PROCEDURE

1. Using a globe, locate water and land on Earth. Stimulate the class discussion to determine that there is more water than land on Earth.

2. Give each student a copy of the Water Grid [WQty/1-1]. Model for the students how to count by tens and ones to color in 97 squares of the grid with a green crayon. This represents the amount of salt water in the world. The remaining three squares represent the fresh water on Earth. Color two of those squares yellow. Those represent the amount of frozen fresh water that is not available for our use. Color the remaining square blue. That represents the fresh water available for us to use. Help the children absorb that this is the available water for *all* living things on Earth. Explain that the amount of water on Earth is finite, and that we are essentially using the same water that was here for the dinosaurs (before people lived) and that was used by their great-great grandparents.

3. Use the globe again and identify the oceans as water we can't drink or use for farming. Ask: Where is the water that you use every day? Where does it come from? List the places the children have seen water (answers may include: lakes, creeks, reservoirs, ditches, puddles, rivers, wells, wetlands, bogs, etc.). Explain that the water we use comes from our watershed. Explain what a watershed is, and that the locations listed are all components of our local watershed. List the names of the areas if they are familiar to the students (Lake Lewisville, Pecan Creek, Clear Creek, etc.).

4. Give each student a cup of water. Take the class outside and have them spread out and find unpaved ground to pour their cup of water. Explain that they are to watch carefully what happens to the water and note what kind of ground (grassy, bare, wet, etc.) they pour their water on. Bring the students back together to discuss where they poured their water and what happened. Have more water available to pour on different types of ground/soil. Explain that just like their cup of water, some of the water in our watershed is underground. Ask: How is the underground water used? (water for trees, plants, animals and people)? Ask: How do plants get the water they need out

of the ground? (If the class is unfamiliar with the root system of a plant delivering water, set up an experiment to demonstrate this concept. For example: split a celery stalk from the base up about 4 inches. Put one half of the stalk in a cup of red food coloring and the other half in a cup of blue food coloring. After a few hours the students will see the colored water has moved up the stalk and to the leaves.) Ask: Do you have any ideas how people get the water we need out of the ground? They may mention wells, pipes, pumps and other ideas.

5. While still outside with the class, begin the Transpiration Experiment. To demonstrate that there is water in plants (and to prepare for the introduction of the term transpiration), put three self-sealing bags over three different leaves (do not remove these leaves from the branches or bushes) and seal. Ask students to predict what will happen. Tell the student that they will check their experiment later. (This works best on a sunny, warm day.)

6. Return to the classroom and add groundwater to the list generated in Step 3. Explain to the students again that all the sources of water listed are parts of their watershed. Our watershed is where we get the water we use everyday!

7. Ask: What happens to our watershed when we have a drought? (Explain the term if it is unfamiliar). Use the Ecoplex Web Site to check the levels (elevations) of water in Lake Lewisville from 1997 through 1999. (Note the drought elevation in 1999.) What happens if we have drought conditions? Can we make it rain?

8. Review three steps of the water cycle from the water cycle lesson. Teach the water cycle song from that lesson. Return to the Transpiration Experiment. Allow students to observe the water droplets in the baggies. Explain that transpiration is how water in the water cycle moves through plants. Help the class understand that transpiration and groundwater are important additional parts of the water cycle. Brainstorm where they fit into the water cycle. You can leave the bags on the leaves and check them again later.

9. Each child will make a water cycle bracelet using elastic string and the following colors of beads to represent the water cycle: yellow (sun), clear (evaporation), dark blue (condensation), light blue (precipitation), brown (groundwater), green (transpiration). Students will string the beads in order onto the

elastic cord and tie off.

10. Understanding that we cannot make it rain or ‘hurry up’ the water cycle, what can we do when our watershed sources are low? Brainstorm ways to use less water (introduce the term conserve) in our daily lives. Is it a good idea to always practice efficient water use? If this is not obvious to the students, refer back to the Water Grid made in Step 2.

11. Tell the student that the study of water is Hydrology and the scientists who study Hydrology are Hydrologists. Establish an additional classroom helper—Hydrologist. His/her job will be to remind us to use our water resources wisely while at school.

SO WHAT?
(LIFE APPLICATION)

Ask the students to list, draw, or cut out magazine pictures of all the ways they use water each day. Think of at least one way to conserve water for each use pictured or listed.

CURRICULUM
EXTENSIONS

Art

Create a large classroom mural of a watershed with groups of children drawing different components of the watershed.

Make a rain stick. A large one can be made using an empty laminating film roll and driving nails in randomly. Add some dried beans and cover the ends with cellophane held in place with rubber bands. Individual rain sticks can be made using paper towel or wrapping paper rolls, straight pins, rice and cellophane.

Science

Have the class write a song to the tune “Down By the Bay” renamed “Down By the Bog”. The first verse can be: Down by the bog, Where the cattails grow, Back to my home, I dare not go, For if I do, My mother will say, Did you ever see a snake baking a cake?, Down by the bog. (Other animals: fish, frog, dragonfly, salamander, etc.)

Make Rain! Boil water in a teakettle. A “cloud” will form just beyond the spout. Hold an aluminum pie plate filled with ice cubes in the “cloud” area. As students watch the underside of the pie pan, they will notice “rain”! (As the water vapor was cooled it condensed into water droplets that got heavy and fell.)

Well, Well: Demonstrate how a well can remove groundwater. Individually, in small groups, or as a teacher demonstration, construct a well model. Place a clear straw in an 8-10 ounce clear cup. Press the straw against the side of the cup. Put about ¼ cup of large rocks (quarter size) in the bottom of the cup. Then add about ¼ cup of smaller rocks. Using a watering can or a paper cup with pencil point size holes in the bottom, let water (rain) fall on the rocks (about 1/3 cup). Ask where the water is now. Explain that when water accumulates among rock layers we call it an aquifer. An aquifer is one place we find groundwater. We can tap this water by the use of wells. Cover the end of the straw with your finger and lift the straw. It should have water in it. Let the water flow into another cup. Explain that a well works like this using a pump to get the water out of the ground.

Groundwater quantity is directly affected by the absorption properties of where precipitation falls. To demonstrate absorption set up absorption experiment in the science center. Put various materials (sponges, cotton, sand, clay, plastic, rocks, etc.), a medicine dropper and a container of water where the students can drip water on the different materials and record in a science journal how different materials absorb water. Brainstorm different kinds of surfaces on Earth (bare ground, grassy areas, cement, rocks, mountains, etc.) and think about the amount of groundwater that will be absorbed in each area.

Math

When we turn off the water as we wash our hands instead of leaving it running the whole time, we can save one gallon of water each time we wash. How much water can you save in one day doing this? (one week? one month? one year?)

Record how long it takes for water to be absorbed into the ground (as in Step 3) on various types of weather days (rainy, wet days vs. dry, hot days) and different types of ground/soil surfaces.

Social Studies

Research and list states/countries that are in drought conditions.

Language Arts

Draw and describe the water cycle.

Read <u>The Rain Stick</u>, a fable by Sandra Robinson.

	TEKS Science: 1.1A,B, 1.2A,B,C,D,E, 1.3A,B,C, 1.4B, 1.5A,B 1.7A,B, 1.9B, 1.10A,B,C
RESOURCES	FAQs http://www.ecoplex.unt.edu The Cloud Book by Tomie DePaola What Makes It Rain? by Keith Brandt Water by Frank Asch A Drop Around The World by Barbara McKinney

Kindergarten
Water Quantity Lesson

Drip! Drop! Water Does Not Stop!

LEARNING OBJECTIVE

The students will begin to understand that the amount of water on Earth is finite, and that most of it is not available for human consumption or use. The students will begin to understand the hydrologic (water) cycle and recognize responsible and efficient water use behaviors.

STUDENT PERFORMANCE OBJECTIVES

* The student will use a globe to identify water on Earth and understand that the amount of water is finite.
* The student will identify and begin to understand the basic components of the hydrologic cycle.
* The student will recognize and apply responsible and efficient water use behaviors to his/her personal life.

BACKGROUND

The surface of our planet, Earth, is seventy five percent water. All life on Earth from the largest whales to the tiniest insect depends on water to survive. Every living organism is composed of more than sixty-percent water. We use water to drink, cook, manufacture goods, grow crops, produce energy, transport items, and for recreation. Ninety-seven percent of all the water on Earth is salt water. Salt water cannot be used to maintain terrestrial (land) plants, including food crops. It is also not a suitable source of water for most animals. Only 3% of the Earth's water is fresh water. Two thirds of the fresh water is in frozen form as glaciers, ice caps, and snow. This leaves only about 1% of all the water on Earth to meet our needs for fresh water.

The amount of water available on Earth is finite and essentially the same water has been moving through the water cycle since the beginning of time. We are using the same water that was used by dinosaurs and our great-great grandparents.

The three basic parts of the hydrologic cycle are evaporation, condensation, and precipitation. Evaporation is the process in which the heat energy of the sun causes water to change from a liquid to a vapor (gas). Condensation is the process of changing from a vapor (gas) back into liquid form. Condensation is what forms clouds. Precipitation occurs when water droplets or ice particles condensed from vapor increase in size and fall to the Earth's surface.

Each individual uses approximately 50 gallons of water in our homes each day, but only 1% (approximately two quarts) is used for drinking. Because water has historically been viewed as a plentiful and renewable resource, many of our uses of water are wasteful. Seventy five percent of home water use occurs in the bathroom. There are many ways to change our water use behaviors to use less water. Some water conserving practices are: inspect plumbing for leaks, never use toilets as a trash basket, wash only full loads of clothes and dishes in machines, take showers instead of baths, limit showers to 2 to 5 minutes, don't leave the water running while cleaning, washing cars, washing face, hands, or teeth, and install water saving devices that might be available for faucets, toilets, and showers.

MATERIALS

* Globe
* Clear container (one cup)
* Self sealing bags (Ziplock® type)
* Small container (such as a medicine cup) to fit inside a self sealing bag
* 30 gallon trash can, empty
* 2 gallon bucket
* 1 liter container (soda pop container will work)
* Clear container to hold two tablespoons of water
* Notes to parents [Wqty/K-1]
* **TEACHER PREPARATION**: ***Several days prior to this lesson***, set up the **Evaporation Experiment:** Fill a clear jar or cup half-full of water. Mark the water level with a permanent marker. Call the class's attention to the cup and tell them that they will observe and record changes in the container for several days. ***The day before the lesson,*** set up the **Condensation Experiment:** Put water in a small medicine cup. Set the cup in a corner of the self sealing bag, being careful not to spill any inside the bag. Tape it at an angle (which allows the cup to be level) to a *sunny* window.

OPENING

Ask the class:

What do you know about water? Record the students' ideas.

PROCEDURE

1. Display a globe. Lead the discussion for children to discover that most of the Earth is water and most of the water is in the oceans. Ask the students if ocean water is different than the water in our homes. Continue the discussion to establish that

water in lakes, creeks, faucets and other water we use is fresh water. Water in oceans is salt water. Establish that salt water cannot be used for drinking or irrigation. Show the children that some water is frozen in polar ice caps, glaciers, and as snow.

2. Demonstrate the amount of water on Earth that is available for our use in the following way: show a 30 gallon trash can, a two gallon size bucket (full of water), a 1 liter container (full of water) and two tablespoons of water in a clear container. Ask the children to imagine that all the water on the Earth (refer back to the globe) is in this 30 gallon trash can. Knowing that we cannot use salt water to drink or grow food, ask which of the other containers they think represents the freshwater available for us to use. Listen to the ideas and ask the students to explain their guesses. Explain to the class that *if* the 30 gallon trash can represents all the water on Earth (salt water and fresh water) then the container holding the two tablespoons of water *represents* all the usable fresh water that is available for all the people and other living things in the world. Allow the children time to react and talk about the demonstration.

3. Explain to the class that there is no Anew@ water on Earth. The water that was here when dinosaurs lived (before any people lived) is essentially the same water on the Earth today, though there may be less of it.

4. Ask the students: Where does rain come from? Through discussion among the students and perhaps a simple visual of their ideas, lead them to organize the water cycle. (Some classes may have so little prior knowledge of the water cycle that the teacher must lead the lesson).

5. Ask the students: What is evaporation? Listen to the children's responses. Explain that water evaporates from the Earth=s surface. Remind them of mud puddles that appear and then evaporate after a rain. Explain that water evaporates from the Earth's surface by changing from a liquid to a gas. Observe the Evaporation Experiment that you started several days earlier. Have the children notice that the water level has changed. Evaporation is occurring. Call attention to the visual developed by the children earlier in the lesson. Write evaporation at the appropriate place.

6. Gather the children around the Condensation Experiment that

was set up yesterday. Condensation occurs when the water vapor (gas) changes back into a liquid. This is occurring in the sealed sack. Condensation is how clouds are formed. Other examples of condensation include a "sweaty" soda can and wet car or home windows that they like to draw on. Write condensation in the visual of the water cycle.

7. Precipitation is the easiest component of the hydrologic cycle for young children to grasp. Brainstorm with the students all the ways moisture falls to Earth from the sky (rain, snow, sleet or hail.). Write precipitation on the visual of the water cycle.

8. After reviewing evaporation, condensation, and precipitation, teach the following song (tune of AOh My Darling Clementine"). AThe Water Cycle@: Evaporation, condensation, precipitation falling down, That is the water cycle and it keeps on going >round! Use the student's ideas to establish hand motions for the song. Divide the class into three groups representing evaporation, condensation and precipitation. Change the song into a skit to demonstrate the water cycle. Be sure the students realize that this is a continuous cycle that has been going on since the beginning of time with essentially the same water that they will use today!

9. Refer back to the water available on Earth demonstration. Lead the children to the realization that approximately the same amount of water is available for us to use now as was available before people lived on Earth. Brainstorm all the ways children use water in one day.

10. Tell the children that much of our water is wasted each day. Ask the students to describe how they brush their teeth. (This will include turning on the water and letting it run.) Show the class a one-gallon container. Explain that most of us use one gallon of water every time we brush our teeth because we leave the water running when we don't need it. Fill one cup with water and demonstrate using only one cup of water to brush your teeth. Show the children again how to brush their teeth while turning the water off when it is not needed. Introduce the term water conservation.

SO WHAT?
(LIFE APPLICATION)

Give each child a plastic or paper cup to use at home along with a note to parents [WQty/K-1]. The note explains that their child will demonstrate how to save water by brushing his/her teeth using only one cup of water, or by turning off the water when not needed while brushing his/her teeth. Brainstorm other ways the students can use water more efficiently (see Background).

CURRICULUM EXTENSIONS

Math

Make an edible necklace to represent the water cycle pattern using Fruit Loops® or other colored cereal. Yellow can represent evaporation, red-condensation, and blue-precipitation.

Puddle Problems: After a rain, measure a rain puddle(s) using non-standard measurements. Record how long it takes the puddle(s) to evaporate.

Art

Allow the class to "paint" on the sidewalk using only water. Notice and record how long it takes for the "paintings" to evaporate. Try this on different weather days. Record the data.

Science

Salty Flowers: Set up an experiment using two flowers. Water one plant with fresh water and the other one with salt water. Record the daily changes in the plants. Conclude whether or not salt water is good for growing plants (food).

Language Arts

Give each child a large, blue construction paper raindrop to draw, write or dictate an adventure story titled: "If I Rode a Raindrop". Create a class book.

Draw, label and explain the water cycle.

TEKS

Science: K.1B, K.2A,B,C,D,E, K.3A,B,C, K.4A, K.5 B,C, K.9A,B,C, K.10 A,B

RESOURCES

FAQs

www.ecoplex.unt.edu

The Cloud Book by Tomie DePaola

What Makes It Rain by Keith Brandt

Water by Frank Asch

A Drop Around the World by Barbara McKinney

Second Grade
Water Quantity Lesson

Now You See It—Now You Don't!

LEARNING OBJECTIVE

Students will begin to understand the process of wastewater treatment and realize that the water they use each day has been used many times before and will be used many times again.

STUDENT PERFORMANCE OBJECTIVES

*The student will begin to understand that water must be treated before it can be reused.
*The student will identify ways that water is wasted.
*The student will learn that drought is a problem in Texas.
*The student will identify ways to conserve water.

BACKGROUND

The amount of water on Earth is finite and continually passes through the hydrologic cycle (water cycle). For more information see the water cycle and watershed lessons. All of the water that we use whether it is in homes, businesses, or schools must be cleaned or treated before it can be used again.

Regardless of where we live, large urban areas, smaller cities and towns, or rural areas, our used water is piped to a wastewater treatment system so that it can be reused. In urban and suburban areas wastewater travels through underground sewer pipes to the wastewater treatment plant. At this facility, the water is treated by various processes. First large objects (rags, sticks, bottles, etc.) are removed by screening. Next, grit chambers are used to allow heavy particles like coffee grounds and small stones settle to the bottom. The sedimentation tanks are next and allow lighter solids time to sink to the bottom. The sediment is called sludge and it is sucked out of the bottom and processed by itself in a different place. This sludge can be used to make compost. The wastewater moves on to the aeration tank. Air is bubbled into the water. This works like large air stones in an aquarium. The air helps bacteria grow. Bacteria and protozoa decompose the wastes in the water. Next the water moves through another sedimentation tank to allow sludge to settle to the bottom. Some of this sludge is removed and some of it is used for the aeration tanks. Chlorine gas is added to kill any harmful organisms that are left. The chlorine is removed and the water is sent to reservoirs and other parts of the watershed.

Before we can use the water in our homes or businesses, it will go to a water treatment plant to be further cleaned and purified for drinking. When water enters the water treatment plant from the reservoir or river, it is sometimes treated to control odor. Then it goes into big mixers (these look like paddle wheels). Next, a chemical is added to produce floc (tiny, sticky particles, which attach to and help sink the dirt particles). After the floc settles, the water passes through two or three sand filters (activated carbon is sometimes used to remove trace toxicants) and chlorine is added to kill any remaining bacteria. It will then be stored in water tanks at the plant and around the city.

Since we cannot control rainfall, the amount of water in our local watershed varies. Drought is a problem in many countries of the world and in several regions of the United States including parts of Texas. Drought is a long period of dry weather and continued lack of rain. When an area experiences drought, water levels within the local watershed become low. Drought conditions require water conservation practices. Personal choices about responsible water use become very important. The GLOBE© Water Use Chart [WQty/2-1] identifies some common water related activities and the quantity of water each requires. It will provide opportunities for students to discuss responsible water use behaviors.

MATERIALS

* GLOBE© Water Use Chart [WQty/2-1]
* Clear, plastic, 6 – 8 oz size cups (The number of cups and the next five materials listed depends whether your class will work independently or in small groups for the activity in Step 2.)
* Spoons, plastic or metal
* Coffee filters
* Powdered Alum (available at grocery store in spice section)
* Funnels
* Optional: (see Procedure Step 2) Clean sand, aquarium gravel, paper cups (available at discount stores)

OPENING

Brainstorm a class list of all the ways the students use water in their daily lives. Be sure to include personal hygiene, clothes washing, car washing, and entertainment.

Ask the class:

Where does the water go after you use it? (Down the drain!) Then what?

PROCEDURE

1. All the water that leaves our homes, schools, and businesses goes to a Wastewater Treatment Plant. Explain to the class the steps in wastewater treatment. Use the Background information to explain the process. Explain that the aeration tanks containing bacteria and protozoa to eat the organic materials works like the natural biological process that happens in the woods when an animal dies—it's just fast-forwarded in water treatment! After wastewater treatment the water is returned to the local watershed, but it is not ready for drinking again until it goes through the water treatment plant. It is these two plants working together which allows us to reuse our water.
2. The students will participate in the following activity to observe a simulation of the water treatment process. Decide whether the students will work individually or in small groups. Give each student (or group) three clear plastic cups, one coffee filter, and a spoon. Each student (or group) will collect one spoonful of dirt and put it in the cup. Add water to within one inch of the top. Stir well to mix. Add ¼ teaspoon of alum to help create "floc". Wait 10 to 15 minutes for the heavier particles to settle. This is a good time to begin journal entries for this activity. Spread the coffee filter flat and fold in half three times to form a "slice of pie" shape. Place it in a funnel and spread the layers for maximum filter effectiveness. Pour the alum treated water into the filter and observe the cleaner water. Using a paper cup with 10-12 pencil point holes in the bottom, make an alternative or additional filter. Place a cut or folded coffee filter in the bottom of the cup. Add approximately one inch of clean gravel (aquarium type) on top of the filter. Put approximately one inch of clean sand (available at discount stores) on top of the gravel. Students will prepare another cup of dirty water and pour it through the sand filter. These two filters could be compared by having each half of the class use a different filter.
3. Explain to the students that the wastewater treatment plant must get the water clean enough to return it to our lakes and reservoirs. Remind them of the recreational uses of the lakes and reservoirs and connect them to clean water. Before we can use the water in our homes, it must go to the water treatment plant then to storage tanks around the city. As needed, water from the tanks feeds into underground water pipes that go through the city and to our faucets. Ask if any of the students can remember seeing water storage tanks around the city. Ask if any of their families or friends have been on extended hikes in mountains and carried water treatment tablets or hand pumps

that allowed them to treat the mountain stream water before drinking it.

4. Be sure the students understand that it is the water cycle and the treatment of wastewater that allows us to continue using the same water that their great-great grandparents used.
5. Ask the student what they know about drought. What happens in a drought? How are humans, animals and plants affected during a drought? Use the Ecoplex Web site to determine if an area is currently in drought conditions. Check current water levels (elevations) and other data available on the Ecoplex Web site for one or two of the reservoirs or lakes in the Dallas/Ft. Worth metroplex watershed. (Lake Lewisville data from 1997 through 1999 will show how drought affects elevations.) What should people do about their water use when levels are below normal? Why? Check your local city's web site for information about water restrictions during a drought.
6. Wasting water is a problem in our culture. Use the GLOBE© Water Use Chart [WQty/2-1] to encourage discussion among the students about water usage.
7. Teach the following chant using the beat of a military marching "Jody": We're looking for some water now. (students echo) Are you using it and how? (students echo) Wasting water must now stop! (students echo) Drip! Drop! (students echo) Waste must stop. (students echo) Drip, drop! Waste Stops! Walk on!
8. Take the students on a "Water Watch Walk" around the school to observe different uses of water. Be sure to watch how students get their drinks and wash their hands, visit the cafeteria and observe janitorial uses of water. Encourage the students to generate suggestions for how to stop any wasteful water behaviors that they observed.
9. When the class returns to the room, have a student hold a bucket or other container under the faucet to collect water while waiting for the water to warm up to face or hand washing temperature. The other students will record the time it took warm water to reach the faucet (this might involve questions and discussion about the hot water tank location). Ask for ideas on how they could use that water instead of just letting it go down the drain. (Water classroom plants, pets, cleaning, drinks, etc.)
10. Do the tooth-brushing demo (Procedure Step 10) from the water cycle lesson.

SO WHAT?
(LIFE APPLICATION)

Each student will make two water use awareness signs. One sign will be for the areas of the school where water is used (bathrooms, drinking fountain, kitchen, etc.). The other sign will be for their home water use areas to remind family members of efficient water use. Approximately seventy-five percent of water use in the U.S. occurs in bathrooms.

CURRICULUM EXTENSIONS

Math

Pick a time when the entire family is leaving home at the same time (going to a movie, out to eat, etc.). With a parent's help, read the water meter when everyone is out of the house. Read it again when you return. If the meter reading has changed, you have a leak and need to find out where it is and how to repair it to prevent wasting water.

Science

Put a few drops of food coloring in the toilet tank. Wait about 15 minutes. If there is any color in the toilet bowl water, you have a leak that needs fixing to prevent waste. Water leaks account for approximately 5% of water use in the U.S.

Social Studies

Map locations of water tanks around the city. Have a map of the city and add a tank each time a student locates one around the city. (Call the water department to find out the exact locations for mapping.)

Encourage the students to do a home "water walk" (Procedure Step 7) to identify ways families can use water more efficiently.

Invite a wastewater treatment plant and a drinking water treatment plant employee(s) to visit the classroom to talk about the details of the local wastewater and drinking water treatment processes and to discuss career opportunities with the water department.

Take a field trip to your local wastewater or drinking water treatment plants.

Art

Encourage students to design and decorate water storage tanks.

TEKS

Science: 2.1A,B,2.2A,B,D,E,F,2.3A,B,D,2.5B,2.7A, 2.9B,2.10A,B

RESOURCES

FAQs

www.ecoplex.unt.edu

The Cloud Book by Tomie DePaola
What Makes It Rain by Keith Brandt
Water by Frank Asch
A Drop Around The World by Barbara McKinney

Water Quantity – What to Do and How to Do It

1. Prior to beginning the activity, make copies of the "Water Use Chart".
2. Give each student a copy of the "Water Use Chart." Ask them to use this chart to record the ways they use water and the number of times they use water in that way. In some cases, such as when they wash hands, get a drink from a water fountain, or take a shower they'll need to record the length of time (or average) the water was running.
3. The next day, have the students calculate the rate at which water comes out of the water fountain and washbasin. Time how long it takes the water to fill a container of known volume, and convert this to gallons or liters per minute. (For younger students, you may want to calculate these figures in advance.) Have students use these rates to calculate the amount of water they use at school. Use the figures from the chart "What You Need to Know" to calculate the amount of water used to flush toilets, shower, wash hands, etc.
4. Have students compare their calculations to the predictions they made earlier. Discuss.
5. Lead a discussion about the importance of conserving water. Have students brainstorm ways they could cut down on water use at home and at school. The "Water Saving guide" from the San Francisco Convention Bureau may assist with ideas on ways to conserve water.
6. Once again, have students monitor their water use during the school day and at home, this time practicing methods of saving water. The next day, ask them to calculate their water use. What were the results? How much did each student save? What is the total amount the class saved?

WATER SAVING GUIDE

Conservative Use Will Save Water		Normal Use Will Waste Water
Wet down, soap up, rinse off – 4 gallons	**SHOWER**	Regular Shower – 25 gallons
May we suggest a shower?	**TUB BATH**	Full tub – 36 gallons
Minimize flushing. Each use consumes 5-7 gallons	**TOILET**	Frequent flushing is very wasteful
Fill basin – one gallon	**WASHING HANDS**	Tap running – 2 gallons
Fill basin – one gallon	**SHAVING**	Tap running – 20 gallons
Wet brush, rinse briefly ½ gallon	**BRUSHING TEETH**	Tap running – 10 gallons
Take only as much as you require	**ICE**	Unused ice goes down the drain
Please report	**LEAKS**	A small drip wastes – 25 gallons a day
Turn off light, TV, heaters and air conditioning when not in a room	**ENERGY**	Wasting energy also wastes water
Thank you for using this column		And not this one

WATER USE

Breakdown of the 394 billion gallons* (1,491 billion liters) of water used daily in the United States:

Thermoelectric Utilities	187 billion gal./day
Irrigation	137 billion gal./day
Public Supply	36 billion gal./day
Industry	26 billion gal./day
Rural & Livestock	8 billion gal./day
Total:	**394 billion gal./day**

Daily Water Use:

Flushing the Toilet	**1.5- 7 gal.
Taking a Shower	25-50 gal.
Taking a Bath	36 gal.
Washing Clothes	35-60 gal.
Washing Dishes (machine)	10 gal.
Brushing Teeth	2 gal.
Washing Hands	2 gal.
Watering the Lawn	5 –10 gal./min.

Students' Prior Knowledge

Start by showing students an empty beverage container (a 2-liter pop bottle or a 1 – gallon container) and tell them how much water it will hold. Have each student predict how much water they use each day. Would it be more or less than the container holds? What are the students' predictions of their water use. Discuss: *Is it important to know how much water you use personally? Why or why not?* List student's responses by making a chart on the chalkboard. Use it for recording students' predictions. Compare their responses after the activity is complete.

Name:___________________
Date:___________________
Class:___________________

WQT/7-1

<u>WATER USE CHART</u>

Complete the water use chart using the multiplying factors in the rows and columns. These factors are approximate.

	WATER USE	TIMES PER DAY	AMOUNT USED	TOTAL USED PER DAY	TOTAL USED PER WEEK	TOTAL USED PER MONTH (Mult. weekly use X 4.3)	MONTHLY USE FOR YOUR FAMILY (Get monthly bill to calculate)
1: Baths (mult. X 30 gal for approximate use)							
2: Showers (mult. X 6 gal per minute) [3 gal with low flow shower head]							
3: Bathroom flushing (mult. X 1.5 gal each flush)							
4: Washing face and hands (mult. X 5 gal)							
5: Getting a drink (mult. X 0.25 gal)							
6: Brushing Teeth (mult. X 2 gal)							
7: Cooking (mult. X 10 gal)							
8: Other							
----------------------	-----------------	------------------	**TOTALS:**				

Use the chart to answer the following questions.

1: In which area did you use the most water? ________________________Why?____

2: Write down at least 3 ways that you can conserve water use in your home. ____

____ ____

3: Look up the population of your city. ________________ Estimate water use for entire town based on your family's water use. ________________

Name:____________________
Date:____________________
Class:____________________

WQT/7-1

WATER USE CHART

Complete the water use chart using the multiplying factors in the rows and columns. These factors are approximate.

LONG ISLAND SOUND STUDY

A Partnership to Restore and Protect The Sound

THE IMPACT OF ATMOSPHERIC NITROGEN DEPOSITION ON LONG ISLAND SOUND

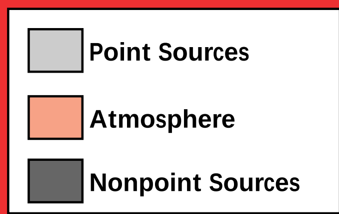
The Long Island Sound Comprehensive Conservation and Management Plan (CCMP) identifies low dissolved oxygen, or hypoxia, as the most serious water quality impairment in the Sound. The annual summertime occurrence of hypoxia in the deeper waters of western Long Island Sound reduces the amount of healthy habitat necessary to support fish and shellfish. The CCMP identifies excessive discharges of nitrogen, a nutrient, as the primary cause of hypoxia, and sewage treatment plants as the primary source of this excess nitrogen. To address this problem, the Long Island Sound Study (LISS) is implementing a phased approach to reducing nitrogen loads to the Sound from sewage treatment plants, industrial dischargers, and nonpoint sources.

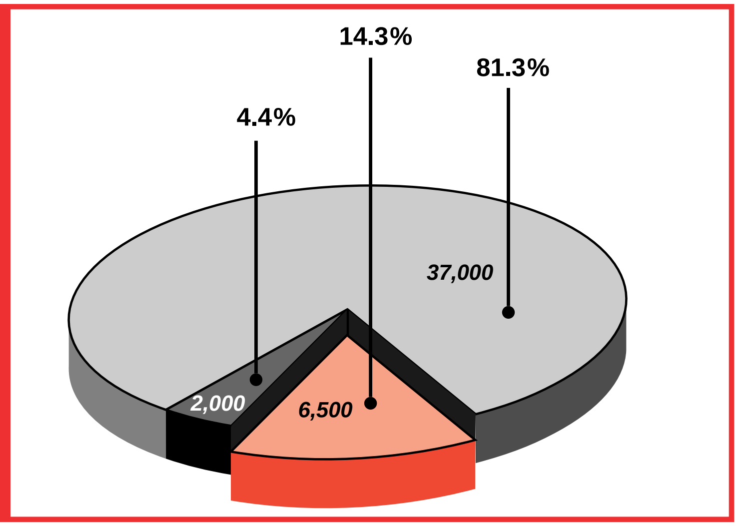
These phased nitrogen reductions, however, may not raise dissolved oxygen to levels necessary to support all life stages of marine organisms in Long Island Sound. Additional measures will likely be required to achieve the states' water quality standards for dissolved oxygen. These measures may include advanced treatment at sewage treatment plants upstream of the Connecticut border, several "non-treatment" techniques, and reductions in atmospheric nitrogen loadings, the subject of this fact sheet.

Recent research has brought to light the importance of managing atmospheric sources of nitrogen if water quality objectives are to be met and maintained in Long Island Sound. The primary sources of atmospheric nitrogen are emissions generated by various combustion processes that use fossil fuels (e.g., energy production, fueling of motor vehicles and other machinery).

While atmospheric sources of nitrogen were always considered in estimating nitrogen loads to Long Island Sound, they only included direct deposition to surface waters of the Sound. Direct deposition contributes only 6.3 percent of the human-caused load of nitrogen to the Sound from the Connecticut and New York portions of the watershed. However, atmospheric nitrogen is also deposited upland and on surface waters adjacent to the Sound and is carried into the Sound when rain falls or as particles settle during dry periods. Nitrogen is carried with stormwater runoff from coastal areas, with rivers and streams from throughout the drainage basin, and with currents moving into the Sound from the Atlantic Ocean and New York Harbor. This is called "indirect deposition."

Human-Caused Nitrogen Loads to Long Island Sound (Tons/Year)



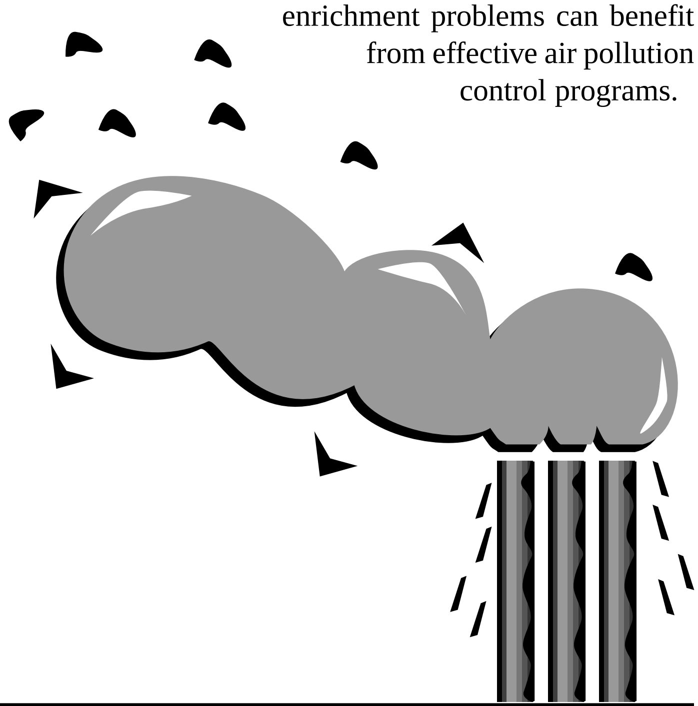


The LISS recently prepared an estimate of the indirect deposition of nitrogen to Long Island Sound from the Connecticut and New York portions of the watershed. Based on this analysis, the combined direct and indirect deposition of nitrogen from atmospheric sources is estimated to be 14.3 percent of the human-caused load to the Sound.

Oxides of nitrogen (NOx) contribute to both the atmospheric nitrogen that reaches the Sound and ground-level ozone, which causes human health problems when it reaches dangerous levels in the air. Through the Ozone Transport Assessment Group, air pollution managers from the eastern states have submitted specific recommendations to EPA for reducing NOx emissions to address the problem of ozone.

Computer modeling by the Chesapeake Bay Program has estimated that reducing NOx emissions through implementation of the mandatory Clean Air Act requirements will result in significant improvements in dissolved oxygen levels in Chesapeake Bay. Such modeling has not been performed for Long Island Sound. However, simple calculations that apply Chesapeake Bay derived estimates to the New York and Connecticut portions of the watershed suggest that implementation of the Clean Air Act could achieve around 5 percent of the Long Island Sound nitrogen reduction target.

When direct and indirect sources of nitrogen are considered together as a single source, atmospheric nitrogen is probably the second most important cause of hypoxia in Long Island Sound after point source discharges. In addition to improving dissolved oxygen levels in the Sound, the control of NOx emissions will reduce ground-level ozone. Hence, an opportunity exists to achieve both air and water quality management goals through aggressive implementation of the Clean Air Act. Long Island Sound and other estuaries along the east coast that have nitrogen enrichment problems can benefit from effective air pollution control programs.



Prepared and funded by the Long Island Sound Study. September 1997

Sponsoring agencies: U.S. Environmental Protection Agency, Connecticut Department of Environmental Protection, and New York State Department of Environmental Conservation.

Produced by New England Interstate Water Pollution Control Commission (NEIWPCC).

LONG ISLAND SOUND STUDY

A Partnership to Restore and Protect The Sound

ALTERNATIVE STRATEGIES FOR HYPOXIA MANAGEMENT:

Creative Ideas to Complement Advanced Treatment

The Long Island Sound Comprehensive Conservation and Management Plan (CCMP) identifies low dissolved oxygen, or hypoxia, as the most serious water quality impairment in the Sound. The annual summertime occurrence of hypoxia in the deeper waters of western Long Island Sound reduces the amount of healthy habitat necessary to support fish and shellfish. The CCMP identifies excessive discharges of nitrogen, a nutrient, as the primary cause of hypoxia, and sewage treatment plants as the primary source of this excess nitrogen. To address this problem, the Long Island Sound Study (LISS) is implementing a phased approach to reducing nitrogen loads to the Sound from sewage treatment plants, industrial dischargers, and nonpoint sources.

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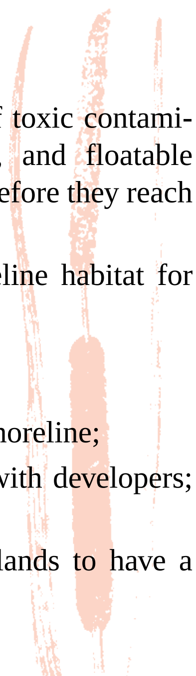
Solving a large, complex environmental problem like hypoxia in Long Island Sound requires creative solutions. New ideas are being considered as part of a dynamic process that takes advantage of changes in technology and different ways of thinking. This fact sheet highlights some of the methods other than advanced treatment that have been considered to improve dissolved oxygen levels in the Sound. Some are more feasible than others, and some may never be implemented. The alternatives are listed in order, from those most likely to be put in place to the least likely.

In assessing the alternatives, the LISS considered the requirements outlined in the federal water pollution control regulations. The requirements call for the use of treatment over nontreatment techniques (e.g., increasing the flow of receiving waters to enhance dilution or using in-stream mechanical aerators to increase oxygen levels). However, nontreatment techniques may be considered as a method of achieving water quality standards on a case-by-case basis when treatment technologies are not sufficient to achieve the standards.

Creation of Artificial Wetlands

Creating artificial wetlands can provide treatment for storm water runoff entering Long Island Sound. Artificial wetlands, if well-designed and managed properly, may be able to remove nitrogen from runoff. However, it is, at best, a partial solution that can be incorporated into the overall nitrogen control strategy, complementing natural wetland protection and restoration efforts.



Advantages:

- m Provides nitrogen removal;
- m May help reduce loadings of toxic contaminants, sediment, pathogens, and floatable debris by filtering them out before they reach the Sound; and
- m May provide valuable shoreline habitat for birds and marine life.

Disadvantages:

- m Limits public access to the shoreline;
- m Presents potential conflicts with developers; and
- m Requires large areas of wetlands to have a measurable benefit.

Aeration of Bottom Waters

Locating mechanical aerators in hypoxia "hot spots" would introduce oxygen to oxygen-depleted waters. Aerators also would help break up vertical density stratification in the water column, allowing mixing of oxygen-rich surface waters with oxygen-depleted bottom waters. Although impractical for large areas, this alternative may be considered after planned nitrogen reductions have reduced the areal extent of hot spots.

Advantages:

- m Serves as a direct solution to the low dissolved oxygen problem;
- m Easy to operate;
- m Has flexibility and can be used in a variety of locations;
- m Has relatively low capital costs;
- m Has proven successful in small scale operations; and
- m Can be switched on and off.

Disadvantages:

- m May cause resuspension of sediments and associated chemical contaminants;
- m May disrupt marine organism movement and migration;
- m May eject bacteria and viruses into the atmosphere;
- m Creates froth on the water's surface from the bubbles;
- m Requires long-term maintenance of mechanical equipment; and
- m Intense energy requirements could inflate the costs.

Seaweed Farms

Raising benthic macro algae (seaweeds) may help alleviate the hypoxia problem by removing nitrogen from the water column through biological uptake. As with creation of artificial wetlands, seaweed farms are at best a partial solution that can be incorporated into an overall nitrogen management plan.

Advantages:

- m Has existing market for seaweed and its byproducts;
- m Removes nutrients from the water column;
- m Generates dissolved oxygen through photosynthesis; and
- m Seaweed farms in other countries have proven to be successful.

Disadvantages:

- m Has limited effectiveness as a single solution to the hypoxia problem;
- m Uncertainty of whether there is species of

seaweed that would be feasible for aquaculture in Long Island Sound; and

- Floating structures may interfere with navigation.

Relocation of Sewage Treatment Plant Outfalls

This alternative involves redirecting New York City sewage treatment plant outfalls from the East River to New York Harbor, and relocating Westchester County outfalls toward central Long Island. It had been determined that relocation of the Westchester County outfalls is not cost-effective. Relocation of the East River outfalls needs further evaluation.

Advantages:

- Improves dissolved oxygen in western Long Island Sound and the East River;
- Reduces toxic contaminant loading in the East River;
- Is cost-effective; and
- May reduce combined sewer overflow impacts (i.e., nitrogen, toxic contaminants, pathogens, and floatable debris).

Disadvantages:

- Causes adverse water quality impacts at new discharge locations;
- Introduces new pollutant loads to the Hudson River circulation pattern;
- Increases nutrients to the New York Bight and Raritan Bay;
- May cause changes in flora, fauna and fish migration patterns in the Sound;
- Increases salinity and temperature alterations in the western Sound;
- May cause adverse effects at Atlantic Ocean beaches; and
- Disturbs habitat near the diffuser field at the discharge.

Tide Gates

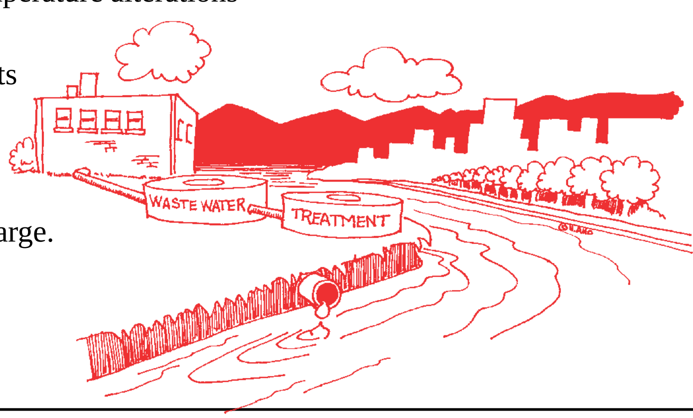
Installing tide gates could prevent tidal currents in the East River from entering Long Island Sound. Preliminary estimates by two engineering firms placed construction costs at $500 million to $1 billion. Some of the cost could be defrayed if the tide gate served a dual purpose, such as providing a structure for a railroad crossing. Operational costs are anticipated to be relatively low. This alternative is not likely to be pursued, however, because it has the potential to change the whole ecosystem in the western Sound, resulting in unintended consequences that are difficult to predict and may prove to be irreversible.

Advantages:

- May increase the overall circulation in the Sound and adjacent water bodies;
- Prevents nitrogen and other pollutants from entering the Sound from the west end;
- Causes reduction in coliform bacteria concentrations; and
- May flush Long Island Sound and New York Harbor with cleaner Atlantic Ocean water.

Disadvantages:

- Affects tidal heights and currents;
- May cause potential changes in flora, fauna and fish migration patterns in the Sound;
- May alter salinity and temperature regimes in the western Sound;
- Increases pollutant loading to New York Harbor and the New York Bight; and
- Impedes vessel navigation in the western Sound.



Altering the Basin Morphology of the Sound

Dredging the Mattituck Sill, East River, and Hempstead Sill may increase water circulation in the Sound. Like tide gates, this option has the potential to alter the ecosystem of the Sound, resulting in consequences that are difficult to predict and may be impossible to reverse.

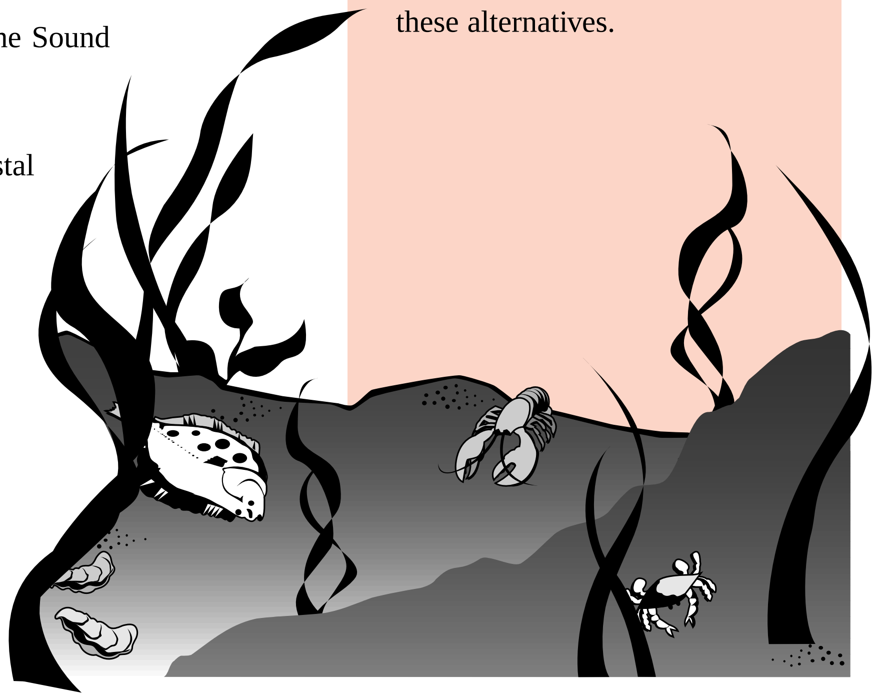
Advantages:

- Increases bottom water renewal from the Atlantic Ocean;
- Can be implemented in phases, allowing for evaluation of effects;
- May be a potential source of sand for activities such as beach nourishment; and
- Is technologically simple.

Disadvantages:

- Presents disposal problems for any contaminated dredged material;
- May cause changes in salinity in the Sound and associated ecological effects;
- Is expensive;
- May have adverse effects on coastal erosion; and
- Causes changes in characteristics of surface sediments and benthic communities in dredged areas.

All of these alternatives are currently being subjected to varying degrees of evaluation by LISS Management Conference participants. New York City in particular is very interested in exploring the feasibility of an East River tide gate and the relocation of sewage treatment plant outfalls. The development of a "systemwide" computer model, which includes Long Island Sound, New York/New Jersey Harbor, and the New York Bight, will help assess the broader, regional impacts of some of these alternatives.



Prepared and funded by the Long Island Sound Study. September 1997

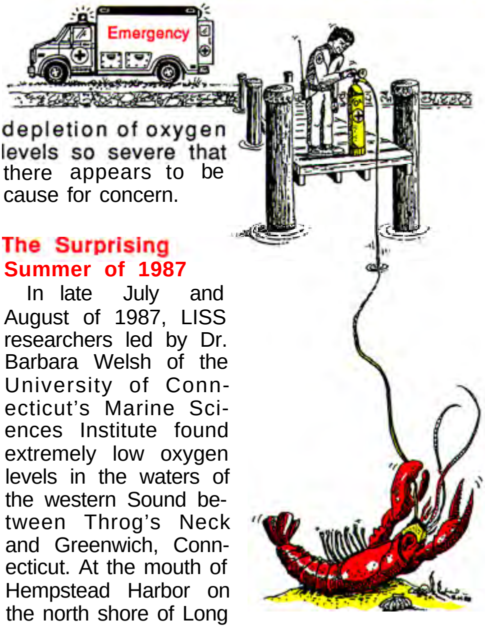
Sponsoring agencies: U.S. Environmental Protection Agency, Connecticut Department of Environmental Protection, and New York State Department of Environmental Conservation.

Produced by New England Interstate Water Pollution Control Commission (NEIWPCC).

LONG ISLAND SOUND STUDY

FACT SHEET #1

Hypoxia in Long Island Sound



What is Hypoxia?

Hypoxia is the scientific term for low disolved oxvgen levels in the watery Just as people need oxygen to breathe, marine organisms require oxygen dissolved in the water (D.O.). Biologists generally consider 3 parts per million (ppm) to be the minimum dissolved oxygen concentrations needed for sustained health of marine life. When D.O. falls below this level hypoxia exists. During hypoxic episodes, stressed marine organisms may become ill, die or move to more oxygen-rich waters. The harmful effects of severe hypoxia on the biota of an estuary, as evidenced in the Chesapeake Bay, was the reason that the Long Island Sound Studv (LISS) decided to conduct a study of this phenomenon.

How Does Hypoxia Happen?

Hypoxia can occur naturally in the deeper areas of coastal water bodies like Long Island Sound in the summer. During the warm, stable weather the surface waters heat up and form a distinct layer “floating” over the bottom waters, which are more dense due to greater salinity and cooler temperature. The result is the formation of a sham densitv gradient called a pycnocline (pick-no-kline), which restricts mixing between the two layers. Oxygen added to the surface waters by wave mixing and photosynthesis of marine plants is thus prevented from mixing into the depths, where it is needed to replace oxygen consumed by marine life and the decomposition of organic material. Hypoxia is the result.

In the fall, cooling water temperatures and strong winds combine to dissipate the pycnocline and restore oxygen exchange throughout the water column. Although scientists have known about hypoxia for many years, it is difficult to distinguish a “natural” hypoxic episode from one that is sianificantlv exacerbated by man’s activities. However, recent LISS research has found depletion of oxygen levels so severe that there appears to be cause for concern.

The Surprising Summer of 1987

In late July and August of 1987, LISS researchers led by Dr. Barbara Welsh of the University of Connecticut’s Marine Sciences Institute found extremely low oxygen levels in the waters of the western Sound between Throg’s Neck and Greenwich, Connecticut. At the mouth of Hempstead Harbor on the north shore of Long Island, there was literally no oxygen in the bottom waters, and almost none at the surface (see map). Fish sampling in this region was conducted by LISS scientists from the Marine Fisheries Program of the Connecticut Department of Environmental Protection soon after the initial discovery of hypoxia. The results graphicallv illustrated the impact of such a severe hypoxic event on marine life -- not one fish was found in any of the sample trawls, and 80% of the bottom-dwelling invertebrates (such as starfish and crabs) were dead! During the same time period, there were reports by lobstermen in the area that dead lobsters had been brought up in their pots. Unlike the fish, the trapped lobsters had been unable to escape the low oxygen area and had suffocated. The hypoxia lasted well into August, eventually extending as far as Bridgeport: and healthy D.O. levels were not restored until mid-September.

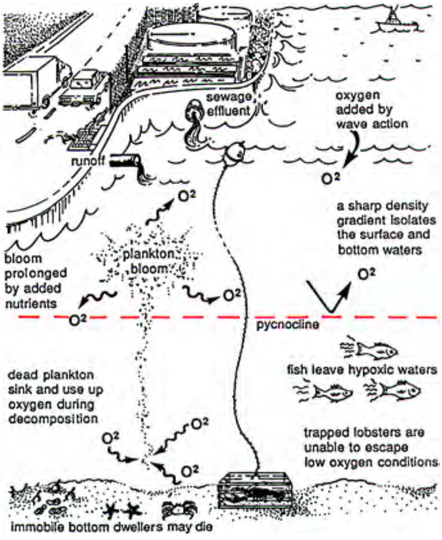
What's Happening?

Although research is continuing, LISS scientists believe that the evidence points to nutrient input from stormwater runoff and sewage treatment plants as a major factor in hypoxia. The hypoxic event of 1987 coincided with an intense "bloom" of tiny marine algae called phytoplankton, which were so numerous that they turned the surface waters in the area a deep red-brown color. Such a growth explosion can occur naturally, but as the algae use up the nutrients in the water, the growth slows down and the bloom ends. However, *a billion gallons a day of treated sewage are discharged into the waters of the Sound every day,* and nutrients such as phosphorous and nitrogen that are contained in this discharge appear to be fueling the algal blooms for much longer durations than would normally occur. As the millions of plants that die each day during these prolonged blooms sink to the bottom waters and decompose. This uses up oxygen, increasing the intensity and extent of the natural summer hypoxia (see diagram).

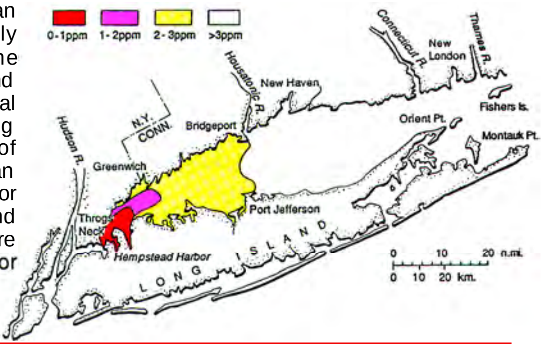
Are Things getting Worse?

Historical data is too sketchy to be able to state with certainty that summer hypoxia in Long Island Sound is getting worse, although there are no records of such an extensive hypoxic event as occured in 1987. It may be that a number of natural factors combined to make 1987 such an unusual year. Whatever the reason, if hypoxia continues in this severity future adverse impacts on the fisheries and shellfisheries of the Sound can be expected. Firmly establishing the causes of hypoxia, and assessing the potential impacts to the living marine resources of the Sound, will be an important challenge for LISS participants and a key element to future management plans for Long Island Sound.

The Dynamics of Hypoxia in Long Island



Bottom Water Dissolved Oxygen (ppm) August 1987



The Long Island Sound Study

The Long Island Sound Study (LISS) is a five year federally-funded research and management initiative that began in 1985 as part of the National Estuary Program, a recent addition to the federal Clean Water Act created to protect estuaries of national importance. The LISS is a cooperative bi-state effort involving federal, state, interstate, and local agencies as well as research institutions, educational organizations, and environmental groups. Concerned individuals or organizations interested in getting involved with the Study can do so through the Citizen's Advisory Committee (CAC). For more information on the CAC, or on the public education activities of the Study of which this fact sheet is a part, contact: the Connecticut Sea Grant Marine Advisory Program, UCONN at Avery Point, CT. 06340. (203) 445-8664.

This fact sheet was produced by the University of Connecticut Sea Grant Marine Advisory Program, an arm of Sea Grant and the Cooperative Extension Service, with support provided by a cooperative agreement with the Environmental Protection Agency. CTSG

LONG ISLAND SOUND STUDY

Toxic Contamination in Long Island Sound

Of the 55,000 chemicals in use today, many are poisonous or toxic. The effect of toxic contaminants on the health of Long Island Sound, and on those who use it, is a major concern of the Long island Sound Study (LISS).

What is Being Done About Toxic Contamination?

LISS Investigators are evaluating information that identifies which toxic substances are of concern, where they come from, where they end up, how they affect the ecosystem, and what the health risks are for human consumers of seafood products. Ultimately, the LISS will produce a Comprehensive Conservation and Management Plan (CCMP) that will include a section on management of toxic substances. One goal of the Study is to reduce impacts from toxic contamination on Long Island Sound resources. Another is to minimize human health risks

Which Toxic Contaminants Should We Be Concerned About?

Land use and the manufacture, use, and disposal of everyday products all contribute contaminants to the system. The LISS has established a list of toxic pollutants we should be concerned about in our area that reflect past and present activities in the Sound's drainage basin (Table 1). Although metals are naturally found in the environment, their levels are often elevated by human activities. Because copper, zinc, cadmium, and chromium are commonly used in industry, they are found on the LISS target list. Other metals on the list such as lead have also built up in the Sound as a result of everyday activities, primarily automobile use.

The LISS list also contains organic (carbon-based) pollutants. Many of these substances are synthetic, that is, they do not occur naturally in the environment. Polychlorinated biphenyls (PCBs) and most of the pesticides listed are no longer in general production; some are still found in the Sound, however, because they take years to disperse and break down. Also listed are polynuclear aromatic hydrocarbons (PAHs) which are ubiquitous components of petroleum products. They are also produced during the combustion of organic materials such as fossil fuels, trees, trash, and even charcoal barbecues. PAHs are widely distributed by the atmosphere Long Island Sound is likely to be contaminated with PAHs near sources such as petroleum terminals, urban harbors, coal piles, and industrialized basins. Some PAHs are known carcinogens and pose a potential problem wherever they are found.

What Are The Sources of Toxic Contaminants in Long Island Sound'

Understanding the relative contributions of the various sources of toxic substances is necessary in order to develop effective strategies to protect the Sound. Both active sources or discharges and any environmental contamination resulting from historic activities must be evaluated. Currently, active discharges are regulated under the pollution discharge elimination system (PDES) permits. Management strategies are more cost effective when they are preventative, i.e. developed for ongoing activities and discharges. Once contamination occurs, cleanup is extremely costly and difficult.

Toxic substances enter the Sound's waters as a result of natural processes and human activities. Pollution sources are categorized as either **point**

Table 1. LISS Chemical Contaminant Target List

INORGANIC COMPOUNDS

Metals
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Zinc

ORGANIC COMPOUNDS

Pesticides
- Chlordane
- Dieldrin
- DDT, DDD, DDE
- Heptachlor
- Lindane
- Trans-nonachlor

Polychlorinated biphenyls (PCBs)

Polyaromatic hydrocarbons (PAHs)

sources, for example, discharge pipes, or **nonpoint** sources, such as stormwater runoff and atmospheric deposition (see Fact Sheet **#7**). Wastewater and runoff have different types and concentrations of contaminants. For example, in the Long Island Sound area, sewage treatment plants appear to be a major source of copper pollution, whereas urban runoff contributes much of the lead contamination. Recent research has shown atmospheric deposition is an important source of heavy metals such as copper, lead, mercury, and zinc. Another pollution source which cannot be ignored, is sediment already in the Sound. Prior to the **1970s,** lack of stringent discharge controls led to locally contaminated sediment that can release pollutants when resuspended (see Figure 1). The contaminants may also be accumulated and redistributed by marine organisms when ingested or physically disturbed.

What Happens to Toxic Substances Once They Enter The Sound?

Once toxic chemicals are released into the environment, they may move back and forth between the water column, bottom sediment, and the food chain many times. This cycle ends when they are buried deep in the sediment or, as for some toxic organic substances (**DDTs**), broken down into harmless compounds (Figure 2). The residence time (average length of time a contaminant remains in a system) of a toxic organic substance depends upon the characteristics of the substance as well as the environment in which it is found. Controlling factors include the compound's structure, the medium's chemistry, and the presence of other chemicals. **PCBs** and chlorinated hydrocarbons such as DDT have long environmental residence times. They are foreign to the natural environment and natural metabolic processes have not evolved that quickly break them down.

Although toxic substances are found in organisms and in the water of Long Island Sound, the majority of the contaminants are attached or bound to sediment particles. Sediment found in urban harbors often contains high concentrations of contaminants since the harbors are adjacent to past or existing pollutant sources (Figure 1). It follows that sedentary and some mobile marine life living in areas that have highly contaminated sediment usually contain higher concentrations of contaminants than those found in cleaner areas such as the open Sound (Figure 3).

The uptake of organic and inorganic substances by fish and invertebrates is controlled by environmental conditions, the character of the substance, and the physiology of the organism. Generally the level of a pollutant in an organism's tissue is determined by factors such as the length of exposure (concentration over a period of time), how much fat tissue the organism has, and by its ability to metabolize and/or excrete the pollutant. Considering the wide range of contaminants, physical and chemical conditions, and marine life, it's not surprising that straightforward relationships between exposure and pollutant concentration in living tissues have not been defined.

Studies conducted for the **LISS** and the National Oceanic and Atmospheric Administration's Mussel Watch indicate that levels of some metals and pesticides in Long Island Sound shellfish tissues have declined. Figure 4 shows the levels of metals in oyster meats have declined since the 1970s. This is the result of numerous factors, including improved treatment of industrial and sewage treatment plant discharges as required by the Federal Clean Water Act. Other factors are the movement of industries that pollute away from the Northeast and the phasing out of products that pollute such as leaded gasoline, lead paint, and persistent pesticides.

How do Toxic Substances Affect The Ecosystem?

Some substances in high concentrations can kill marine life. Other substances have a more subtle effect on marine life in terms of behavior, reproduction, or how they impact the key components of intricately balanced food webs. The net result could be a reduction in productivity and an imbalance in marine life communities towards pollution tolerant species such as the opportunistic benthic worm Capitella. This factor is more pertinent to the condition or "health" of marine resource populations rather than to the health of seafood consumers.

What Are The Human Health Risks?

Often, toxic substances are found at higher levels in organisms than in the water in which the organisms are found. This phenomenon, bioaccumulation, has special significance for seafood. Bioaccumulation occurs when the amount of

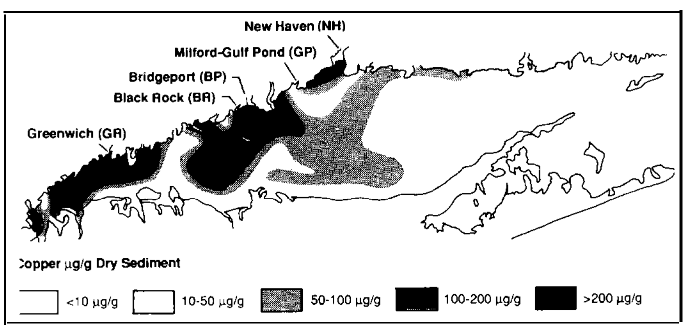


Figure 1. Distribution of Copper in surface sediments of Long Island Sound. Source: Greig, et al., 1977.

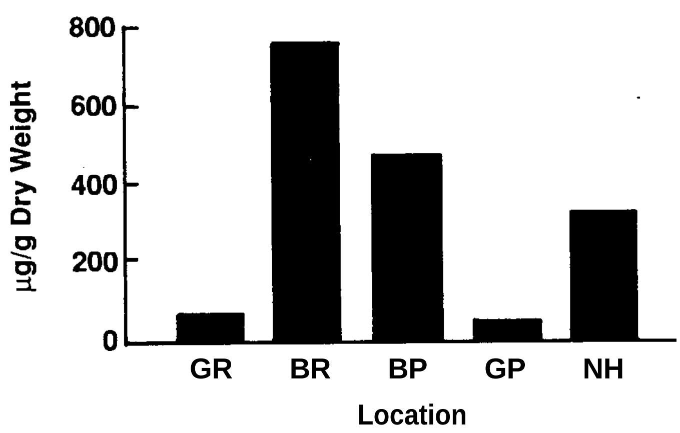
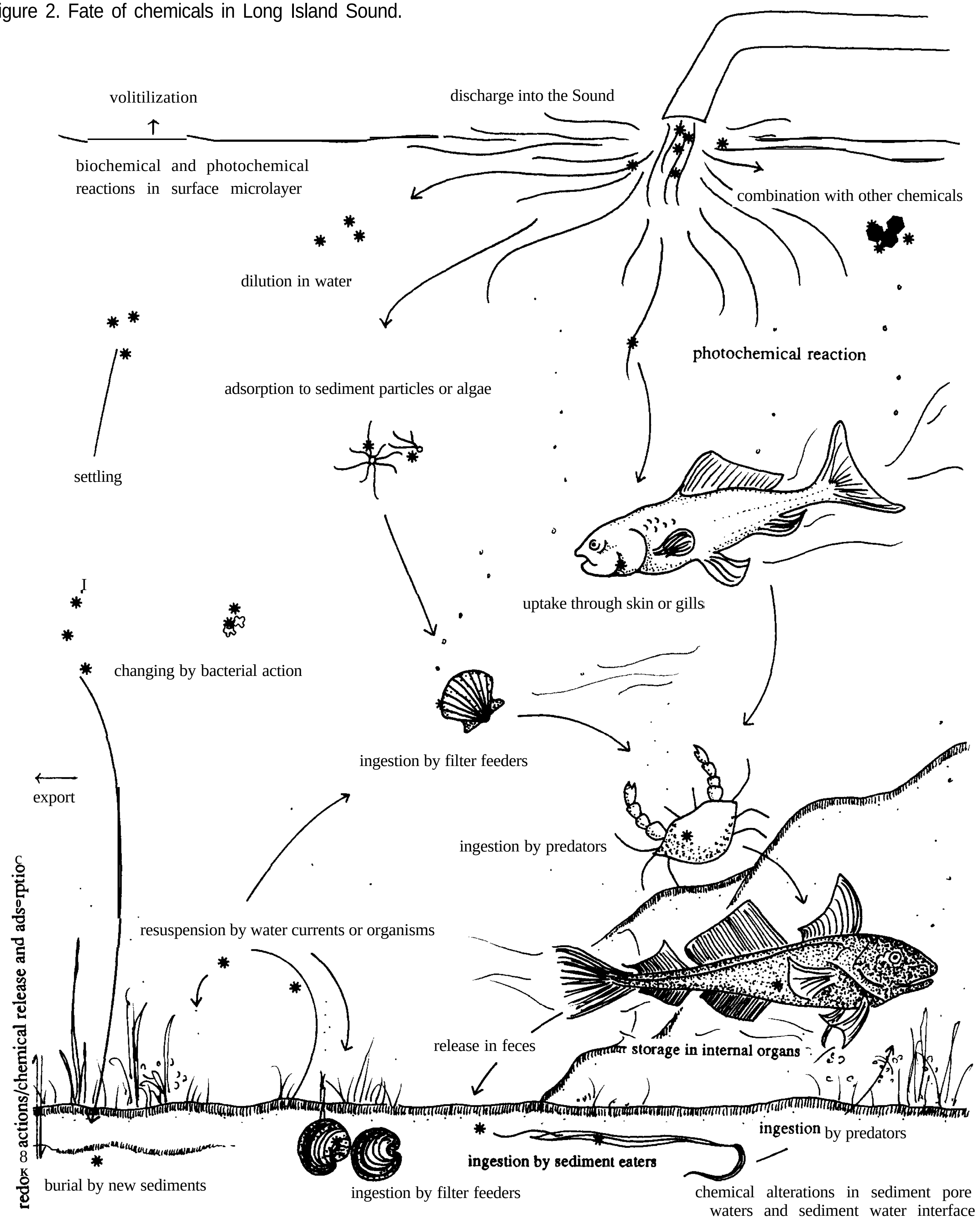


Figure 3. Copper in oysters from Long Island Sound. Source: Connecticut Department of Environmental Protection, 1986.

Figure 2. Fate of chemicals in Long Island Sound.



contaminant taken into the organism exceeds the amount removed or excreted. Bioaccumulation can cause organisms to have high levels of toxic substances in their tissues, and consequently may be a health risk to seafood consumers. Public health advisories are published to inform consumers about potential risks from eating large amounts of specific types of seafood (see Fact Sheet #9). In Long Island Sound, advisories for saltwater fish exist for only striped bass, bluefish, and lobster tomalleys. New York also has an advisory for American eels. These advisories are all because of elevated levels of PCBs. The state health officials in

Connecticut and New York involved with the LISS are working to ensure that health risks are addressed as part of the CCMP.

Managing Toxic Contaminants in Long Island Sound?

The LISS will provide information to help environmental managers focus on reducing toxic contamination in the Sound. The LISS is attempting to reduce toxic contamination in the Sound and educate the Long Island Sound community about contamination issues.

Presently, New York has water quality standards for over 20 chemicals. The LISS may also recommend additional or revised water quality standards for some toxic substances. Currently, criteria for toxic chemicals in the sediment are not well defined but they are being developed at the Federal level. The LISS will monitor progress in the development of sediment criteria and other guidelines for seafood and make recommendations for criteria usage when appropriate.

Control of toxic contaminants from point discharges around Long Island Sound is an ongoing process. The industrial pretreatment program requires industries to reduce levels of toxic substances in their effluent prior to discharging to sewage treatment plants. Conversely, any industries that discharge directly to surface waters are regulated by the PDES permitting program. The regulatory approach has evolved from being soley based on effluent limits to a combination of these limits with biological methods. Permits require some dischargers to conduct a **bioassay,** a test that exposes sensitive fish and aquatic invertebrates to its wastewater discharge. If the test organisms are impaired or die, the facility is required to determine the cause of the mortality and modify their operations to eliminate or neutralize the toxicity. Although the bioassay test does not evaluate the cumulative impacts of the buildup of pollutants within the system, it does evaluate the combined effect of all contaminants in the discharge, providing an added level of protection that numerical limits do not offer.

The densely populated nature of the land surrounding the Sound makes stormwater runoff a critical issue. Runoff carries contaminants picked up from the land to surface waters. Tackling the problem of runoff as a source of contaminants requires effective land use controls and wetland protection programs.

Until the controls being developed for all types of discharges and waste reduction become effective at reducing the levels of toxic substances in the Sound, health concerns are being identified and the public informed of them. In the future, additional control over the input from both point and nonpoint sources of chemical contamination should be the result of the coordinated efforts of an informed community of citizens, environmental scientists and managers, and elected government officials.

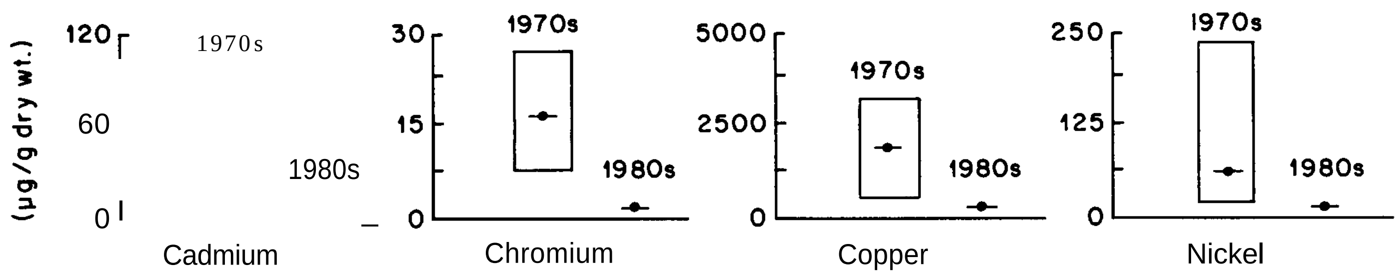


Figure 4. The mean and range of concentrations (mg/g dry wt) of selected heavy metals in oysters collected at the mouth of the Housatonic River in the 1970s compared to those collected in the 1980s. Source: 1970 data, Feng and Ruddy and 1980 data, CT Department of Environmental Protection.

The Long Island Sound Study

The Long Island Sound Study (LISS) is a six-year research and management project that began in 1985 as part of the National Estuary Program, a recent addition to the federal Clean Water Act created to protect estuaries of national importance. The LISS is a cooperative effort involving research institutions, regulatory agencies, marine user groups and other concerned organizations and individuals. The purpose of the Study is to produce a management plan for the Sound that will be administered by the three major LISS partners, the Environmental Protection Agency and the states of New York and Connecticut. To get involved with the Study, or for more information, contact: the New York Sea Grant Extension Program, 125 Nassau Hall, SUNY, Stony Brook, NY 11794, Tel. (516)632-8737; or the Connecticut Sea Grant Marine Advisory Program, 43 Marne Street, Hamden, CT 06514, Tel. (203)789-7865.

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Written by Paul Stacey and Melissa Beristain, artwork by Catherine Walker and Mitzi Eisel.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY SEA GRANT

Funding provided by the Long Island Sound Study Cooperating Agencies: The U.S. Environmental Protection Agency, Connecticut Department of Environmental Protection, New York Department of Environmental Conservation.

LONG ISLAND SOUND STUDY

Nutrient Reduction: New Solutions to Old Problems

Nutrient Reduction Action Plan Demonstration Projects

Over the past three years, the Long Island Sound Study (LISS) has been investigating the nature of the **hypoxia** (low dissolved oxygen) problem in Long Island Sound. There is a growing consensus among researchers that excess nutrients are the primary cause of the reduced oxygen levels observed in the Sound (see Fact Sheet #1). Measures to improve this condition, such as controlling the flow of nutrients. particularly nitrogen, to the Sound. are challenging and could be costly. Original estimates attached a price tag of several billion dollars to the reduction of nutrient pollution from point sources — sewage treatment plants and industry.

To determine the effectiveness of several "low-cost"nutrient reduction measures, the LISS is funding two pilot projects called Action Plan Demonstration Projects. Each will investigate the effectiveness and applicability of certain nutrient reduction technologies in the Sound's watershed.

Biological Nutrient Removal Project

Currently, wastewater is treated by two processes, **called primary and secondary treatment** before being discharged into the Sound. Primary treatment removes solids and some organic matter, while secondary uses biological processes to treat wastewater to further reduce organic wastes in the effluent (see Fact Sheet #3). Conventional wastewater treatment plants remove only small amounts of the nutrients nitrogen and phosphorus. Typically, a primary treatment plant can remove 5 to 15 percent of the total nitrogen and phosphorus from the waste stream. A secondary plant will remove an additional 5 to 10 percent of these nutrients.

Using **biological** nutrient **removal** (BNR) techniques, wastewater treatment experts believe that it may be possible to increase nutrient removal from existing sewage treatment plants at reduced costs. The BNR process, shown in Figure 1, transforms nitrogen, which enters the plant as ammonia, into nitrogen gas that is released into the atmosphere. BNR is a two-step process utilizing natural reactions. **nitrification** and **denitrification.** Figure 2 gives one example of these reactions in nature. To set up BNR for wastewater treatment. the aeration tank is altered so that an anoxic or anaerobic (low or no oxygen) zone is created at one end and the other sections remain aerated or aerobic. Sewage and bacteria from secondary settling tanks are mixed into the low oxygen zone. In the aerated section% ammonia (NH_4^+) is converted to nitrate (NO_3^-) in a two-stage reaction called nitrification. Denitrification requires low oxygen conditions. The bacteria extract oxygen from nitrates, causing harmless nitrogen gas (N_2) to be released into the atmosphere. Consequently, nitrogen is reduced in the wastewater effluent (discharge).

These BNR techniques may require only minor changes in operation and process control rather than complete reconstruction of the plant where they can be applied.

Two sewage treatment plants that discharge into the Long Island Sound Study area, the Stamford Water Pollution Control Facility in Stamford, CT and the Tallman Island Sewage Treatment Plant in Queens, NY are evaluating the BNR method. Their goal is to biologically remove 80 percent of the nitrogen from the effluent. These plants were selected because of their facility designs, past records of compliance with permit limits, **and plant** operator skills and controls. Additionally, neither plant is at or over capacity.

The Stamford facility implemented BNR on March 1, 1990. This plant, designed to treat 20 million gallons per day (MGD)

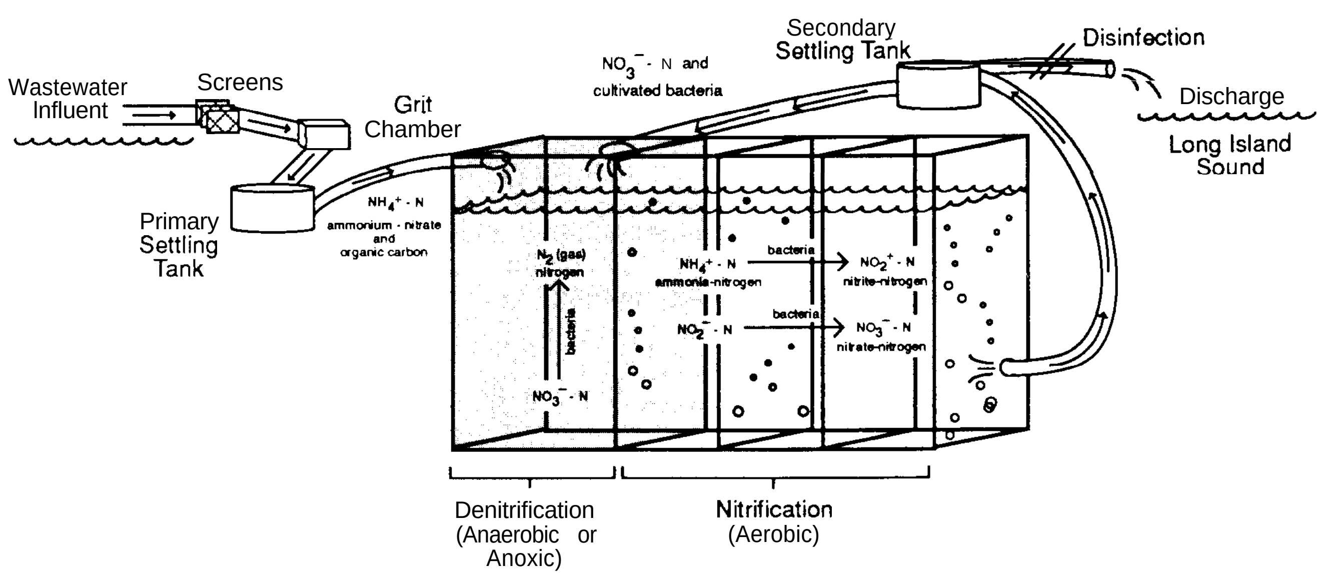

Figure 1. Example of biological nutrient removal process in an altered aeration tank

has an average daily flow rate of 16 MGD and is now removing more than 97 percent of the ammonium-nitrogen (NH_4^+) and 65 to 75 percent of the total nitrogen in the effluent.

In June 1990, work began at the Tallman Island plant to implement a similar wastewater treatment process. This plant is much larger than the one in Stamford. Designed to treat 80 MGD, it treats an average of 63 MGD. The BNR treatment process will be evaluated in one quarter of the plant (affecting 16 MGD of the flow through the plant) and the effluent quality of both the BNR and old treatment processes will be monitored closely.

The $105,500 LISS demonstration grant will enable the Tallman and Stamford facilities to document the operational limits associated with the BNR process. One important factor that will be tested is the technique's effectiveness in colder temperatures, when bacteria are less active.

The staff at both facilities and their city governments are very dedicated to the project's success. They have increased personnel and provided financial resources to ensure the project's thorough analysis.

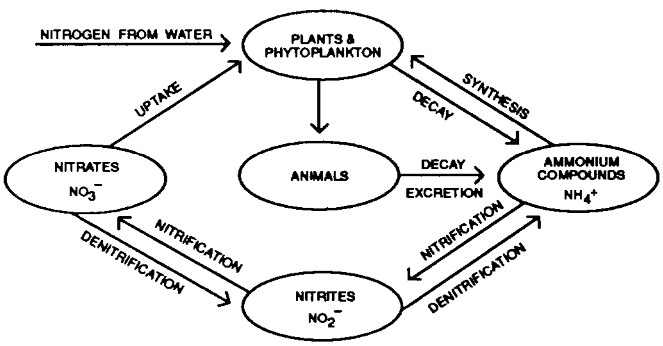

Figure 2. Example of nitrogen cycle in nature. Adapted from Garrels, Mackenzie and Hunt, 1975.

Agricultural Nutrient Management Project

Nonpoint sources of pollution also contribute nutrients to Long Island Sound via land and river runoff. In the Housatonic River basin, the Litchfield County Soil and Water Conservation District, the Connecticut Council on Soil and Water Conservation, the USDA Soil Conservation Service and Connecticut Cooperative Extension System have received funding from the LISS and the Connecticut Department of Environmental Protection to conduct an agricultural nutrient management demonstration project. The objective of this project is to demonstrate the feasibility of using customized agricultural nutrient management plans to decrease nutrient runoff to Long Island Sound.

Present inorganic fertilizer application practices and poor distribution of animal wastes on croplands may result in overfertilization of some fields. The excess fertilizers may run off the land into the surface waters or be transported in the groundwater to nearby streams. Eventually the streams will transport the nutrients to Long Island Sound.

Soils are tested to measure nutrient levels and to determine whether it is necessary to apply fertilizer and in what amounts. Fertilizer added to soil already containing enough nutrients to support the crop to be grown may wash away with **runoff** or **leach** into the groundwater.

By 1991 twenty-seven farms will have prepared individual nutrient management plans. The plans will be based on the type of farm, nutrient levels in the soil and current fertilizer and manure application practices. The management plans will be evaluated for their effectiveness in maintaining crops and reducing runoff of nutrients from each property.

An integral part of this project is an information and education program designed to encourage farmers to volunteer to participate in the project. By participating, farmers can decrease their operational cost by using less fertilizer on their land.

The results of this $80,000 demonstration grant will be applicable throughout the Sound's drainage basin and will identify the economic and environmental benefits of using agricultural nutrient management plans.

The Long Island Sound Study

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LONG ISLAND SOUND STUDY

Pathogens

Long Island Sound is as famous for its fish and shellfish as it is for boating, swimming, and scuba diving. The Sounds sheltered embayments are the most desirable areas for many recreational and commercial activities. Yet, it is on the shorelines of these embayments that developments are concentrated. Pathogen contamination, caused poor land use and flawed waste disposal practices, often impairs our ability to swim or harvest shellfish in many bays. In 1989, the dockside value of Long Island Sound's commercial bivalve shellfishery – clams, oysters, and mussels (excluding bivalves harvested in relay and depuration programs) – was over $30 million. Because pathogen contamination closes beaches and restricts shellfish harvesting, it seriously affects the region, economically and socially.

Origins and Effects of Pathogens

Certain bacteria, viruses, and protozoa are known as pathogens. When people ingest these microorganisms or allow them to enter their bodies, they may incur illnesses and diseases such as gastroenteritis, cholera, typhoid fever, salmonella, or hepatitis A. Pathogens that concentrate in the fecal waste of infected humans and warm-blooded animals, find their way to Long Island Sound via both point and nonpoint routes (see Fact Sheets #3 and #7). Specific sources of pathogens include improperly and untreated sewage discharges from combined sewer overflows (CSOs), sewage treatment plant breakdowns, and pumping station bypasses; stormwater runoff; waterfowl and animal wastes; septic systems; inadequately treated sewage discharges from boats; and illegal connections to storm drain systems.

Testing for Pathogens

As yet, there is no practical test for pathogens, human or otherwise. Consequently, their presence cannot be accurately measured. Instead, the appearance of indicator organisms determines the presence of pathogenic organisms. Coliform bacteria are used as indicators and, like pathogens, are found in the digestive tracts of all warm-blooded animals, on plant matter, and in the soil. Because coliform bacteria are typically discharged with sewage wastes, their presence in significant numbers serves as an indication that other harmful bacteria or viruses may be present.

Because coliforms are not always pathogens, they are not perfect indicators. Despite the limitations, standards based on coliforms have minimized typhoid and cholera outbreaks caused by eating shellfish or swimming polluted waters. Scientists are evaluating the reliability of other indicators. These new indicators may improve our ability to identify the presence of human pathogens.

Currently, three types of indicators are measured: total coliform, which comes from decaying matter, feces, and soil; fecal coliform, which is a component of total coliform bacteria; and enterococcus, which comes from feces of warm-blooded animals, including humans. All suggest the possible presence of harmful bacteria and viruses.

Stormwater runoff that contains animal wastes and soil washed from the land is often a major source of fecal coliform bacteria (see Figure 1). In many older cities, sanitary and storm sewer systems are combined. So when it rains, the volume of these combined flows often exceeds the capacity of the sewage treatment plant. This results in the discharge of untreated wastes containing fecal and other coliforms into coastal waters. (In Figure 1, CSOs are part of the urban runoff category.) The outflows of combined sewers and sewage treatment plants have a higher probability of disease transmission because they carry high levels of bacteria in a concentrated form.

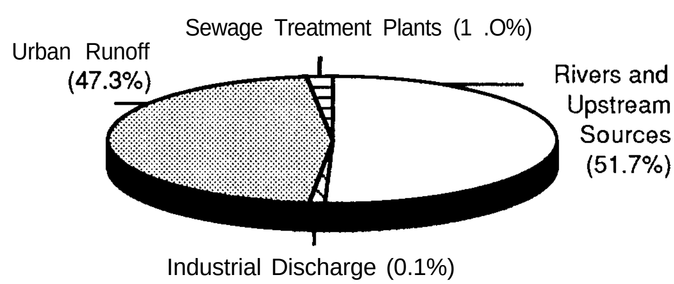

Figure 1. Estimated fecal coliform discharges to Long Island Sound in 1986. The urban runoff category includes CSOs; the river load includes point and nonpoint sources from upstream. Source: National Coastal Pollutant Discharge Inventory: Estimates for Long Island Sound.

Effects of Pathogen Contamination

1. Closure of Bathing Beaches

Swimming in contaminated waters can lead to

Beach Closure Standards

Westchester County * / New York City and Nassau County *	Total coliform greater than 2,400/100 ml
Suffolk County, New York	Fecal coliform greater than 400/100 ml
Connecticut (single sample)	Enterococcal organisms greater than 61/100 ml

* Rainwater runoff can raise total coliform levels because it carries decaying matter and animal and human waste. Certain beaches in Mamaroneck Harbor are automatically closed following rain events. Nassau County recommends people refrain from swimming in certain areas after significant rainfall because the coliform levels may be increased but not exceed the standard.

Coliform standards are based on a log-mean average for 5 or more samples within 30 days.

bacterial and viral infections. Therefore, beaches are monitored and closed by the health department when levels of indicator organisms exceed acceptable standards. But because these standards are set by local health departments, they may vary among jurisdictions (see box). Figure 2 shows the number of Long Island Sound beach days lost due to coliform contamination. Many of New York's beach closures were not the direct result of measured coliform levels - rather, they were precautionary closings caused by sewage treatment or pumping station failures in the vicinity of a bathing beach. The increased number of beach closures in 1989 is related to the record rainfall experienced that year.

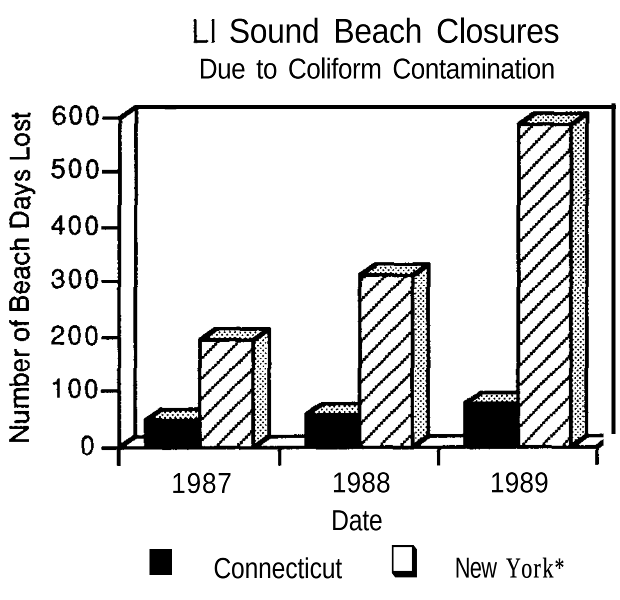

Figure 2. Long Island Sound beach closings due to coliform contamination. Number of beach days lost equals the sum of the number of days all beaches were closed. • Excludes New York City beaches

2. Closure of Shellfishing Grounds

Pathogen contamination also limits the use of shellfish resources. Bivalve shellfish, such as oysters, mussels, and clams, feed by filtering large quantities of water and extracting food particles. If the shellfish are growing in polluted areas, this process will collect and even concentrate pathogens in their digestive systems. By eating whole, partially cooked, or raw contaminated shellfish, viable pathogens can be passed on to the consumer. Other forms of seafood, such as lobsters, crabs, and shrimp, are not filter feeders, and are usually cooked before eating. Therefore, they are not as likely to be contaminated with pathogens. The LISS Fact Sheet #9, "Seafood Issues," describes how to ensure the shellfish you eat are safe and are of high quality.

Shellfish Sanitation Program

Shellfish growing waters are routinely tested for coliform levels. This is to assure the shellfish being harvested are safe for human consumption. Under the National Shellfish Sanitation Program, initiated in 1925, States are responsible for ensuring that shellfish are harvested only from clean waters. The New York State Department of Environmental Conservation and the Connecticut Department of Agriculture, along with some coastal municipalities, monitor and regulate the Sound's shellfish resources and enforce contaminated shellf'ishing area closures. Shellfish can be harvested only from areas where the median coliform values are routinely found to be below 70 total or 14 fecal coliforms per 100 milliliters of water.

Shellfish can be moved from pathogen contaminated waters to clean waters, where they will flush out the pathogens over a period of several weeks. Transplanting or relaying shellfish to clean waters allows for natural purification or flushing. Controlled purification takes place in depuration plants in which shellfish are held in tanks with rapidly circulating water. Both types of activities are carefully regulated by state agencies.

The Shellfish Sanitation Program has been very

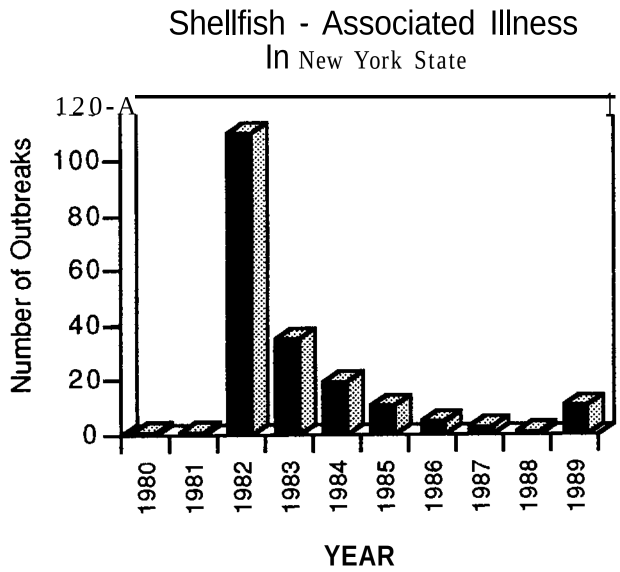

Figure 3. Shellfish-associated illness reported in New York State. Source: Bureau of Community Sanitation and Food Protection, New York State Dept. of Health.

Extent of Pathogen Contamination in Long Island Sound

	Connecticut (acres)	New York (acres)	Total (acres)
Potential shellfishing grounds	392,419	471,220	863,639
Prohibited or restricted areas	78,009 (20%)	82,445 (18%)	160,454
Productive shellfish beds	52,500	66,000	118,500
Prohibited or restricted areas where beds are productive	18,375 (35%)	48,500 (73.5%)	66,875

As of January 1990. Source: NY Dept. of Environmenta Conservation and CT Dept. of Agriculture.

effective in controlling outbreaks of shellfish-borne disease. Figure 3 summarizes shellfish-associated illnesses reported in New York State over the past decade (it includes shellfish harvested outside state waters). In 1982, many reported illnesses were traced to clams harvested in New England and Europe. In 1989, only ten outbreaks were reported in Connecticut, no major outbreaks were reported in previous years. An outbreak represents two or more illnesses at one location.

The LISS and Pathogen Contamination

Figure 4 compares average total coliform concentrations for wet and dry weather conditions from June to September 1989. This type of data, when combined with other available information, will be used to characterize pathogen contamination in Long Island Sound. Figure 5 shows the decreasing trends in total coliform levels in the East River and Western Sound.

Shellfish Area Classifications

Approved or Certified Areas:
Shellfish can be freely harvested from areas that meet appropriate state and National Shellfish Sanitation Program bacterial standards. These areas are regularly sampled by shellfish regulatory agencies.

Conditionally Approved or Certified Areas:
Any area influenced by occasional and predictable deterioration of water quality. Shellfish can be directly harvested only under specified conditions (i.e., when water quality meets certified criteria under identified situations of reduced pollutant inputs). The area is temporarily closed when certified criteria are not met. Rainfall is a major factor that affects conditional closings.

Restricted Areas:
Areas that do not meet the certified area criteria. Shellfish may be harvested from these areas for transplanting or depuration under special permits from the State Shellfish Control Agency.

Conditionally Restricted Areas:
Any area predictably influenced by pathogenic contamination, as with conditionally certified areas.

Prohibited Areas:
No harvesting is permitted from areas that are grossly contaminated or for which no shoreline survey and water quality assessment has been recently completed.

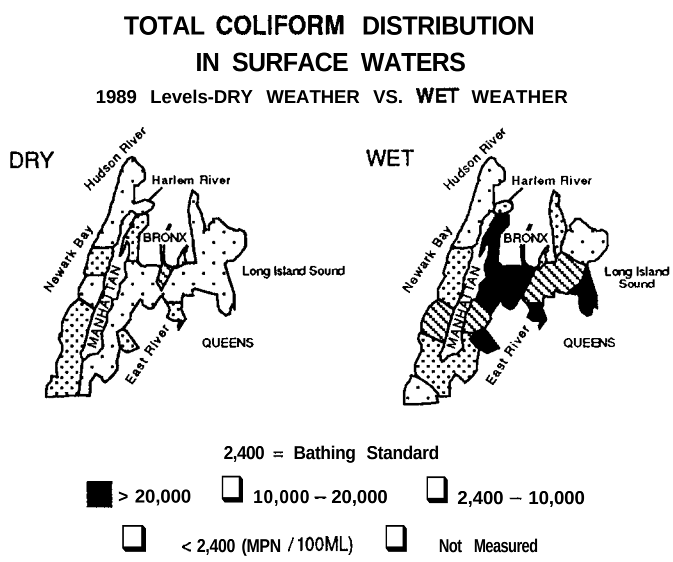

Figure 4. Comparison of wet and dry weather average total coliform concentrations measured at the surface from June to September 1989. Bathing standard is applicable in western Sound only. Source: New York City Department of Environmental Protection.

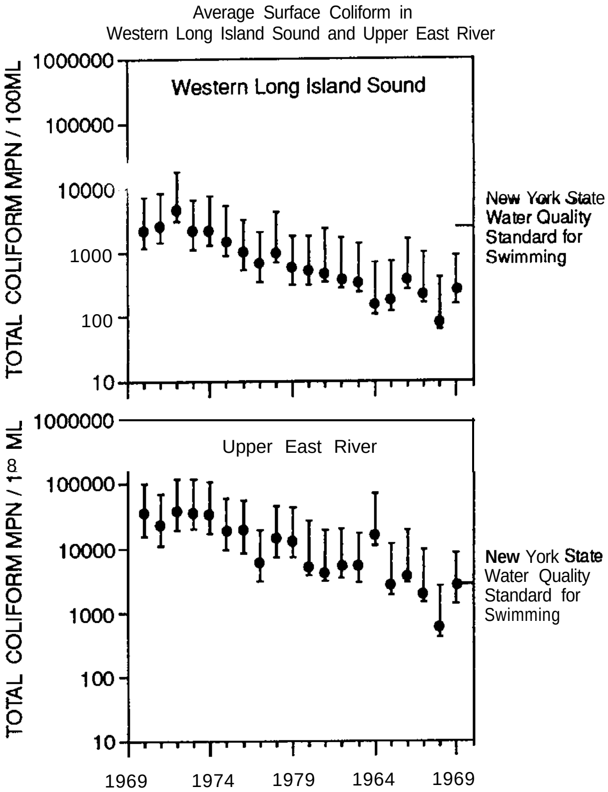

Figure 5. Average total coliform concentrations measured at the surface from June to September 1970 through 1989 in the East River and Western Sound. Bathing standard is applicable east of the Whitestone Bridge. Source: New York City Department of Environmental Protection.

The Long Island Sound Study (LISS) is investigating ways in which the Sound's water quality can be maintained or enhanced. Under an Action Plan Demonstration Project, the LISS is studying the relationship of urban stormwater runoff to coliform levels in the Mamaroneck Harbor area. Nonstructural coliform reduction management practices (catch basin cleaning, street sweeping, and an educational program on pet waste ordinances) have been implemented and evaluated. Although the results have shown that these measures alone did not reduce coliform levels, the project's goal of improving water quality can still be achieved. Coliform modeling will provide estimates of effluent limits for point source discharges into the Harbor. These estimates can be used to develop goals that will continue to reduce pathogen inputs to the Sound.

In its Comprehensive Conservation and Management Plan (due out in November 1991), the LISS will identify specific actions to reduce pathogen contamination in the Sound. Scientists and managers will characterize the conditions for pathogen closures in the Sound, identify standards used, and evaluate the need for a uniform beach closure standard.

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LONG ISLAND SOUND STUDY

The Impact of Septic Systems on the Environment

Nearly half of the homes and businesses in the Long Island Sound watershed have septic tank waste disposal systems. When properly sited and maintained on a routine basis, septic systems are an excellent waste management alternative. However, when not properly sited or maintained, they can cause contamination of surface and groundwater resources, which leads to public health and pollution problems.

How Septic Systems Work

Septic systems have two key components, a **receiving tank** and a **leaching system.** A sewage line carries wastewater from the kitchen, bathroom and laundry room to the underground septic tank, where heavy particles settle out of the liquid, forming a layer of **sludge** on the bottom of the tank. Light materials float, forming a layer of **scum** on top of the water in the tank (see Figure 1). Bacteria use the solid materials, liquefying these waste products. To allow sufficient time for particles to settle and for bacteria to break down the sludge, a septic tank should be large enough to hold at least one day's flow of wastewater from the home, and to provide storage for sludge and scum.

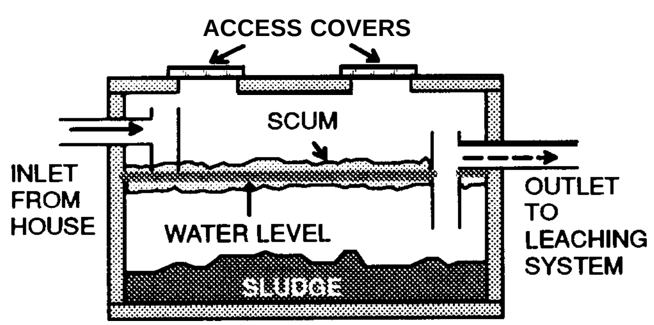


Figure 1. Cross section of a typical septic tank.

Each addition of wastewater to the septic tank displaces an equal amount of liquid into the leaching system. This may consist of a large perforated ring, leaching pit, or a series of absorption trenches, depending on the regulations in effect in your area when your system was installed. The leaching system is designed to allow the liquid from the septic tank (called effluent) to be released into and filtered by the surrounding soil. Bacteria in the soil further degrade the waste, removing harmful organisms, organic matter, and some nutrients. Ultimately, some of the effluent enters the groundwater.

Groundwater Contamination

Septic systems will operate effectively if, and only if, they are designed properly, situated in areas that allow proper operation, used only for the purposes for which they were designed, and given periodic maintenance. Even a properly operating system will discharge nutrients (phosphates and nitrates) and some bacteria or viruses to the groundwater. An improperly maintained or failing system will discharge even more contaminants to the groundwater.

Domestic wastewater can contain bacteria and viruses that cause dysentery, hepatitis, and typhoid fever. To protect public health, it is important to minimize the amount of these organisms that reach surface or groundwater. Fortunately, soil and soil bacteria can effectively remove most pathogens (disease--causing microorganisms) from wastewater treated in a properly functioning septic system.

When nutrients such as **nitrogen** and **phosphorus are** discharged from septic systems into the groundwater, they contaminate drinking water supplies, and also represent a potentially important nonpoint source of pollution to ponds, streams, and the Sound (see LISS Fact Sheet #7, Nonpoint Source Pollution in Long Island Sound). The connection between ground and surface water pollution is closely linked since the base flow of streams draining to Long Island Sound comes primarily from groundwater contributions. (see Figure 2).

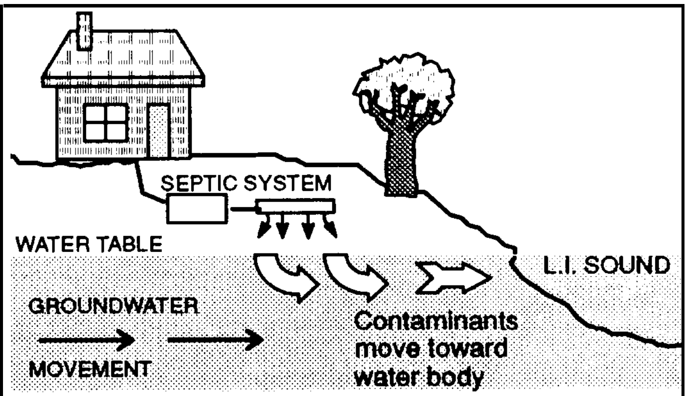


Figure 2. Groundwater can transport biological, chemical and nutrient contaminants to nearby surface waters.

In freshwater systems, phosphorus causes excessive aquatic weed growth that can limit the uses of ponds and lakes. In the Sound, nitrogen fuels massive algae blooms, which in turn die, using up oxygen as they decompose. This causes **hypoxia,** a loss of oxygen in the bottom waters, which has serious ecological implications for Long Island Sound (see LISS Hypoxia Management Update).

Infectious diseases and nutrients are not the only concern. The improper use of septic systems has been shown to contribute to contamination of groundwater by toxic chemicals. Contaminants that may enter groundwater through septic systems include heavy metals and toxic chemicals from small commercial establishments, toxic household products, and organic chemicals typically found in septic tank cleaning products. Given that over 50 percent of all drinking water used in the United States is groundwater. improper use and failure of septic systems should not be taken lightly.

In order to improve the level of wastewater treatment and minimize the 'amount of disease organisms, nutrients, and chemicals that enter ground and surface waters, you should make sure your system is in proper working order, follow simple maintenance procedures, and conserve water.

SIGNS OF SEPTIC SYSTEM FAILURE

- Slow drainage or sewage backup in drains or toilets.
- Excessive lush grass growth in the system area, even during dry weather.
- Unpleasant odors around your home.
- Excessive growth of aquatic weeds or algae in lakes or ponds adjacent to your home.

HEALTH EFFECTS OF A FAILING SYSTEM

- Improperly treated wastewater can contaminate drinking water supplies, causing disease.
- Infectious diseases are spread by mosquitoes and flies that breed in areas where liquid wastewater reaches the surface.
- Risk to the public, especially children and animals who come into contact with surface flows and may drink contaminated groundwater.

What You Can Do

Maintenance is the single most important factor that determines the length of time a septic system will function properly. Too often homeowners forget that whatever goes down the drain or toilet ultimately finds its way into the soil (and possibly the groundwater) or remains in the septic tank until it is pumped out. The following maintenance practices will help keep your system functioning well and help minimize its impact on the environment.

Pump out your septic tank. When a system is poorly maintained (not pumped out on a regular basis), solids build up in the septic tank, then flow into the leaching system, clogging it beyond repair. Since it may cost $5,000 or more to replace a septic system, having a reputable contractor pump out your septic tank every two to three years is well worth the price. Maintain records of system maintenance and know the location of the system's components.

Watch what you put down the drain. The use of a garbage grinder will add SO percent more solids to the system, and result in the need for more frequent pumping out of the septic tank. Don't put grease or cooking oil down the drain — it congeals and can clog your pipes, septic tank, and leaching system. Dispose of unwanted household chemicals properly- do not pour them down the drain where they can contaminate groundwater; instead save them for the next household hazardous waste collection day in your community. Remember, the less you put into the system, the longer it will function properly.

Avoid Additives. There is no scientific evidence that demonstrates the effectiveness of any additive. Various products marketed for that purpose do not improve the performance of the septic tank, nor do they reduce the need for routine maintenance. Organic chemicals, such as chloroform and trichloroethylene, are typically found in septic tank cleaning products. Some of these chemicals are suspected of causing cancer, and they are generally ineffective as septic tank cleaners.

Conserve Water. Conserving water by installing low flow fixtures in your home and by adopting more conservative water use practices can extend the life of the system, delay the need for repair, and lessen the likelihood of contaminating local surface and groundwater. Distribute laundry chores throughout the week to avoid overloading the system on any given day. Don't connect downspouts from roofs or basement sumps to the system; in heavy rain they will quickly overload its capacity. Instead, make sure such drainage is diverted away from the leaching system area. Minimizing water usage during periods of heavy rainfall will reduce the potential for system malfunction.

FOR MORE INFORMATION:

For more information about septic systems, a comprehensive series of fact sheets titled "Your Septic System" is available through Cornell Cooperative Extension. If you have a question about your septic system, call your local Department of Health or Cooperative Extension office.

The Long Island Sound Study

The Long Island Sound Study (LISS) is a multi-year research and management project that began in 1985 as part of the National Estuary Program, a recent addition to the federal Clean Water Act created to protect estuaries of national importance. The LISS is a cooperative effort involving research institutions, regulatory agencies, marine user groups, and other concerned organizations and individuals. The purpose of the Study is to produce a management plan for the Sound that will be administered by the three major LISS partners, the U.S. Environmental Protection Agency and the states of Connecticut and New York. To learn more about or become involved with the Study, contact the New York Sea Grant Extension Program, 125 Nassau Hall, SUNY at Stony Brook, Stony Brook, NY 11794-5002, (516) 632-8730; or the Connecticut Sea Grant Marine Advisory Program, 43 Marne St., Hamden, CT 06514, (203) 789-7865.

This fact sheet was produced by the New York Sea Grant Extension *Program and the Connecticut Sea Grant Marine Advisory Program. Graphics, layout and text by Trent R. Schneider.* Funding provided by the Long Island Sound Study. Cooperating Agencies: the U.S. Environmental Protection Agency, Connecticut Department of Environmental Protection, New York Department of Environmental Conservation. 9/91

LONG ISLAND SOUND STUDY

Water Conservation and Marine Water Quality

Water Use and Marine Pollution

Clean water is a resource that is taken for granted. Pure water is necessary for growing food, manufacturing goods, disposing of wastes, and for our own consumption. Water conservation is most frequently thought of as a measure to protect against water shortages. While protecting water supplies is an excellent reason to practice conservation, there is another important benefit of water conservation — improved water quality in the marine environment.

The link between water use and marine pollution may not be immediately apparent, yet water use is a considerable source of pollution to our coastal waters. When water is used for household, industrial, agricultural, or other purposes, it is degraded and polluted in the process. Called **wastewater,** this byproduct of human activities may carry **nutrients, biological** and **chemical contaminants, floating wastes,** or other pollutants. Upon discharge, wastewater ultimately finds its way into groundwater or surface waters, contributing to their pollution.

How Wastewater Reaches Groundwater and Surface Waters

The Long Island Sound watershed is home to tens of millions of people who use and dispose of billions of gallons of water daily. This wastewater reaches groundwater and surface waters in a number of different ways.

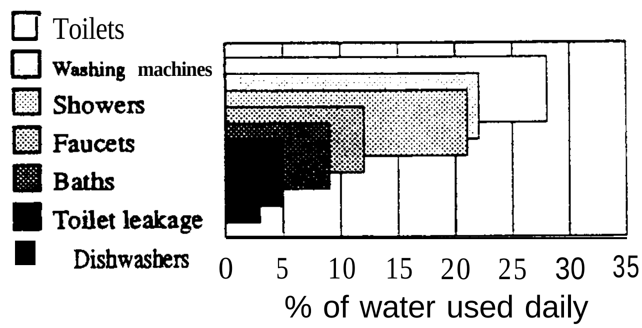
♦ *Sewage Treatment Plants (STPs) — The* largest contributors of wastewater to the Sound are sewage treatment plants. Over 1.2 billion gallons of wastewater from homes and businesses are discharged daily by the 44 STPs adjacent to the Sound. While this wastewater is treated before discharge, it still contains pollutants that impact the Sound. Long Island Sound Study (LISS) researchers have found that STPs contribute toxic contaminants and bacteria, and are one of the largest sources of nutrients to the Sound.

Conserving water can reduce the volume of wastewater flowing to treatment plants, enabling the plants to more efficiently treat incoming waste. Conservation can also defer expansion costs at STPs that are nearing capacity, lengthen the working lifetime of plants, and help reduce operating and maintenance costs.

♦ *Combined Sewer Overflows (CSOs) — In* older urban areas, the storm and sanitary sewers are combined in underground pipelines. When it rains, street runoff mixes with sewage in the pipes and overwhelms the capacity of the sewer system. To avoid street and home flooding, the extra volume is released into coastal waters without being treated. Combined sewers discharge floatable wastes, bacteria, nutrients, and other contaminants from the sewer system and roadways directly into local waterways.

Water conservation can reduce wastewater volume at a plant, in effect providing additional capacity for a portion of the runoff-sewage mixture to be contained for treatment.

♦ *Septic Systems* -In areas not served by STPs, most wastewater is disposed into on-site septic systems. Even a properly operating system will discharge nutrients and some bacteria or viruses to the groundwater. Excessive water usage encourages flushing of these pollutants to the groundwater, and shortens the lifetime of the system as well. The connection between ground and surface water pollution is close in the Long Island Sound area since the flow of streams draining to the Sound comes primarily from groundwater contributions. Reducing the amount of water discharged to septic systems can protect surface water quality and drinking water supplies.



Most people use between 50 and 80 gallons of water per day in the home. Since about 3/4 of this use is in the bathroom, it is the logical place to concentrate water conservation efforts.

♦ *Outdoor Water Usage* — Excessive water use outdoors can also lead to pollution of surface and ground waters. Overwatering lawns or gardens causes runoff that can carry dangerous pesticides and fertilizers with it. Leaving the water running while washing the car or hosing down the driveway can transport toxic automotive products and detergents into storm drains. Excessive water use near septic system components accelerates the flushing of contaminants from the system. All of these activities can contribute to pollution of valuable water resources.

The Problem

The various pollutants carried by water contribute to water quality problems in Long Island Sound. Excess nutrients can lead to hypoxia, or low dissolved oxygen levels in marine waters. Toxic materials can contaminate bottom sediments and build up in the food chain. Pathogens, or disease-causing organisms associated with the release of raw sewage and runoff containing human or animal wastes, can cause the closing of beaches and shellfishing areas. Floatable debris litters our beaches and threatens marine life. Together, these pollutants impair the overall health of the Sound, its marine life, and our ability to use and enjoy this coastal resource.

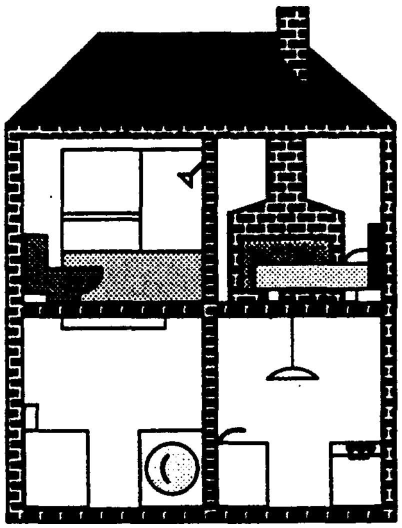
Water Conservation

Because water use is the link between homes and businesses and coastal water quality, conserving water whenever and wherever possible will help protect coastal waters, and also save the consumer money on water use bills, water heating, sewer bills, and maintenance costs for heavily used septic systems.

The average person uses 50–80 gallons of water per day in the home, arid the equivalent amount outdoors, depending on the season. Since a large percentage of water use takes place in the bathroom, that is where water conservation efforts should begin.

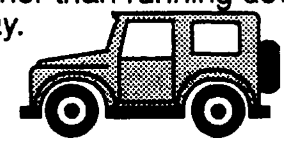
Conserve water in the bathroom:

- **retrofit with low flow showerheads, faucet aerators, and toilet dams that are simple and inexpensive to install.**
- **check for and repair leaks in toilets and faucets.**
- **adopt simple changes in water use habits; turn the water off during shaving and tooth brushing, and take short showers instead of baths.**



Conserve water outdoors:

- **water lawns and gardens only when necessary, preferably during early morning hours to reduce evaporation.**
- **attach a pistol-type sprayer to the end of the garden hose, so that the water only runs when actually in use.**
- **wash the car on the lawn, so that the water used seeps into the ground rather than running down the driveway.**



Practice other indoor conservation measures:

- **wash only** full loads of laundry or dishes.
- **wash dishes in a full sink or dishpan instead of under running water.**

Other ways to conserve outdoors:

- **improve soil content with organics and mulching** tilled areas to increase **the soil's capacity to hold water, reducing the need for frequent watering.**
- **learn more about xeriscaping — landscaping with plants that require little or no supplemental watering.**

The Long Island Sound Study

The Long Island Sound Study (LISS) is a multi-year research and management project that began in 1985 as part of the National Estuary Program, a recent addition to the federal Clean Water Act created to protect estuaries of national importance. The LISS is a cooperative effort involving research institutions, regulatory agencies, marine user groups, and other concerned organizations and individuals. The purpose of the Study is to produce a management plan for the Sound that will be administered by the three major LISS partners, the U.S. Environmental Protection Agency, and the states of Connecticut and New York. To learn more about or become involved with the Study, contact the New York Sea Grant Extension Program, 125 Nassau Hall, SUNY at Stony Brook, Stony Brook, NY 11794–5002, (516) 632–8730; or the Connecticut Sea Grant Marine Advisory Program, 43 Marne St., Hamden, CT 06514, (203) 789–7865.

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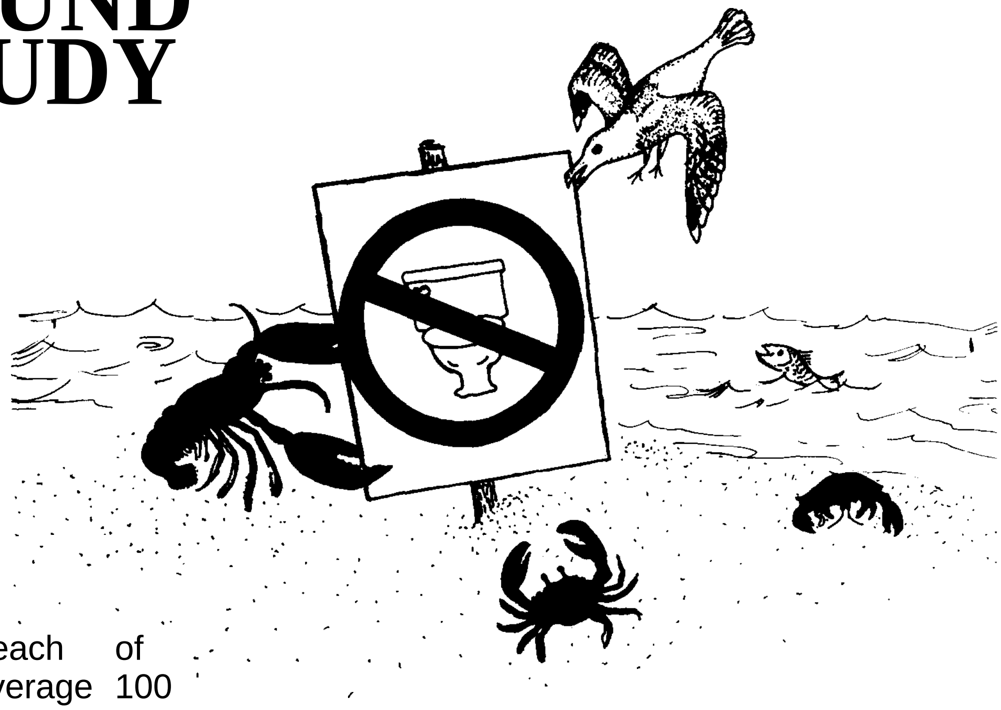
LONG ISLAND SOUND STUDY

Wastewater Treatment



What is Wastewater?

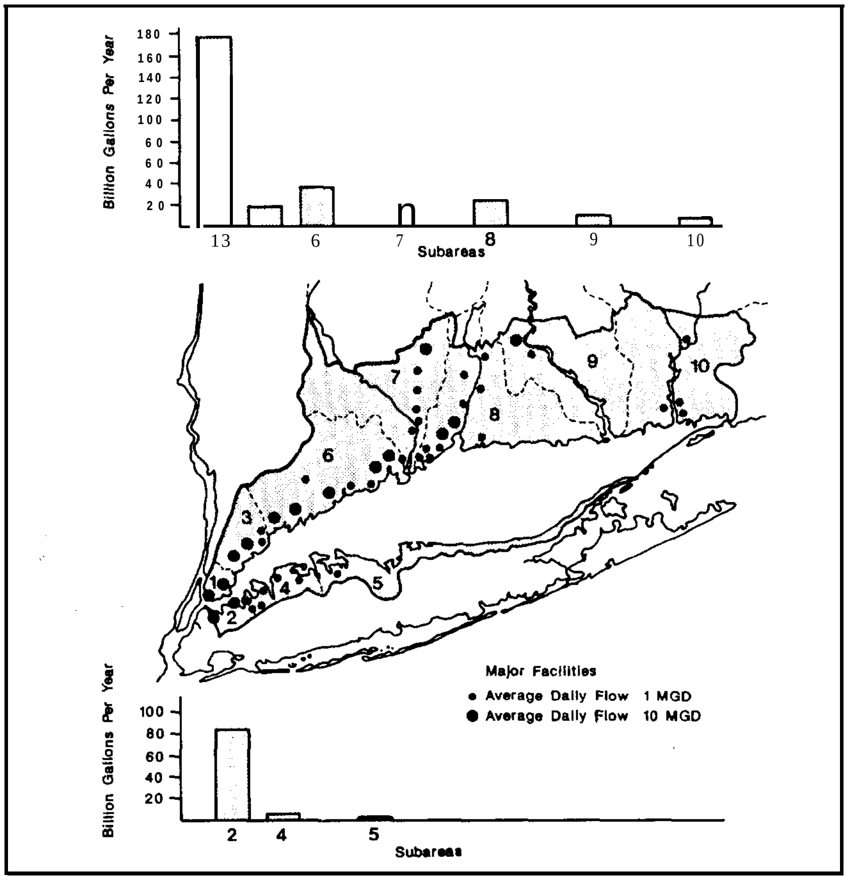
There is no question that the natural resource most critical to our everyday activities is water. We use water freely in our homes, yet give little thought to what happens to it after it goes down the drain. In fact, each of us pours or flushes an average 100 gallons of water per day down household drains. This water, plus water discharged to sewers by commercial and industrial enterprises, is called wastewater. In areas serviced by sewers, wastewater flows to a local treatment facility, or sewage treatment *plant (STP)*. Currently 44 such facilities discharge over 1 billion gallons of treated effluent into Long Island Sound every day. While most of us prefer not to dwell on the subject of sewage, what happens to wastewater should greatly concern all of us.

Why Should We Be Concerned About Wastewater?

Although typical wastewater is over 99% water, the remaining 1% may contain substances that are potentially harmful to aquatic life and to us. Many products we use in our everyday life (bathroom cleaner, for instance) introduce toxic contaminants to the wastewater. Also, more "natural" substances such as bacteria and *nutrients* enter wastewater from human wastes. Improperly treated wastes pose risks both to the health of Long Island Sound and to the people who enjoy its resources. Contaminants can threaten the health of the Sound's fish and shellfish, affect the health of people who swim in its waters, and pose a threat to people who eat seafood. Excess nutrients pose a special threat to Long Island Sound by stimulating algal blooms that deplete dissolved oxygen after they die and decay (see Fact Sheet #1). For these reasons, the quality of the Sound's water is closely tied to the location, volume, and treatment level of the effluent being discharged by STPs.

How Is Wastewater Treated?

Before our coastal areas became so heavily populated, much of the wastewater we produced was piped directly to our rivers, streams, and bays without undergoing treatment. Nature provided the necessary purification. As population density increased, the aquatic systems could no longer absorb the large volumes of wastewater without environmental damage and human health risk. People found that wastewater needed to be treated before its release into the environment. The three levels of sewage treatment *(primary, secondary,* and *advanced* or *tertiary)* vary in their ability to remove harmful components such as organic matter, nutrients, and toxins.



ANNUAL WASTEWATER TREATMENT PLANT DISCHARGES
(From National Oceanic and Atmospheric Administration)

Primary Treatment

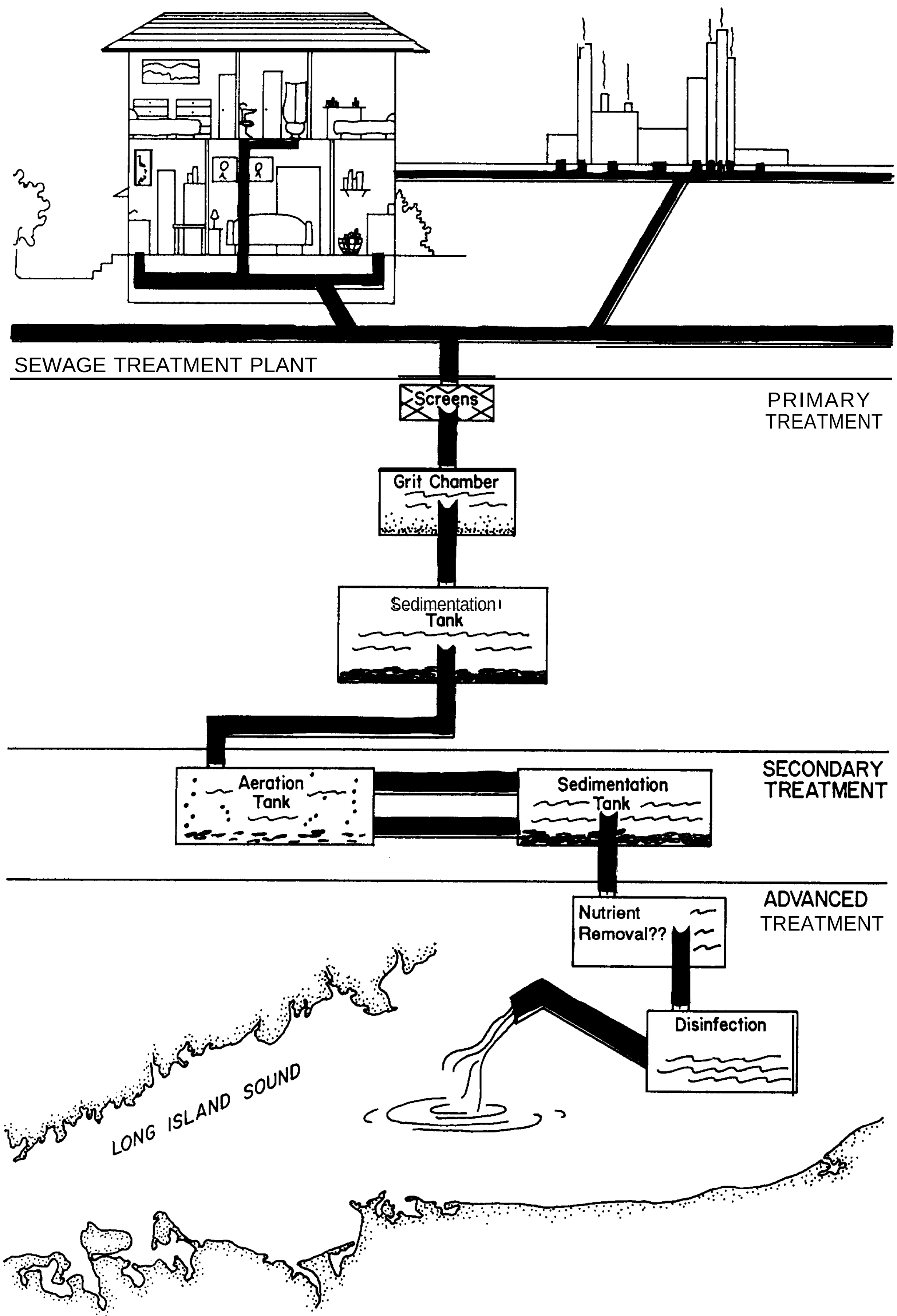
Primary treatment involves a process which removes heavy solids by mimicking the natural downward settling of particles that occurs in a pond. The wastewater flows through a screen that removes large debris, and then passes through a grit chamber to remove grit, sand, and gravel. Next, wastewater travels through a settling tank where, as in a pond, the slow flow allows fine materials to settle out. The effluent may be disinfected (usually with chlorine) to kill *pathogens* - disease causing organisms - and discharged.

Primary treatment is inadequate for the Sound because oxygen-absorbing organic matter in the wastewater is not removed. If the organic content of the discharged effluent is high enough, its natural breakdown by bacteria after can severely deplete the oxygen in the water.

Secondary Treatment

Secondary treatment involves moving the location of the natural bacterial breakdown of organics from the waters of the Sound to the vats of the treatment plant. The secondary treatment process can be compared to the natural purifying action of a stream, where the turbulent mixing of the water accelerates the breakdown of organic matter. In the treatment plant, these natural processes are simulated and enhanced by oxygenating the wastewater.

The Journey of Wastewater to Long Island Sound



Secondary treatment can remove up to 90% of the organic material in sewage, This is important because the decomposition of organic matter depletes the water of dissolved oxygen. It is crucial to reduce this oxygen demand in the effluent, because the health of any body of water depends on its ability to maintain a certain amount of dissolved oxygen.

Advanced or Tertiary Treatment

In some cases, secondary treatment is not enough to protect the environment. Secondary treatment breaks down most of the organic material, but it does not remove nutrients produced in the process or any toxic materials added to the wastewater stream entering the STP. Thus, the plant's effluent may still cause oxygen depletion or contain substances that can alter the environmental balance of the receiving water. If this balance is upset, a more advanced level of treatment, sometimes called tertiary, may be needed to remove the causative agents. The type of advanced treatment needed depends on the specific material(s) to be removed.

The Long Island Sound Study, Wastes, and You

The Long Island Sound Study (LISS) is currently assessing the impact of sewage treatment plant discharges on Long Island Sound. A computer model is being developed that will link these discharges to the water quality, helping LISS managers to devise a strategy to protect the Sound (see Fact Sheet #2) . It may be that advanced treatment will be needed at some plants. Dealing with the effects of STP effluent will be a major part of the Study's management plan for the Sound.

Means of improving the health of the Sound can and must be implemented by everyone living around it. Simple tasks practiced in the home (such as judicious use of lawn fertilizer) can reduce input of contaminants and nutrients into the Sound. (Contact the NY and CT Sea Grant Programs for more information). Without a coordinated effort to reduce the input of wastes to the Sound, it will continue to suffer from environmental degradation that, if continued for an extended period, may become irreversible.

The Long Island Sound Study

The Long Island Sound Study (LISS) is a six-year research and management project that began in 1985 as part of the National Estuary Program, a recent addition to the federal Clean Water Act created to protect estuaries of national importance. The LISS is a cooperative effort involving research institutions, regulatory agencies, marine user groups, and other concerned organizations and individuals. The purpose of the Study is to produce a management plan for the Sound that will be adminsistered by the three major LISS partners, the Environmental Protection Agency and the states of Connecticut and New York . To get involved with the Study, or for more information, contact: the New York Sea Grant Extension Program, Dutchess Hall, SUNY, Stony Brook, NY. 11794, Tel. (516) 632-8737; or the Connecticut Sea Grant Marine Advisory Program, 43 Marne Street, Hamden, CT 06514, Tel. (203) 789-7865.

SEA GRANT

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Funding provided by the Long Island Sound Study. Cooperating agencies:

CT DEP

EPA NEP

NYS DEC

LONG ISLAND SOUND STUDY

A Partnership To Restore And Protect The Sound

Supporting the Sound

WHAT CAN I DO TO HELP THE SOUND?

Cleaning up and protecting Long Island Sound (LIS) is a complicated and expensive process, involving scientists, elected officials, regulatory agencies, educators, and others -- but where do citizens fit in? The answer is: *almost everywhere!* Each individual can do something. Find the level of involvement you are most comfortable with. The truth is that without public involvement and support, pollution of the Sound will continue. The battle for cleaning up LIS is being fought on many fronts, and there are many ways that you, as a concerned citizen, can help. Its easy, and can be fun and rewarding!

Here are four ways you can get involved:

- make small and large changes in personal habits to benefit the Sound,
- become informed,
- become involved by joining a marine user group or citizen action group, and
- communicate with elected officials.

The suggested actions listed below will give you an idea of how and where to get started. As you contact some of the people working for the Sound, you'll likely discover other options in your area. However you choose to become involved, it's important that you ***make your voice heard!***

★ Individual Efforts:

In the home

Landscape in ways not harmful to the plants and animals of Long Island Sound. Use native vegetation, which provides habitat for other species. Leave grass clippings on the lawn to recycle nutrients. Limit use of pesticides and chemical fertilizers in your garden and lawn by substituting natural products and techniques. Call Sea Grant for **Sound Gardening** educational materials.

Conserve water at home and in the office. You can reduce the volume of waste water that must be treated by a sewage treatment plant or septic system. This will increase the efficiency of treatment and save you money.

Never pour motor oil or other auto fluids down a drain or sewer or discard them with the trash (in

Connecticut and New York, it is against the law!). New York State requires most service stations to accept motor oil for recycling. In Connecticut, municipal recycling stations accept motor oil for recycling. Some service stations will accept brake and transmission fluids and antifreeze; if not, save these in separate containers for local hazardous waste pickups.

To minimize malfunctioning avoid adding unnecessary kitchen grease and solids to septic systems. Inspect septic tanks annually, and pump out every three to five years. An improperly working septic system can contaminate ground water flowing to local streams and can pollute Long Island Sound.

Use as few hazardous products as possible. When you must, use those labelled CAUTION, as these are less toxic than products labelled DANGER or WARNING. Buy only as much of the products as you need; you will then eventually throw out only the container, not the toxic substance it contained. Remember that substances poured down drains, storm sewers, or on the land are likely to be transported to the Sound.

Learn how to properly dispose of the toxic products that you use. Many counties and municipalities have hazardous waste collection days. Call your local waste or sanitation department for a schedule.

Don't be a litterbug! Never throw litter, especially plastic, into the street, down storm drains, or onto the beach. Reduce-Reuse-Recycle as much as possible. Rainfall carries the trash into the sewers where it eventually travels into the Sound threatening fish and wildlife that may become entangled in it and it can threaten the safety of boaters.

If you live in Connecticut, buy a Long Island Sound License Plate and help benefit the Sound by funding projects to improve habitat restoration, public access, public education and outreach and research. Call 1-800-CT-SOUND for information and order forms.

In and on the Sound

Boaters, remember it is illegal to discharge wastes from a Type III (holding Tank) marine sanitation device. Pump-out facilities must be used to prevent release of pathogens directly into coastal waters. Contact the Connecticut Department of Environmental Protection and New York Sea Grant for a guide to marine pumpout facilities.

Individuals should pick up pet waste and dispose it in a toilet or in the trash. Pet waste contains bacteria and viruses that can contaminate shellfish and be a reason for closing beaches.

Be sure that you gather all six-pack rings and other plastic items for proper disposal. If they are washed into the Sound, marine animals may eat these items or become entangled in them.

Encourage anglers, hunters and commercial fishermen to adhere to applicable management measures and regulations to minimize non-harvest mortality (catch and release, discards).

In Your Community

- ❑ Participate in policy decisions and attend public meetings, such as your local planning and zoning, conservation or wetlands commission meetings. Speak out on local issues that can have ramifications for your town and Long Island Sound.

- ❑ Organize citizen water quality monitoring efforts or participate in an ongoing program.
- ❑ Organize beach cleanup efforts or participate in an ongoing program.
- ❑ Organize a storm drain stenciling project in your neighborhood.
- ❑ Participate in beach grass plantings.

For more information on how to do the things listed in this section just contact any office on the last page.

★Become Informed

So everyone concerned about the Sound can become more informed, the Long Island Sound Study (LISS) publishes a quarterly newsletter. To be added to the LISS mailing list, please fill out the coupon on the last page and return to the New York office. By becoming more knowledgeable, you will be a more convincing advocate for the Sound in your conversations with friends and neighbors. In addition, you will be able to identify organizations, programs, and elected officials that share your concerns. Detailed information on the Sound is available from a number of educational organizations. Contact the LIS Office for organizations in your area.

Look for us on the World Wide Web

http://www.epa.gov/region01/eco/lis/

★ Become Involved

If you use LIS to swim, fish, scuba dive, or boat, there is probably a "user group" in your area that represents people who share your particular interest in the Sound. These organizations often have a LIS agenda of some kind, and may be active in fund-raising or lobbying efforts. Ask around at your local marina, bait shop, dive shop, beach, or the LIS Office.

Citizen groups take an active role in issues that affect LIS on a local, regional, or national level. Joining a citizen group typically involves going to meetings and supporting staff people who serve as environmental watchdogs, lobbying for particular programs, or taking legal action on behalf of the group. Citizen groups are an important part of the partnership needed to effectively clean up the Sound.

★ Contact Elected Officials

Voice your concerns about LIS directly to elected officials. Find out who your local, state, and federal government representatives are and let them know that the Sound is important to you. Because many decisions affecting the Sound are made at the local level, you can personally make an impact by interacting with municipal commissions. Your input really can make a difference!

However you choose to get involved, it's important to make your voice heard! The future of the Sound depends on people like you getting involved in the process and doing good deeds.

THE LONG ISLAND SOUND STUDY

The Long Island Sound Study (LISS) is a research and management project that began in 1985 as part of the National Estuary Program, a section of the federal Clean Water Act created to protect estuaries of national importance. The LISS is a cooperative effort involving research institutions, regulatory agencies, marine user groups, and other concerned organizations and individuals. The Study produced a plan (completed in March of 1994) to clean up and protect the Sound. The Plan is being implemented by the Environmental Protection Agency and the states of Connecticut and New York. The Sea Grant Program in New York assists with public outreach activities including fact sheets, lectures, and workshops. For more information on the Study or LISS public education activities, contact:

EPA LIS Office
Stamford Government Center
888 Washington Blvd.
Stamford, CT 06904-2152
(203)977-1541

EPA LIS Office
Marine Science Research Center
SUNY
Stony Brook, NY 11794-5000
(516)632-9216

CT DEP
Office of LIS Programs
79 Elm Street
Hartford, CT 06106-5127
(860)424-3607

NYS DEC
Division of Marine Resources
205 Belle Meade Road
East Setauket, NY 11733
(516)444-0467

This fact sheet was produced by Chester Arnold, Connecticut Sea Grant Marine Advisory Program and revised December 1995 by Kimberly Zimmer, New York Sea Grant Extension Program for the Long Island Sound Study.

Funded by the Long Island Sound Study, Cooperating agencies: United States Environmental Protection Agency; Connecticut Department of Environmental Protection; New York State Department of Environmental Conservation.

To be placed on the mailing list, please tear off and return this coupon to: EPA Long Island Sound Office, Marine Science Research Center, SUNY, Stony Brook, NY 11794-5000.

NAME____

ORGANIZATION (if any)______________________________

ADDRESS____

____

PHONE____

LONG ISLAND SOUND STUDY

Floatable Debris

In the summer of 1988, debris washing up on Northeastern shores marred the beauty of our beaches and raised the specter of threats to public health caused by pollution. In the wake of these **washups,** the public in the Long Island Sound area began asking questions: what is this debris, where does it come from, and what are the health risks involved? As always, fact must be carefully sorted from fiction.

What Is It, and Where Does It Come From?

Material that washes up on the beach is called floatable marine debris, or simply **"floatables". Float**ables are unique in that they are an aspect of water pollution that is readily visible to even the untrained eye. This type of pollution has been with us since the first castaway sent a message in a bottle, but only recently has it gained attention as a serious water quality problem. These days, bottles are joined by paper, wood, sewage, garbage and street litter, as well as the highly publicized plastic and medically-related items.

Contrary to what you might think, there was no sudden outbreak of "dumping" activity - legal or otherwise - behind the **washups**. Although frequently mentioned together in the press, beach debris is unrelated to either sewage sludge or dredge spoil disposal. In addition, no municipal garbage has been legally disposed of in Northeast coastal waters for over 50 years, nor is illegal disposal common enough to account for much of the problem. The sources of floatables are more pervasive and complex than illegal dumping. Most of this debris started out on our streets as common litter, *or* in our homes as household waste. This includes the "medical waste," predominantly medically-related household items such as insulin syringes, that were flushed down toilets. The most important sources of floatables are described below (see also Figure 1).

Storm Drains and Combined Sewer Overflows

When it rains, litter washed off the streets is carried either directly into the water, or more commonly into storm sewers. Many storm sewers feed directly into LIS or a tributary, discharging floatables and other pollutants after every rainstorm. In other areas, the storm sewers are connected to the sanitary sewers used to carry household wastewater and human waste to the local sewage treatment plant (STP). This type of system, where both storm water and sewage are passed through a STP, is called a combined sewer system, and is common in New York City and many of the older urban areas along the Sound such as Norwalk, Bridgeport, and New Haven. With a combined system, the flood of water from any substantial rainfall (usually over 0.04 inch per hour) overloads the capacity of the STP, and everything in the system, including sewage and floatable debris, is allowed to pass unscreened and untreated into the water. This "raw" discharge is called a *combined sewer* ***overflow (CSO)*****. CSOs** are probably the single greatest source of floatables in the Northeast, and the primary reason why slicks in the western Sound during 1988 were characterized by sewage waste combined with plastic floatables.

Sewage Treatment Plants

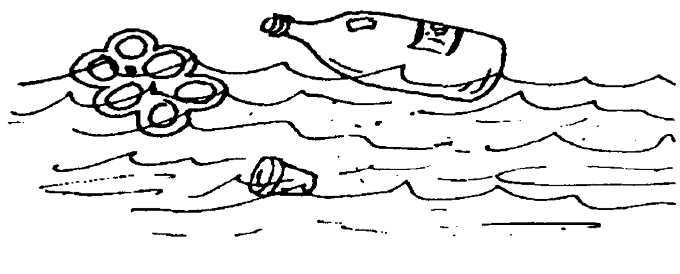
During the summer of 1988 beaches in Stamford, Huntington, Bridgeport and other towns along LIS were closed by high coliform bacteria counts resulting from the presence of sewage. Although CSO discharges can account for much of this, there were also instances of **STP's** being disabled by power outages or equipment failure. In such cases, untreated wastewater carrying both sewage and floatables can be discharged directly into the Sound.

Offshore Sources

A huge volume of waste material, much of it floatable trash and plastic, has been dumped daily into the oceans by the naval, commercial shipping and fishing fleets of the world. This waste is considered such a threat to a wide variety of marine life that an international agreement to control off shore disposal was put into effect in the United States in 1989. Although this material is not a major source of beach debris in the Northeast, some of it may find its way inshore.

Marine Transfer and Landfills

Floatable debris can enter the water through mishandling of solid waste that is being loaded on barges for transport to a landfill. Despite **onsite** precautions like collection booms and skimmer systems, material can also escape from the landfill **itself,** particularly during the



offloading of garbage from barges. Although marine transfer operations are considered to be a significant source of floatables in the New York/New Jersey Harbor area, they are not a major source of floatables to LIS, because only in the far western Sound do any water-borne garbage operations occur.

Other Sources

There are a number of smaller, yet significant, sources of beach debris. In addition to the off shore fleets, fishing and recreational vessels using our coastal waters contribute some overboard trash and sanitary waste. Rivers, especially during high flow periods in the spring, also add to the influx of floatables. Finally, beachgoers themselves add to the problem by littering. In fact, many of the syringes on Connecticut beaches were found above the high water mark, indicating that they had not come from the sea but from drug users at the beach.

Why was 1988 So Bad?

In terms of the pollution of Long Island Sound and surrounding waters, Summer 1988 was pretty much "business as usual". Why, then, was there a marked increase in beach debris? The major reason was the weather. The spring of '88 was very dry, causing an accumulation of debris on streets and in storm sewers of the region. The dry perii was followed in mid-summer by a series of torrential rains which swept the streets clean, overloaded combined sewers, and flushed large amounts of debris into nearshore waters.

Once in the water, the movement of floatables is dictated primarily by wind conditions, which vary from year to year. During most years, offshore summer winds help to disperse much of the floatable material. In 1988, however, persistent South-Southwest winds in July collected floatables into large slicks and then pushed them onshore, bringing home to us - quite literally - an awareness of what we have been putting into our coastal waters for years.

The good news is that this weather pattern is unlikely to occur every year - in fact, the last time was in 1976, when beaches on Long Island were also closed because of washups. The bad news is that whether or not it washes onshore, the waste is out there every year, and its volume may be increasing. Long Island Sound and its neighbor to the south, New York/New Jersey Harbor, are surrounded by some of the most heavily populated areas in the country. As the population living in a watershed continues to grow, so does the amount of household waste, sewage, and street litter. Another factor is that our use of plastics has tripled since 1970, increasing the percentage of floatable waste.

How Safe Is the Beach?

The beach closures of 1988 were caused by high bacterial counts (indicating sewage), concerns about the health hazards of medically-related debris, or both. Of the two, sewage contamination poses by far the greater threat to human health. Coliform bacteria, used as a test for the presence of sewage, are not a danger, but indicate the potential presence of other microorganisms which can be harmful in high concentrations. Swimming in sewagecontaminated water can lead to bacterial and viral infections, most often gastrointestinal. In contrast, floatable debris, when not combined with sewage, is not particularly dangerous to humans. While unsightly and sometimes downright disgusting, most of this material is common trash.

What About Medical Waste?

The amount of real medical waste found on beaches in 1988 was very small. Much of the material termed "medical waste" was either misidentified trash or medically-related household items - frequently insulin syringes used by diabetics. These items, flushed down the toilet, can easily end up in the Sound during CSO discharges or STP failures. Environmental officials have concluded that intravenous drug users frequenting the shore were also a significant source of syringes. Although no material discovered on LIS beaches was found to originate in a doctor's off ice or medical facility, some isolated incidences of medical waste found in the New York/New Jersey Harbor area almost surely resulted from illegal disposal.

Proper disposal of medical waste is a serious health concern not limited to the beach alone. However, it's important to emphasize that the chances of getting AIDS or other infectious diseases from beach debris of any kind is practically non-existent. Here's why:

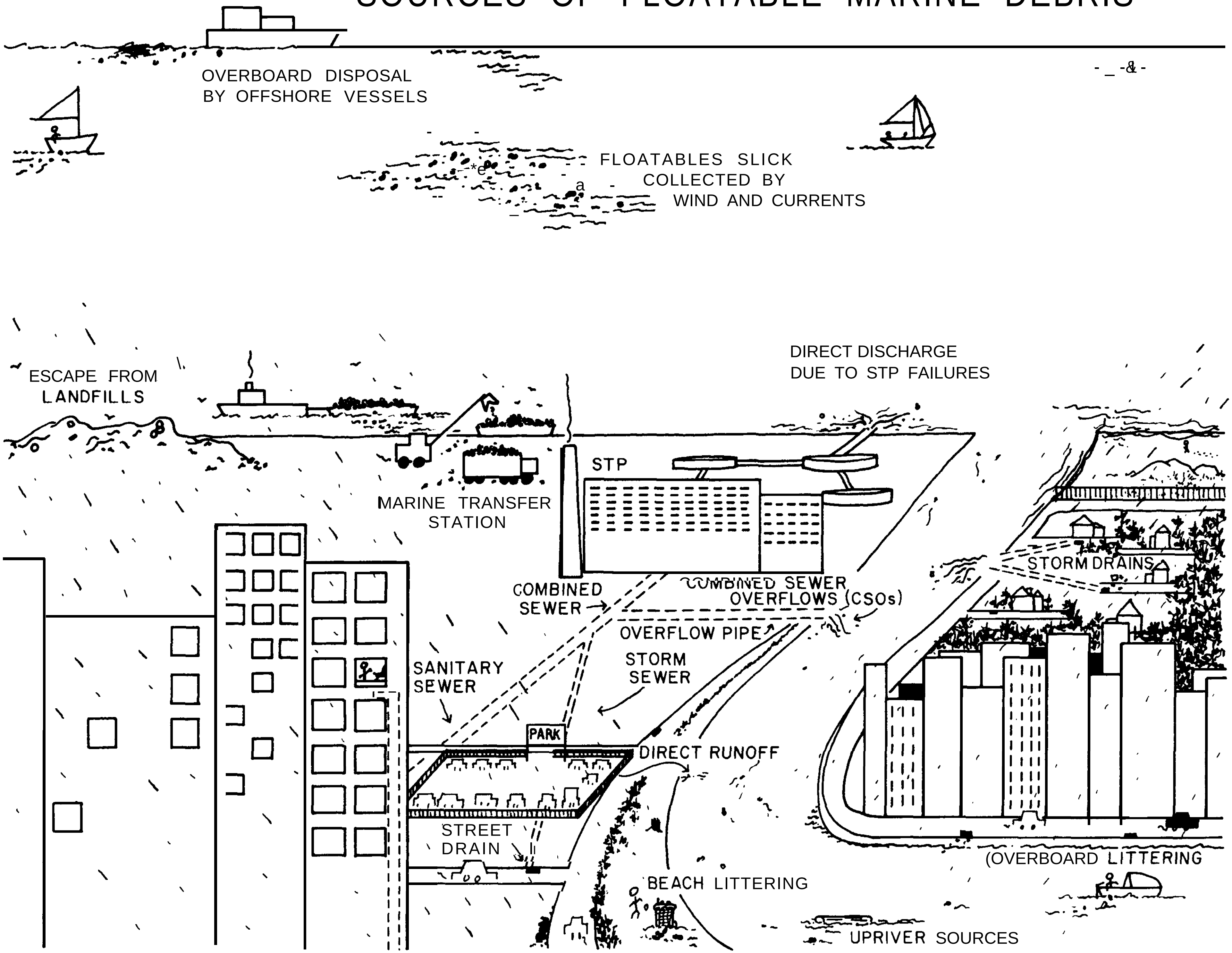
- The chance of any debris being real medical waste is slight (on New York beaches in 1988, only 1% of the beach debris was medically related).
- The chance of any medical waste being infectious is slight - about a 10% nationwide, according to EPA.
- The AIDS virus is fragile and unable to survive for long in the stressful chemical and physical environment of the ocean (it can't survive in fish, either).
- *Tremendous dilution also occurs in the ocean, further decreasing the virulence of any pathogens.

Despite the minimal health risks involved, beachgoers should approach suspicious-looking debris with caution. Although syringes pose little threat, blood vials could conceivably be a hazard if stepped on (breaking the skin). Certainly, anything that looks like medical waste should be left alone and reported immediately to beach authorities. Based on the experiences of the last two summers, beach managers have been devising guidelines and strict procedures to deal with future washups.

The Headlines of 1988

The summer of '88 was unprecedented both in the media coverage of the beach closings and in the effect that these stories had on people's behavior. Although much media coverage was accurate, there's no doubt

SOURCES OF FLOATABLE MARINE DEBRIS



that public fears ballooned out of proportion in response to sensational headlines. Justifiable public concerns over water pollution often escalated to near-frenzy pitch as irrational fears overwhelmed common sense. For instance, at the height of the summer furor things like dishwashing gloves, drowned sewer rats, and fish parts were misidentified as surgical gloves, shaved laboratory rats, and human lungs!

As a result, people deserted the beaches in droves for backyard swimming pools and mountain resorts. For instance, despite the fact that beach closures on the south shore of Long Island could be measured in hours rather than days or weeks, attendance at state park beaches in that area dropped by 5.6 million from1987 to 1988. Seafood retailers and restaurants throughout the Northeast saw business drop off, as public concern over beach safety spilled over into worries about the health effects of seafood consumption. Estimates of the loss to Long Island economy alone during the summer of 1988 are as high as 1-2 billion dollars! Whether warranted or not, the bottom line is that there were drastic - for some, disastrous - social and economic consequences resulting from the floatables problem.

What Can Be Done About Floatable Debris?

The one good thing about floatable debris is that the sources of the problem are generally understood, and there are few if any scientific mysteries to be deciphered before action can be taken. Encouraging as this may be, it doesn't make the problem any less difficult to solve. Unfortunately, floatables will be with us in varying degrees for some time to come.

The floatables problem is where the two major environmental concerns of water pollution and solid waste disposal meet. Stopping floatables at their sources - our households and streets - will be tied to such increasingly familiar issues as litter control, recycling, and enforcement of existing laws.

At the next level of the problem, the underground infrastructure systems in our towns and cities must be changed. Storm and combined sewers, a major source of floatable debris, also degrade water quality in other ways, discharging sewage, toxic contaminants and excess nutrients to the Sound (see LISS fact sheets **#1, #2, #3**). The redesign and restructuring of these systems are major public works projects, involving massive doses of money, long periods of time, and inconvenient disruption of services. For instance, the cost of separating combined sewers or abating their effects is estimated to be about 1/2 billion dollars in Connecticut and $1.5 billion in New York City. Nonetheless, the states of New York and Connecticut and the City of New York are all undertaking such projects, and are looking at ways to combat runoff -caused, or nonpoint source, pollution (see fact sheet **#7**). In addition to upgrading sewage treatment plants, better operation of STPs and striiter enforcement of laws regulating their discharge are being called for. A new federal law calls for New York, Connecticut, and New Jersey to begin a pilot program to track medical waste disposal in June 1989.

More immediate attempts at controlling floatables involve debris collection, either in the water or after it has washed up on beaches. An example of the former is the effort being undertaken in New York/New Jersey Harbor by a consortium of federal, state, and local agencies; an example of the latter is Operation Beachwatch in Connecticut, which has set beach testing and cleanup guidelines for local coastal authorities. Officials feel that although they do not attack floatables at their sources, programs to keep debris off beaches may restore to the public some of the confidence it lost during the last two summers.

Lastly, the Long Island Sound Study (LISS) plans to incorporate the control of floatables into its management plan. This plan, the sum of 6 years of research and planning by the Study, will be a blueprint to guide the federal government and the states of Connecticut and New York in the protection and cleanup of Long Island Sound. Because sources of floatables often coincide with sources of other pollutants, the Study has already given much consideration to possible solutions. When the LISS management plan is implemented, the persistent problem of floatable debris hopefully will be once again reduced to an occasional message in a bottle.

The Long Island Sound Study

The Long Island Sound Study (LISS) is a six-year research and management project that began in 1985 as part of the National Estuary Program, a recent addition to the federal Clean Water Act created to protect estuaries of national importance. The LISS is acooperative bi-state effort involving research institutions, regulatory agencies, marine user groups, and other concerned organizations and individuals. The purpose of the Study is to produce a management plan for the Sound that will be implemented by the three major LISS partners, the Environmental Protection Agency and the states of Connecticut and New York. To get involved with the Study, or for more information, contact: the New York Sea Grant Extension Program, Dutchess Hall, SUNY, Stony Brook, NY. 11794, Tel. (516) 632-8737; or the Connecticut Sea Grant Marine Advisory Program, 43 Marne Street, Hamden, CT 06514, Tel. (203) 789-7866.

This fact sheet was produced by the Connecticut Sea Grant Marine Advisory Program and the New York Sea Grant Extension Program. Written by Chester L. Arnold, Jr. Layout and editing by Peg Van Patten.

Funding provided by the Long Island Sound Study. Cooperating agencies: United States Environmental Protection Agency, Office of Water, National Estuary Program; Connecticut Department of Environmental Protection, New York State Department of Environmental Conservation.

LONG ISLAND SOUND STUDY

A Partnership To Restore And Protect The Sound

COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN FOR LONG ISLAND SOUND

How Low Dissolved Oxygen Conditions Affect Marine Life In Long Island Sound

The information presented here is based on results of laboratory research conducted by the US Environmental Protection Agency's Environmental Research Laboratory in Narragansett, Rhode Island and trawl surveys conducted by the Connecticut Department of Environmental Protection Marine Fisheries Division. Examples are provided for a series of low dissolved oxygen conditions. The timing, duration, and areal extent of low dissolved oxygen conditions are very important in determining the overall affect on marine organisms.

The Long Island Sound Study is using this data to identify dissolved oxygen levels protective of Long Island Sound aquatic resources and to guide management efforts. For additional information, please contact Mark Tedesco in the Long Island Sound Office at (203) 977-1541.

Dissolved Oxygen	Consequences
1.0 mg/L	■ High Lethality (75-90%) in fishes: pipe fish, winter flounder, summer flounder, Atlantic menhaden. ■ Lethality (~ 25%) in three additional fishes: windowpane flounder, tautog, fourspine stickleback. ■ Increased lethality (50%) in juvenile crustaceans: American lobster, sand shrimp, grass shrimp.
1.5 mg/L	■ Lethality in some fishes: pipe fish, 50%; winter flounder, 35%; summer flounder, 25%; Atlantic menhaden, 20%. ■ Lethal threshold for some juvenile crustaceans: American lobster, sand shrimp, grass shrimp.
2.0 mg/L	■ Reduce growth (~ 50%) in juvenile summer flounder and juvenile grass shrimp. ■ Lowest safe dissolved oxygen for survival of juveniles of several fish and crustaceans.

2.5 mg/L	■	Lethality threshold (15%) for the less sensitive planktonic larvae of crustaceans.
	■	Growth reduced (25%) in juvenile grass shrimp and summer flounder; 50% in American lobster.
	■	Additional species of bottom-living fishes show low dissolved oxygen avoidance.
3.0 mg/L	■	Greater lethality (~75%) among the most sensitive planktonic crab larvae.
	■	Growth reduced (50%) in other, less sensitive planktonic crab larvae.
	■	Growth reduced in juvenile American lobsters by 30%.
	■	Bottom-living fishes begin to show low dissolved oxygen avoidance.
4.0 mg/L	■	May reduce survival (30%) of very sensitive planktonic larvae of <u>some</u> crabs.
5.0 mg/L or greater	■	Few adverse effects expected.

Layout and design by Kimberly Zimmer, New York Sea Grant Extension Program for the Long Island Sound Study, March 1996.

Funded by the Long Island Sound Study, Cooperating agencies: United States Environmental Protection Agency; Connecticut Department of Environmental Protection; New York State Department of Environmental Conservation.

http://www.epa.gov/region01/eco/lis/

To be placed on the mailing list, please tear off and return this coupon to: EPA Long Island Sound Office, Marine Science Research Center, SUNY, Stony Brook, NY 11794-5000.

NAME ______________________________

ORGANIZATION (if any) ______________________________

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LONG ISLAND SOUND STUDY

A Partnership To Restore And Protect The Sound

COMPREHENSIVE CONSERVATION AND MANAGEMENT PLAN FOR LONG ISLAND SOUND

PUTTING THE PLAN IN MOTION

1995 marked the first full year of implementation of the *Comprehensive Conservation and Management Plan for Long Island Sound*. The final plan was approved by EPA and the states of Connecticut and New York in September 1994. While EPA and the states continue efforts to plan for longer-term implementation needs, significant progress has been made towards putting the plan in motion. Some of the highlights are summarized below:

Eliminating Adverse Impacts of Low Dissolved Oxygen in the Sound: Low dissolved oxygen (hypoxia) has been identified as the most significant problem in LIS. A phased approach is being used to significantly reduce nitrogen inputs to the Sound to improve dissolved oxygen levels.

Phase 1 froze nitrogen loads from certain point sources at 1990 levels to prevent the hypoxia problem from getting worse.

Actions: All sewage treatment plants that are part of the "no net increase" agreement in Connecticut and Westchester, Nassau and Suffolk Counties in New York are in compliance with nitrogen limits.

◆Improvements currently underway will bring the four New York City plants discharging to the East River into compliance by January, 1997, as well as meeting their Phase II goals.

Phase 2 involved low-cost improvements at sewage treatment plants to begin to reduce the amount of nitrogen reaching the Sound.

Actions: Nitrogen loads to the Sound are now 5,000 pounds per day below 1990 baseline levels, exceeding all expectations.

◆In Connecticut, retrofit projects have been completed at six sewage treatment plants, and are underway at five others, with completion expected by October 1996.

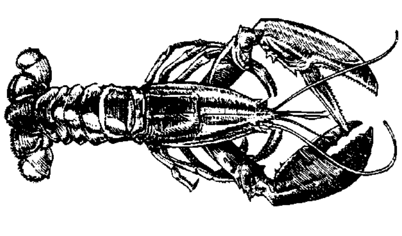
◆Five additional plant retrofits are in the design and construction phase.

◆Connecticut currently has one complete denitrification plant on line, and plans are underway for another.

◆In New York, New York City plans to retrofit its four East River Plants by January 1997.

◆Westchester County has implemented a retrofit at one of its facilities.

◆In both states, an increased share of nonpoint source pollution control funds have been targeted to projects that reduce nitrogen loads to the Sound.



Phase 3 is intended to achieve additional reductions in nitrogen loads necessary to meet the goals for dissolved oxygen in the Sound.

Actions: The LIS 3.0 computer model has been completed, and is being used to develop load reduction targets for eleven geographic management zones that have been identified around the Sound.

◆Newly developed indicators of the impacts of low dissolved oxygen on various species are being used to evaluate the effectiveness of different reduction strategies on living marine resources.

◆A process for nitrogen trading is being investigated as a potential tool to achieve nitrogen reduction in the most cost effective manner.

◆A series of public meetings will be scheduled during 1996 to review the targets and the range of options to meet those targets.

Controlling Major Sources of Pathogens: Pathogens can cause illness in people exposed through bathing in or consuming shellfish from contaminated waters. Pathogen contamination results in closed beaches and shellfish areas, hurting local economies and damaging public perception of the Sound.

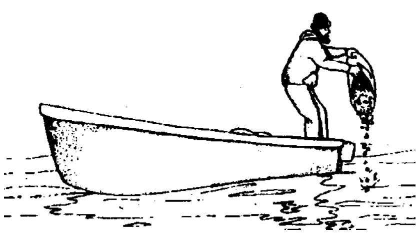
Actions: Phased combined sewer overflow (CSO) abatement projects are underway in both states to alleviate pathogen problems.

◆In Connecticut, projects have been funded in Bridgeport, New Haven, Norwich/Jewett City, Middletown and Hartford, to be completed over the next 20 years.

◆In New York, NYC has increased capture of CSO's from 18% to 40%, and is in almost complete compliance with EPA's minimum standards for CSO controls.

◆NYC's comprehensive sewer abatement program is scheduled for completion between 2001 and 2006.

◆Both states are working on programs to control discharges from vessels.



Oysterman spreading cultch

◆A "no discharge area" has been designated for Huntington/Lloyd Harbors, and Port Jefferson and Mamaroneck Harbors have been proposed for the designation.

◆Fifteen marinas in New York have received funds for construction of boat pump out facilities, and funds have been provided for construction of 17 new pumpout facilities in Connecticut, while seven others will be renovated.

◆Four municipalities in New York and one in Connecticut are actively working to address pathogen abatement through sanitary surveys or stormwater improvements.

◆Broader efforts underway in both states to address nonpoint sources of pollution and stormwater management will also contribute to the control of pathogens to the Sound.

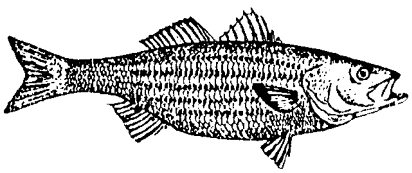
Protecting the Sound from the Adverse Effects of Toxic Substances: Toxic substances can cause adverse human and ecosystem health risks.

Actions: EPA and the states of Connecticut and New York are working together to update the *Interim Plan for Disposal of Dredged Materials in Long Island Sound*.

◆A Regional Environmental Monitoring and Assessment program, which examined the degree of degradation at 29 stations in Western LIS, has been completed.

◆Pollution prevention site assessments were completed at 33 manufacturing facilities in Connecticut and recommendations developed for each on how to reduce toxic discharges.

◆The state of Connecticut has funded research projects to evaluate toxic contaminants and develop management options. Specific projects include toxic contaminant dynamics in the Quinnipiac River Estuary, mercury dynamics in LIS, and decline of greater scaup due to toxic contaminants.



◆In New York City, an aggressive industrial pre-treatment program has reduced the amount of metals discharged by 1,000 pounds per day, and the City has implemented actions to trace and eliminate sources of organic pollution.

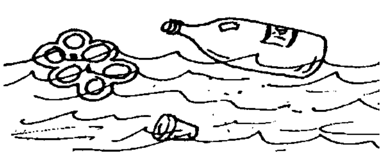
◆The City of Glen Cove, New York is assessing levels of toxics in Glen Cove Creek sediments.

◆Remediation of contaminated sediments has been completed at Jakobson's Shipyard in Oyster Bay, New York.

◆The New York Department of Environmental Conservation completed a PCB monitoring program for striped bass.

◆A toxicity survey of 20 harbors and embayments in the Sound has been completed and will be used to help formulate strategies for sediment management and remediation.

Reducing Litter and Debris in the Sound: Trash floating in coastal waters can be a nuisance or hazard for boaters, can harm wildlife, and reduces our enjoyment of the Sound.



Actions: Efforts to control combined sewer overflows and improve stormwater management are helping to reduce the amount of litter that reaches the Sound.

◆New York City has reduced floatables by 70% by placing booms across tributaries and improving capture of combined sewer overflows.

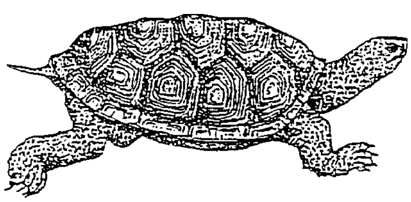
◆During 1995, beach clean ups in New York involved nearly 900 people and resulted in the removal of over 7,000 pounds of trash from close to 30 miles of shoreline.

◆In Connecticut, clean ups involved over 700 people and resulted in the removal of over 4,000 pounds of trash from 23 miles of shoreline.

◆Over 16,000 storm drains have been stenciled since 1991 with the message “Don't Dump-Drains to Long Island Sound”.

◆In New York, over 3,000 drains have been stenciled with a bi-lingual “Clean Streets Clean Beaches” slogan (Spanish and English).

Restoring and Protecting Habitat: The overall abundance and diversity of habitats and living marine resources in the Sound has been diminished due to water quality problems, habitat degradation and loss, and land use impacts.



Actions: A bi-state habitat restoration planning process initiated during 1995 has resulted in the identification of nearly 200 sites that have been degraded and have potential to be restored.

◆A Draft Habitat Restoration Plan and priorities will be completed during 1996 and made available for public review.

◆Fourteen restoration projects were completed under Connecticut’s Tidal Wetlands Restoration and Coves and Embayments programs and several others were initiated.

◆Nearly $1 million was awarded for 12 projects under a new River Restoration Fund, and habitat-related projects were supported under Connecticut’s LIS Research Fund.

◆The NYSDEC has two tidal restoration projects in progress and two in the planning process.

◆DEC has also completed a draft Habitat Action Plan for Oyster Bay/Cold Spring Harbor.

Information summarized from the US EPA, NYS DEC and CT DEP Implementation Status Report to the LISS CAC. Layout and design by Kimberly Zimmer, New York Sea Grant Extension Program for the Long Island Sound Study, March 1996.

Funded by the Long Island Sound Study, Cooperating agencies: United States Environmental Protection Agency; Connecticut Department of Environmental Protection; New York State Department of Environmental Conservation.

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EPA

United States Environmental Protection Agency

Air and Radiation (6205J)

EPA430-F-99-033
November 1999
www.epa.gov

SunWise monitor

An Update on EPA's SunWise School Program

Welcome to the SunWise Monitor

by Bob Perciasepe, Assistant Administrator for Air and Radiation, U.S. Environmental Protection Agency (EPA)

Welcome to the first issue of the *SunWise Monitor*! Through the *Monitor*, EPA will share important information about the SunWise School Program and sun protection with participating Partner Schools and communities across the country. The SunWise Program is designed to teach schoolchildren and their caregivers how to avoid overexposure to the sun. SunWise is already under way in more than 100 pilot schools and is preparing for a national launch in Fall 2000.

Why is EPA championing sun safety today? Many of us are becoming more aware of our impact on the environment, but some might not realize that the consequences of human behavior stretch far beyond Earth's surface.

Years ago, you probably didn't think twice about using an aerosol spray or turning on an air-conditioner in your car or home. Back then, we didn't know that the chlorofluorocarbons (CFCs) released from these products deplete the ozone layer, which absorbs the sun's harmful ultraviolet (UV) radiation.

Since 1996, CFCs and other ozone-depleting substances have been banned from new production in the United States and other developed countries, but it will still take years to repair the damage already inflicted on the ozone layer. In the meantime, increased levels of harmful UV radiation are likely to reach the Earth, causing skin cancer, cataracts, immune suppression, and other health effects. Already, skin cancer is the most common form of cancer in the United States, with more than one million cases reported annually.

In this time of increased risk, EPA's SunWise School Program is an important tool for the protection of our health and the health of our children.

On behalf of EPA, I would like to thank you for your continued support of this vital program. Through our combined efforts, SunWise will play an integral role in assuring the health and awareness of children and caregivers.

TAKE ACTION

Are you keeping yourself and your children safe in the sun? The sun-safety tips below are the cornerstone of the SunWise School Program and a good way for anyone to reduce the risk of UV-related health damage. Other than staying indoors, no single step can fully protect you from overexposure to UV radiation, so follow as many of the action steps as possible.

Limit Time in the Midday Sun

The sun's rays are strongest between 10 a.m. and 4 p.m. Whenever possible, limit exposure to the sun during these hours.

Wear Sunglasses That Block 99 to 100 Percent of UV Radiation

Sunglasses that provide 99 to 100 percent UVA and UVB protection will greatly reduce sun exposure that can lead to cataracts and other eye damage. Check the label when buying sunglasses.

Wear a Hat

A hat with a wide brim offers good sun protection for your eyes, ears, face, and the back of your neck—areas particularly prone to overexposure to the sun.

Seek Shade

Staying under cover is one of the best ways to protect yourself from the sun. Remember the shadow rule: "Watch Your Shadow—No Shadow, Seek Shade."

Cover Up

Wearing tightly woven, loose-fitting, and full-length clothing is a good way to protect your skin from the sun's UV rays.

Always Use Sunscreen

Apply sunscreen liberally on exposed skin and reapply every 2 hours when working or playing outdoors. Even waterproof sunscreen can come off when you towel off sweat or water.

Watch for the UV Index

The UV Index provides important information to help you plan your outdoor activities in ways that prevent overexposure to the sun. Developed by the National Weather Service (NWS) and EPA, the UV Index is issued daily in selected cities across the United States.

Avoid Sunlamps and Tanning Salons

The light source from sunbeds and sunlamps damages the skin and unprotected eyes. It's a good idea to avoid artificial sources of UV light.

Sunscreen Does Not Cause Blindness

Don't believe everything you hear! An e-mail story disseminated widely this past spring claimed that waterproof sunscreen causes blindness in numerous children every year. Neither the American Academy of Ophthalmology, the Poison Control Center, the U.S. Food and Drug Administration (FDA), nor any sunscreen manufacturers, have ever heard of a person being blinded by sunscreen.

The most severe eye injury that sunscreen could cause is an abrasion of the surface of the eye, which could result in moderate discomfort during the healing process but no long-term effects. If sunscreen does get in the eye, the Academy suggests rinsing with water and seeing an eye doctor if the pain does not subside.

According to the American Academy of Dermatology, a person receives approximately 80 percent of his or her lifetime sun exposure by the age of 18. Preventing overexposure in childhood by following the action steps for sun protection, therefore, is essential to preventing skin cancer later in life. (See "Take Action," p.1.)

In the SunWis

Read about SunWise in action! The following
SunWise stories from students and teachers ir

Sun Scientists Use Technology

Students in Glendora, California, are using technology to explore the science behind SunWise. Greg Morrison's science class at Goddard Middle School uses many tools, including the Internet, CD-ROMs, videos, and laboratory experiments to collect, report, and analyze UV-related data. In a favorite class activity, students use hand-held UV monitors, available from EPA, to measure the intensity of UV rays at ground level. After gathering these

data, the students can upl
results to the SunWise We

With the help of the local
Club's Teacher Mini Grant
Morrison runs another pop
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UV rays. The students the

Shop SunWise: Look for Changes in Sunscreen Labels

Sunscreen already tops the shopping list of any SunWise consumer. Now, new labeling changes aim to help shoppers make a more informed decision on sun protection.

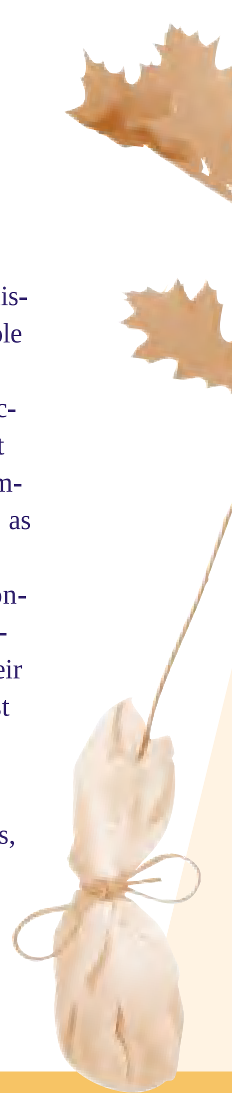
In May 1999, FDA finalized labeling requirements for over-the-counter sunscreen products. While the regulations call for the discontinuation of terms that might be misleading, such as "sunblock," or "waterproof," the most important label change will be the appearance of FDA's three new sun protection categories. Devised to help consumers choose the right SPF level for their needs, the optional rankings will appear as follows:

- **Minimal**—SPF levels from 2 to below 12.
- **Moderate**—SPF levels from 12 to below 30.
- **High**—SPF levels of 30 and higher.

Specific SPF numbers will continue to appear on product labels, though the highest category will be "30+" for values above 30.

Under these new labeling regulations, you'll also start seeing a "sun alert" statement on products discussing the important role of sunscreen in overall sun-related health protection. Products that won't screen out the sun's harmful rays must be marked as well. Labels on tanning lotions, which do not contain sunscreen, must feature a warning about their lack of protection against sun exposure.

For more information on FDA's new regulations, consult its Web site at <www.fda.gov>.



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For more informatio
Mary Ann Moore
Brownstown Middle
20135 Inkster Road
Brownstown, MI 48
matuckermoore@ne

SunWise Milestones

Winter 1996
Conceived SunWise School Program.

Spring 1997
Held initial brainstorming meeting with stakeholders.

Early 1998
Examined other sun protection programs and developed tenets of SunWise School Program.

Mid 1998
Partnered with a number of health and weather organizations and held stakeholder meeting to develop and implement SunWise School Program.

Summer and Fall 1998
Held meetings with community planning teams. Began promoting SunWise School Program to teachers.

Winter 19
Launched Sun
Web Site: <w

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n articles share some exciting
n partner schools across the country.

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and record the effectiveness of different types of sun protection, covering the beads with sunscreens of various SPF levels, sunglasses, wet and dry clothing, and plastic.

In addition, Morrison uses video tapes of national newscasts about the ozone layer, which further demonstrate the scope and breadth of the subject. All these sun-science activities and students' work are featured on Morrison's class Web site, <www.morrisonlabs.com>.

For more information:
Greg Morrison
Goddard Middle School
859 E. Sierra Madre
Glendora, CA 91741
gm@morrisonlabs.com

SunWise Lessons Hit Home

Students at Medway Middle School in Medway, Massachusetts, witnessed first-hand the effects of overexposure to the sun. They remember seeing teacher Cheryl Cook walking the halls after her reconstructive facial surgery due to skin cancer.

"Due to the size and placement of the tumor, I was quite a sight. Even kids who weren't in my class knew who I was," explained Cook. "That's why my efforts to educate kids about the sun have been so successful; they don't want what happened to me to happen to them."

Cook—along with her teaching assistant Maureen Leighton—has incorporated numerous SunWise activities into the lessons of her two seventh-grade classes. In addition to using many of the ideas provided by the SunWise School Program, she invented "SunWise Bingo" and has helped students develop skits, posters, commercials, and songs about sun protection. One skit was called "Sizzle News," and another took the form of a talk show with special guest "U.T. Violet."

Cook's students volunteer each day to take measurements of UV intensity outside, and post results twice a day on a bulletin board. She also encourages the Weather Service Club to announce the UV Index each morning.

As a culminating activity for the 1998-1999 school year, Cook created a video documenting students' performances and creative initiatives. "I am pleased to be part of the SunWise program," she says, "because it is a good life lesson for my students."

For more information:
Cheryl Cook
Medway Middle School
45 Holliston Street, Medway, MA 02053
508 533-7654 ext. 5328

aving a SunWise Field Day

SunWise seventh graders in Brownstown, Michigan, took the sting out of an annual school event by encouraging fellow students to practice sun-safe behavior. Every June at Brownstown Middle School, students spend a "field day" competing in outdoor events. Unfortunately, just as field day was a Brownstown tradition, so were the many sunburned students in school the following Monday.

This year was different, however, thanks to the SunWise School Program and the students in 6th grade and the 7th grade health classes. As participants in the SunWise pilot, the students launched a sun-safe campaign for the field day, encouraging their schoolmates to use sunscreen, hats, and sunglasses during the event. To spread the safety message, the classes created posters to hang in the school's hallways and asked local businesses to donate sunscreen for the students to use on the field day. According to Mary Ann Moore, the 7th grade teacher, there were no occurrences of severe sunburns at this year's field day.

The Brownstown students put their SunWise knowledge into practice again this past Arbor Day when they planted 3-foot oak saplings on the school grounds. Eventually, these trees will provide protective shade for students participating in outdoor activities.

on:

e School

174
etscape.net

May 1999
Conducted pilot testing (phase I) with 25 participating schools.

Summer 1999
Evaluated SunWise progress to date and make improvements to the program.

May 2000
Hold press event to announce debut of SunWise School Program across the country.

998
nWise School Program
ww.epa.gov/sunwise>.

September 1999 to June 2000
Conduct pilot testing (phase II) with more than 100 participating schools.

Fall 2000
Launch SunWise School Program nationwide.

RESOURCES

Looking for more information on the SunWise School Program, general sun safety, or the science behind UV radiation and the ozone layer? Check out the many electronic and print resources EPA makes available to the public free of charge.

SunWise School Program

SunWise School Program Internet Learning Site

www.epa.gov/sunwise

An excellent source for information on the SunWise School Program, this Web site includes general information on ozone depletion, UV radiation, UV health effects, and sun-safety tips. The site also includes an online registration form for joining the SunWise Program, as well as links to other informative educational sites.

Students and teachers can currently use the site to report and interpret daily measurements of UV data. As the SunWise Program develops, additional features and activities, including games and experiments, will be added to the site.

SunWise School Program Guide

This guide provides information about the SunWise School Program, details how to become a Partner school, describes tools available to Partner schools, and explains how the program will be evaluated. The guide may be downloaded as a 322K Adobe Acrobat (PDF Format) file from the SunWise School Program Web site (see address above). To order a hard copy of the guide, contact EPA's Stratospheric Ozone Information Hotline at 800 296-1996. For additional information, contact Linda Rutsch of the SunWise School Program at 202 564-2261.

General Sun-Safety and Ozone Science

The Sun, UV, and You: A Guide to SunWise Behavior

This newly updated booklet presents the science behind UV radiation and stratospheric ozone and the health risks associated with overexposure to the sun. It also provides steps for protecting yourself and your children, defines the UV Index, and provides a list of additional resources.

For more information or to obtain copies of these resources, visit the SunWise Web site at <www.epa.gov/sunwise> or contact Kevin Rosseel of EPA at 202 564-9731.

SunWise Fact Sheets

A number of short, informative factsheets also are available:

- *Health Effects of Overexposure to the Sun*
- *Action Steps for Sun Protection*
- *Ozone Depletion*
- *Ultraviolet Radiation*

Kids Korner

Teachers and their SunWise students are invited to submit articles about their activities, story ideas, artwork, and sun-safety project ideas to be featured in future issues of the *SunWise Monitor*. You can send materials to Linda Rutsch at <rutsch.linda@epa.gov> or U.S. EPA (Mailcode 6205J), 401 M Street, SW., Washington, DC 20460.

The SunWise School Program is an Environmental Monitoring for Public Access and Community Tracking (EMPACT) project.

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April 2000
www.epa.gov/sunwise

SunWise monitor

An Update on EPA's SunWise School Program

A SunWise Survivor Story

Doug Ulman is considered a hero and role model by many. At only 22 years of age, he is a three-time survivor of cancer, including two bouts with melanoma skin cancer. He now dedicates his life to advocacy work—helping young adults with all types of cancer cope with their diagnoses, facilitating support groups, and speaking to organizations across th e country. The SunWise School Program recently had a chance to catch up with him.

Doug Ulman

Tell us about when and how you found out you had skin cancer.

I was first diagnosed in March 1997. During a routine physical with my family doctor, he suggested I have a suspicious-looking mole on my chest removed. I have a lot of moles, and several had been removed prior to this. I went to Johns Hopkins and had it removed. Two weeks later, while back at school at Brown University, I received a call one evening from my dermatologist. He said "Doug, remember that mole we removed?" Of course I remembered, but I hadn't thought about it in 2 weeks. It turned out to be malignant melanoma in situ. Luckily all of the malignant cells were encapsulated, so after surgery, I was essentially cured of that episode.

What type of skin cancer were you diagnosed with and what kind of treatment did you undergo?

In March 1997, I was diagnosed with melanoma in situ. In June 1997, I was again diagnosed, this time with invasive

<Continued on page 3>

A Message From the Dermatologist

It's hard to believe that summer is just around the corner. Of course, that means a break from school, summer vacations, and lots more time spent outside enjoying the warm, sunny weather.

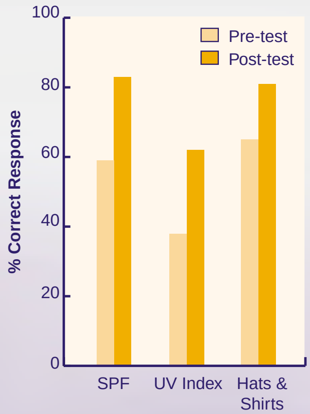
Now more than ever, it is important to properly protect ourselves from the damaging ultraviolet (UV) rays of the sun. Skin cancer has been on the rise and is one of the most prevalent and serious current public health problems. In fact, in the United States alone, we can expect more than 1 million nonmelanoma cancers to be diagnosed this year. Nonmelanoma skin cancer is the most

<Continued on page 7>

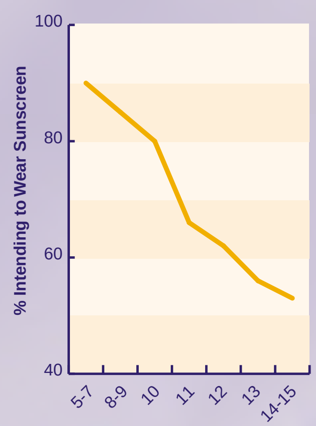
SunWise Honors

In March, EPA's SunWise School Program was awarded the 1999 Excellence in Education Award at the American Academy of Dermatology (AAD) Annual Meeting in San Francisco, California. AAD established the award to recognize groups, organizations, or institutions that have developed an educational program or programs that have contributed uniquely to educational excellence in the specialty of dermatology. The SunWise School Program won the award for a local, state, regional, or national professional society or organization.

Surveys Help Identify SunWise Education Needs



Knowledge Variables
(May 1999 Pilot)



Age of Student Respondents
(May 1999 Pilot)

Student surveys are helping the SunWise School Program understand important information about children's sun-protection knowledge, attitudes, and potential behaviors that will help guide education efforts.

For example, did you know that children are more likely to use sunscreen when they are younger than when they get older? This reinforces the need to continue sun-protection education with students in higher grades.

This information was gleaned from a survey of more than 1,000 students (ages 5 to 15) across the country. To develop a benchmark and analyze students' knowledge, attitudes, and intended behaviors about sun protection, teachers from 12 of 25 schools participating in the SunWise School Program submitted student surveys both before and after using the SunWise learning tools.

"What we found in the pretest presents many challenges—less than 20 percent of the students at SunWise schools used sunscreen, sunglasses, or shirts before the program was conducted, and more than 70 percent of students had at least one sunburn in the previous year," said Alan Geller, Associate Director of Boston University's Cancer Prevention and Control Center, who developed the survey.

"At the pretest, many children did not know what number SPF to use or the value of hats and shirts," Geller said. After teachers used SunWise materials to educate their students, however, a post-test survey showed that their knowledge of the following statements markedly increased:

- I know the correct SPF number to use (pretest, 59 percent, post-test, 83 percent).
- I have to use the most sun protection when the UV Index is 10 (pretest, 38 percent, post-test, 62 percent).
- Wearing a hat and shirt outside are ways to protect myself from the sun (pretest, 65 percent, post-test, 81 percent). (See top graph at left.)

As for their attitudes, although fewer students thought a suntan was good for their skin after learning SunWise concepts, the number who thought "people look healthy with a suntan" did not change significantly from the pretest to the post-test. This shows that it requires continued efforts to change people's attitudes.

Although the survey didn't test how students actually behaved in the sun, it did test their intended practices before and after learning about SunWise behaviors. Significantly more students said they would try to play in the shade after receiving SunWise education, while the overall percentage of those who said they would wear sunscreen this summer did not change. According to Geller, this issue was age: the older children surveyed were less likely to say they would use sunscreen than the younger children, even after they learned more about it. (See lower graph at left.)

These surveys will help guide the SunWise School Program in improving its overall approach and targeting various age groups. "Evaluation is very practical," Geller said. "It's a guide for developing new education programs."

Survivor Story...

<Continued from page 1>

melanoma. Between the two episodes, I have had approximately six surgeries for skin cancer and other biopsy exploratory procedures.

What other steps did you take to cope with your diagnosis?

I became a vocal advocate for sun protection. I speak to kids and young adults all the time to try to convince them that having a tan, which is really just having damaged skin, is not worth the consequences of having cancer. I use sunscreen every day no matter what the weather is like and wear a wide-brimmed hat when I play golf. I take the utmost precaution and want to share my story so that other young people do not have to go through what I did.

What measures can people take to protect themselves from sun damage and avoid skin cancer?

Cover up. Use sunscreen correctly. Apply sunscreen 30 minutes before sun exposure and reapply after 1 to 2 hours of exposure. Wear long sleeve shirts, sun-protective eyeglasses and sunglasses, and wide-brimmed hats. Avoid sun exposure between 10 a.m. and 4 p.m. Develop a daily sun protection routine. For me, that means keeping my sunscreen right next to my toothpaste. When I wash my face and brush my teeth in the morning I put on my sunscreen. It's that simple.

You're very active with advocacy work related to children and young adults with all types of cancer. Tell us more about The Ulman Cancer Fund for Young Adults.

The Ulman Cancer Fund for Young Adults was formed to provide support, education, and resources to young adults, their families, and friends who are affected by cancer. This involves support groups, survivors' networks and information, as well as education and prevention services for young people to teach them early detection and prevention.

Skin cancer can be treated successfully if found early. The most important issue that The Ulman Cancer Fund supports in terms of skin cancer is that children, in conjunction with their physician and parents, need to watch their own skin and look for lesions or changes in moles. If they see a change, they NEED to tell their parents or doctors. Over 50 percent of melanoma cases are found by patients. My second skin cancer diagnosis resulted after a tiny mole on my arm was itching and I mentioned something to my doctor. She decided to take it off as a precaution and it turned out to be invasive melanoma. Who would have of thought that a 19-year-old would have skin cancer twice? Not me. Another message we convey is that skin cancer does not discriminate. It affects young and old. People of all races. Male and female.

"...I want to do everything possible to help others understand the fragility of life and the importance of protecting themselves from skin cancer."

—Doug Ulman

What's in the future for Doug Ulman?

I will continue to dedicate my life to cancer advocacy, including prevention and education awareness. I will not be satisfied until children are allowed to bring sunscreen to school with them, until children are taught in schools about the dangers of skin cancer and that they can avoid getting it by practicing good protection habits. I also want to bring awareness to the fact that cancer is not a death sentence! You can have cancer in your life (you can even have it three different times) and still return to a normal life and, as in my case, go above and beyond what you were doing prior to the diagnosis. I am very lucky to be alive at age 22, and I want to do everything possible to help others understand the fragility of life and the importance of protecting themselves from skin cancer.

For more information on The Ulman Cancer Fund, visit the Web site at <www.ulmanfund.org>.

Official SunWise Program Launch on the Horizon

Following its successful 1-year pilot period, EPA will launch the official SunWise School Program with a press event in May. A new SunWise "Tool Kit" for SunWise schools will be available to all schools beginning in September 2000. Details to follow.

In the SunWise Spotlight...

Read about SunWise in action! The following articles share some exciting SunWise stories from students and teachers across the country.

Exploring Ozone Out West

Ozone science recently took center stage in Colorado as teachers and students in the University of Colorado at Boulder's (CU's) 1999-2000 Science Explorer Program put new science curricula to the test. In a series of 17 day-long workshops held throughout the state, Colorado teachers and students tried out new science lessons focused on ground-level and stratospheric ozone as well as UV radiation.

Teams comprised of one teacher and five students, from fifth through eighth grade, took part in three 75-minute classes during the workshops. Each class featured a variety of ozone-related, hands-on lessons; for example, the teams searched for ground-level ozone by using Schoenbein paper—a special paper made of cornstarch, distilled water, and potassium iodide—which turns blue or purple when in contact with ozone.

In another activity, students and teachers learned about the effects of stratospheric ozone depletion, such as increased UV radiation reaching Earth's surface. Using color-changing, UV-sensitive Frisbees, the teams evaluated the effectiveness of various sun-protection materials, including sunscreen, sunglasses, and fabrics. The teams also constructed chemical models of ozone molecules from gumdrops and toothpicks. Studying the conditions of Antarctica, over which an ozone hole exists, is another topic for curricula activities.

"The student team members work side by side with their teachers in the workshops to develop knowledge and leadership skills," said Lannie Hagan, coordinator of the Science Explorer Program.

After participating in the Science Explorer activities, students and teachers will take their new knowledge and materials back to their classrooms to share with fellow students and colleagues. While this year's workshops and curricula focused strictly on the science of ozone and UV radiation, Hagan noted, "SunWise behavior lessons would be a perfect supplement for teachers to incorporate when they implement the new curricula in their classrooms."

Designed to encourage student interest and aptitude in science, math, and technology in Colorado and the West, the CU-Boulder Science Discovery Program has been operating the Science Explorer Program for 13 years, introducing new curricula to about 300 teachers each year.

For more information about CU's Science Explorer program, contact Lannie Hagan at 303 492-0771.

Students film a "News Flash" on ground-level ozone and its harmful effects on human health.

Students play an ozone board game—"The Hole in the Sky"—to gather facts and statistics on the history of ozone depletion.

Hi-Tech SunWise Students Ask the EPA Expert

Forget MTV—fifth-graders in Dottie Fundakowski's gifted science class used state-of-the-art video conferencing to tap into EPA expertise on ozone depletion and SunWise behavior. As part of a semester-long unit on ozone, Fundakowski's students at The Center for Creative Learning in Missouri's Rockwood School District, participated in virtual discussions with Jeffrey Levy, formerly of EPA's SunWise School Program.

The video conference gave the students, who had already been studying ozone and UV radiation for 6 weeks, the unique chance to interact with a scientific expert. In addition to fielding the students' technical questions about ozone depletion, Levy reminded them of their responsibility to protect their skin and eyes from UV radiation. "Global issues, such as ozone depletion, can be worrisome for high-level learning students," Fundakowski noted. "The video conference with Jeffrey Levy was a great way to have the students learn about experts who are working to reduce ozone problems and to give students an interactive resource for their questions and concerns."

Throughout the past year, Levy participated in a total of 10 ozone-related video conferences with different groups of Fundakowski's students and also hosted an evening session to discuss parents' questions about UV radiation and sun protection. The success of the video-based exchanges has prompted Fundakowski to plan additional conferences. She also shared her students' high-tech activities with other educators at the Midwest Educational Technology Conference, held March 13 through 15 in St. Louis.

The video conferences were just one portion of Fundakowski's unit, which covers both stratospheric and ground-level ozone. Students completed many other SunWise activities, including daily visits to the SunWise UV Index Web site, UV-sensitive bead experiments, and lessons on the labeling of sunscreens. While studying the light spectrum, students became fully informed consumers, learning why sunscreens should protect skin from both UV-A and UV-B rays. In addition to lessons focused on what they can do to protect themselves, Fundakowski's students staged a mock congressional hearing on the ban of aerosol sprays, learning what other countries are doing to protect the planet from ozone depletion.

For the past several years, Fundakowski has found SunWise lessons to be an effective component of teaching ozone science. "I am usually introducing elementary school students to curricula on the atmosphere and sun protection. They know they're supposed to wear sunscreen, but they don't know about the 'why' behind that behavior. The SunWise School Program is very helpful, not only in teaching kids what to do, but in teaching them about the scientific and health reasons attached to those actions."

For more information, contact Dottie Fundakowski at 636 207-2579, ext. 334 or <CCT02@rockwood.k12.mo.us>.

In the SunWise Spotlight... Continued on page 8

SunWise Activity Corner

"Who Wants to Be SunWise?"

Here's a fun way to add some excitement and suspense to the classroom while teaching students about SunWise behavior and ozone science. This activity starts with fairly simple questions and graduates to harder questions. Each question is worth a certain dollar value or number of points. Correct answers are found at the bottom of this page.

Would you like to submit questions for "Who Wants to Be SunWise?" or do you have other fun activities that we could publish in the SunWise Monitor? If so, please contact Linda Rutsch at 202 564-2261, or <rutsch.linda @epa.gov>. If you submit questions for "Who Wants to Be SunWise?", be sure to indicate a dollar or point value, or whether the question should be categorized as very easy, easy, medium, or difficult.

1. The sun is a:
- a. planet
- b. star
- c. meteor
- d. none of the above

2. SPF is the abbreviation for:
- a. skin pollution formula
- b. super protective formula
- c. sun protection factor
- d. super protein food

3. You should wear sunscreen with an SPF of this number or higher:
- a. 3
- b. 5
- c. 8
- d. 15

4. The sun is important for:
- a. photosynthesis
- b. visible light
- c. warmth
- d. all of the above

5. The UV Index is reported on a scale of:
- a. 0-100
- b. 0-5
- c. 0-10+
- d. 2-12

6. The distance from the sun to the Earth is
- a. 86,000 miles
- b. 93 million miles
- c. 26.2 miles
- d. none of the above

7. This mammal secretes an oily pink sunscreen to protect itself:
- a. flamingo
- b. hippo
- c. pig
- d. human

8. The stratosphere is located:
- a. 10-30 miles above Earth's surface
- b. 0-10 miles above Earth's surface
- c. 2 miles from the moon
- d. 93 million miles from Earth

9. Out of every 10 million air molecules, about 2 million are normal oxygen, but only this number are ozone:
- a. one million
- b. one thousand
- c. one hundred
- d. three

Answers: 1. b, 2. c, 3. d, 4. d, 5. c, 6. b, 7. b, 8. a, 9. d

A Message...

<Continued from page 1>

common form of skin cancer. Unlike melanoma skin cancer, it is not usually fatal, but can still cause serious damage to skin and eyes.

The S's of Sun Protection

Fortunately, there are many steps we can take to protect ourselves from skin cancer and other harmful effects of sun exposure. By following these rules, we can avoid damaging sunburns and achieve better overall health.

- Slip on a shirt.*
- Slop on sunscreen (SPF 15 or higher).*
- Slap on a wide-brimmed hat.*
- Sunglasses should be worn to prevent cataracts.
- Shadow rule: if your shadow is shorter than you are, you are more likely to sunburn. Remember, "No shadow—Seek shade." The sun is most intense between 10 a.m. and 4 p.m.
- Sunburns should be avoided at any age and especially by children.
- Sunbathing in natural sunlight and at tanning parlors should be avoided.

So as we turn our sights to summer, let's have fun, but remember to be SunWise! Follow the steps above and check the UV Index daily to help plan your outdoor activities. For more information on the SunWise School Program and the UV Index, visit <www.epa.gov/sunwise>.

— Dr. Thomas F. Downham II, MD
Henry Ford Medical Center
thomasd@ic.net

* Copyright American Cancer Society, 1994.

The UV Index

In addition to the sun-safety tips to the left, the UV Index also can be a valuable tool in helping to avoid too much sun. The National Weather Service, the Centers for Disease Control, and EPA initiated the UV Index for 58 cities in 1994. It is a forecast of the level of skin-damaging UV radiation reaching the Earth's surface at noon. Knowing the intensity of UV radiation enables people to take appropriate sun-protection steps to avoid overexposure. Exposure levels and index values are categorized in the following manner:

Minimal: A UV Index reading of 0 to 2 indicates minimal danger from the sun's UV radiation.

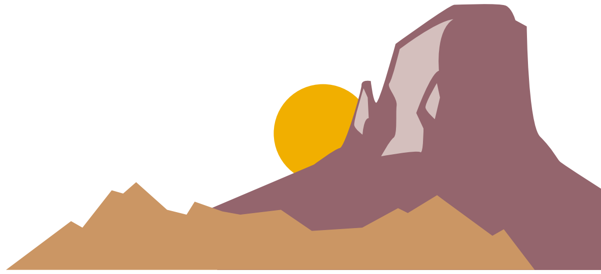
Low: A UV Index reading of 3 to 4 indicates low risk of harm to the skin from the sun's UV radiation.

Moderate: A UV Index reading of 5 to 6 indicates some significant risk of skin damage due to the sun.

High: A UV Index reading of 7 to 9 indicates high risk of harm from unprotected exposure to the sun. Time in the sun should be avoided between 10 a.m. and 4 p.m.

Very High: A UV index reading of 10 or more indicates very high risk of harm from unprotected sun exposure.

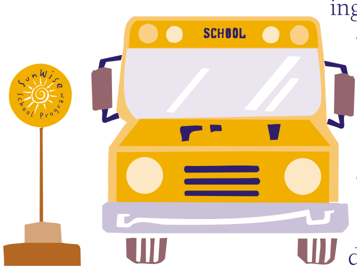
In the SunWise Spotlight... Continued



SunWise on the Road...

Linda Rutsch and Kristin Kenausis recently took the SunWise message on the road to Crestview Elementary School in Boulder, Colorado. Laura Farris of EPA's Region 8 office arranged for the school visit, where four 4th and 5th grade physical education classes were taught how and why to be SunWise.

Each class started out with an introductory slide show explaining the importance of sun safety. In an effort to keep the lesson both entertaining and informative, students in each class were then broken up into four groups, with each group rotating into learning centers set up around the gym. In Laura's learning center, students learned how to pick the best sunscreen, hat, sunglassees, and clothing for optimum sun protection. Laura also demonstrated proper sunscreen application.



In Linda's learning center, students made UV bead bracelets and necklaces. The beads, when exposed to UV radiation, turn an array of vibrant colors. Many students noted that the UV beads would be a great reminder while skiing because they sometimes forget that in the cold of winter, UV radiation still exists, especially considering the altitude and the reflection from the snow.

In Kristin's learning center, the students engaged in a sun-safe relay race. The relay race required that teams of students run to the side of the gym where sun-safe outfits had been left earlier. Once there, they had to dress a chosen person on their team to be sun-safe (with appropriate hat, sunglasses, clothing, and sunscreen bottle), and race back. Each class ended with a review of lessons learned. A good time was had by all who participated.

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www.epa.gov/sunwise

SunWise monitor

An Update on EPA's SunWise School Program

A Ray of Light in Ohio

What do you get when you cross a devoted group of doctors, a medical support group, and a ready-to-use educational program called SunWise? In Montgomery County, Ohio, you get RAYS (**R**aising **A**wareness About **Y**our **S**kin), an active volunteer committee that educates students throughout the county about the dangers of ultraviolet radiation. The committee has reached more than 8,500 students in 20 school districts during the past two years.

Consisting of more than 32 dermatologists, plastic surgeons, internists, obstetricians, optometrists, and neurologists, along with 25 other volunteers, the committee arranges assemblies and classroom presentations in middle and high schools throughout the year. Volunteers use SunWise lesson plans and a captivating slide presentation to teach students about the early signs of skin cancer and what risky behaviors to avoid. In addition, volunteers provide SunWise materials and information to schools and encourage teachers and administrators to join the SunWise program. The committee's efforts have been tremendously successful.

"Not only have we been on the news three or four times, but we've reached an incredible number of students, and we have also discovered several teachers with skin cancer," explained Betty Lacey, a volunteer who took an entire year off work to devote to this cause. "People didn't know what to look for until we showed them pictures."

The pictures she's referring to are a series of clinical photographs of skin cancer—part of the slide presentation developed and used by the committee. Available on the SunWise Web site at <www.epa.gov/sunwise/webpres>, this presentation has been successful in getting students to think twice about sitting in the sun or going to a tanning salon before a wedding or a prom, and it stimulates peer pressure to keep each other safe. "The realistic shots of skin cancer are extremely effective," said Lacey. "Students are usually surprised by the gruesome consequences of too much sun."

<Continued on page 2>

American Cancer Society Embraces Community-Based Program

Five communities across the country are participating in an exciting new American Cancer Society (ACS) program designed to increase awareness about skin cancer and sun-safety techniques. The new initiative engages a multi-faceted approach that targets daycare centers, schools, primary care providers, beach and pool facilities, as well as the media.

Although they do not have a formal partnership with EPA, Mary O’Connell of ACS said that the new community programs will focus on actively promoting SunWise. “If schools do not currently have a sun-protection program, we are encouraging them to contact EPA and join SunWise. EPA spent a lot of time developing this program, and we think it’s a great resource,” O’Connell said.

In addition to asking teachers to devote at least two classroom sessions to sun safety education, ACS is asking schools to examine their sun awareness policies. For example, ACS is looking at whether schools offer shade provision during recess and whether or not children are required to wear hats and apply sunscreen when outside. According to O’Connell, this represents a shift from previous programs, “It used to be that the responsibility for sun safety fell to the individual; however, we’re attempting to integrate policy into the equation,” she said.

At pools and beaches, the new ACS program offers sun-safety training for staff members and lifeguards. “Because they are visible to patrons, it’s important for lifeguards to act as role models and exhibit responsible sun-safety behaviors,” O’Connell said. In addition, ACS asks water-safety instructors to remind their students to “Slip! Slop! Slap! Wrap!” at the end of each lesson. This slogan, which means “Slip on a shirt, Slop on sunscreen, Slap on a hat, and Wrap on sunglasses,” was adapted from a campaign successfully used for many years by the Australian Cancer Society.

Primary care physicians can participate in the program by distributing patient education materials in their waiting rooms, engaging their patients in discussions about sun safety, and, when applicable, tagging the charts of patients who are at high risk for sun-related illness.

According to O’Connell, ACS is optimistic about the success of this new initiative and is currently evaluating its first batch of field tests. Results from these tests will be reported to EPA by the end of the summer. For more information about ACS and its sun-safe communities programs, visit its Web site at <www.cancer.org>.

A Ray of Light...

<Continued from page 1>

The program got its start in 1999 when a group of dermatologists from the Ohio Medical Association passed a resolution to teach students throughout the state about the hazards of the sun and tanning salons. Volunteers from the Montgomery County Medical Alliance and its auxiliary support group decided to take action on the resolution.

When the committee read about the SunWise program in a newspaper article and began using SunWise materials, it began to have success in attracting schools to the idea. “EPA’s program was definitely the springboard for our program,” said Lacey. “Their ready-to-use materials made a huge difference. We are anxiously awaiting new SunWise materials to incorporate into our program.”

For more information about RAYS, send an e-mail to RAYSTASKFORCE@aol.com.

In the SunWise Spotlight...

SunWise Students Want to Know

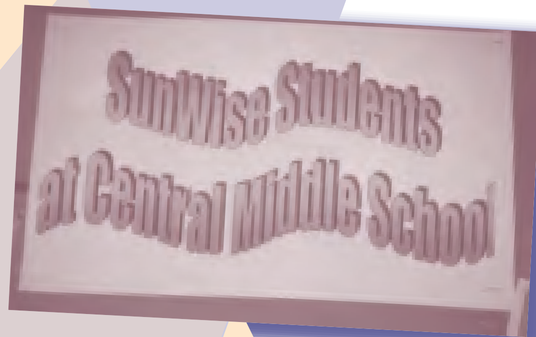
Some say curiosity killed the cat, but, as a group of Illinois students recently discovered, asking the right questions can also save lives. Debbie Brennan, the learning

coordinator at Central Middle School in Tinley Park, Illinois, works with the top 5 percent of the seventh and eighth grade students as part of the school's gifted program. Brennan practices "inquiry learning," a loose system that allows students to ask questions about a topic of their choice and conduct activities to answer them.

"A few years ago in May, a group of my students noticed some high school kids lined up outside a tanning salon in preparation for their prom," Brennan said. "I overheard them complaining that tanning causes skin cancer, and I asked them how they knew for sure." To find the answer, the students began a research project on the effects of exposure to ultraviolet (UV) radiation. Not long after that, Brennan discovered EPA's SunWise Web site. She began working with EPA to create activities based on SunWise materials that fit the Illinois state learning standards, incorporating language, fine arts, science, and math.

For many of their activities, the students conduct both group and individual research and then find creative ways to share what they learn. One part of their research effort was to contact the American Cancer Society, which sent them information, bookmarks, and stickers related to sun safety. Brennan has also forged relationships with a local oncologist and a Chicago-based meteorologist, both of whom are available to answer students' questions.

To share what they learned last year, the students created flyers on sun safety and distributed them to local youth sports teams. The students also decorated and gave away hats and bandanas with UV-sensitive paint and performed experiments by applying sun screen to necklaces they made from UV-sensitive beads. As part of a long-term activity, the students monitor and chart daily local UV intensity. The students also share their information by writing



articles for the school newsletter, posting articles and notices on a school bulletin board, and posting information on their Web site <www.ccsd146.k12.il.us/central/projects.html>.

"My students are very concerned about their world," Brennan said. "SunWise is such a great program because it stirred their creativity and interest, and made them realize they can have an impact."

For more information:

Debbie Brennan
Central Middle School
6611 West 171st Street
Tinley Park, IL
708 614-4510

Ozone —Friend or Foe?

Due in large part to the publicity surrounding holes in the ozone layer, most people are familiar with stratospheric ozone—the kind that protects humans, plants, and animals from the harmful effects of ultraviolet (UV) radiation. But did you know that ozone exists at ground level? More commonly referred to as smog, ground-level ozone is often seen in the skyline of major cities. These two types of ozone affect the environment differently, and both are worth a closer look.

Ozone: Good Up High, Bad Nearby

The Good

Ozone forms in the atmosphere when three atoms of oxygen are combined (O3). Ozone located in the stratosphere—about 15 to 30 kilometers above the earth's surface—protects the environment and its inhabitants from UV radiation that can cause health problems, including skin cancer, eye damage, and suppression of the immune system, as well as damage to crops and ecosystems. To maintain a consistent protective layer for Earth, stratospheric ozone is naturally created and destroyed at a constant rate, but human-made substances, including chlorofluorocarbons (CFCs), interfere with this process. CFCs, methyl bromide, and other substances accelerate and aggravate ozone depletion in the stratosphere. This causes "holes" in the ozone layer—areas where ozone thickness has decreased significantly. Reduced ozone layer thickness means less protection from UV rays and increased risks to human health and the environment. International cooperation has succeeded in reducing the production and use of CFCs and other ozone-depleting substances in certain areas of the world, but these substances persist in the atmosphere and will continue to disrupt the delicate balance of the protective ozone layer for years to come.

- One chlorine or bromine molecule can destroy 100,000 ozone molecules, causing ozone to disappear much faster than nature can replace it.
- Out of 10 million air molecules, about 2 million are normal oxygen, while only 3 are ozone.

The Bad

Ground-level ozone is a major component of air pollution. It is created when oxides of nitrogen (NOx) and volatile organic compounds (VOCs)—byproducts of vehicle exhaust, industrial emissions, and chemical solvents—chemically react in the presence of strong sunlight and warm weather conditions. Exposure to ozone pollution can cause a range of health problems, including chest pains, coughing, throat irritation, and congestion, and it can worsen bronchitis, emphysema, heart disease, and asthma. It can also damage plants and trees and reduce crop production. Decreasing NOx and VOC emissions from power plants and other facilities, and automobile exhaust are two ways of combating the creation of polluting ozone.

The Effects on Climate

Hardly a day goes by without an article or news feature on global warming and climate change appearing in the media. You may be wondering, therefore, whether there is a link between ozone depletion and climate change.

The answer is yes, and in more ways than one. First, ozone-depleting substances are greenhouse gases. They comprise only a small portion of total greenhouse gases produced worldwide, but they still contribute to global climate change. And substitutes for ozone-depleting substances, while helping to protect the ozone layer, are also potent greenhouse gases.

Second, climate change may accelerate ozone depletion, which worsens when temperatures in the stratosphere become colder. Global warming is caused by increases in greenhouse gases and essentially robs the stratosphere of warmth by trapping heat below it. This creates a colder stratosphere and increased ozone depletion, particularly in colder latitudes, such as the North Pole and Arctic Circle. This occurrence could have major consequences in the near future. Just as the ozone layer is expected to begin recovering from worldwide reductions in CFC production and use, higher global temperatures may increase ozone depletion, canceling out the gains made up to this point. As Jason Samenow, a climate scientist in EPA's Office of Air and Radiation states, "These issues should no longer be considered in isolation given the interconnectedness of our changing atmosphere."

Kid's Korner

In May 2000, Linda Rutsch of EPA's SunWise Program gave a presentation on sun safety to first graders at Georgian Forest Elementary School in Silver Spring, Maryland. In addition, she spoke to other students at the school during two assemblies. The school also incorporated SunWise activities into their annual field day in June 2000, including a SunWise relay, UV frisbee activity, shadow chalk drawing, and UV meter and UV bead activity. To make the day even more exciting, it was covered by CNN!

The following are excerpts from some of the letters the students sent to Linda in appreciation for her SunWise savvy.

thank you for coming to our school...I learned that you can get sun barn in cloudy days.

Thank you for coming in our classroom to teach us about sun safety. You are a good teacher. I learned that you have to put sunglasses.

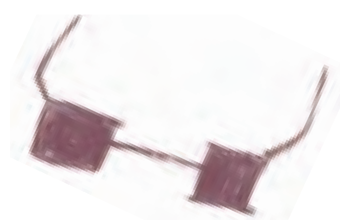
Thank you for showing how to take care of our body by puting sunscreen and sunglass-es too.

Thank you for coming. I will use sunscreen. I will wear a hat.

I learned that even on clou days you can get sunburn, and anamals can get sunburn.

I learn a lot a lot of thing from you. I learn we have to put sunscreen before we go outside, we have to put are clothes, wear sunglasses to protect are eye.

I learned hippos make thier own sunscreen. I also learned if your shadow is smaller than you play in the shade.



(Artwork courtesy of students at Georgian Forest Elementary School, Silver Spring, Maryland.)

UV Index Comes to Town

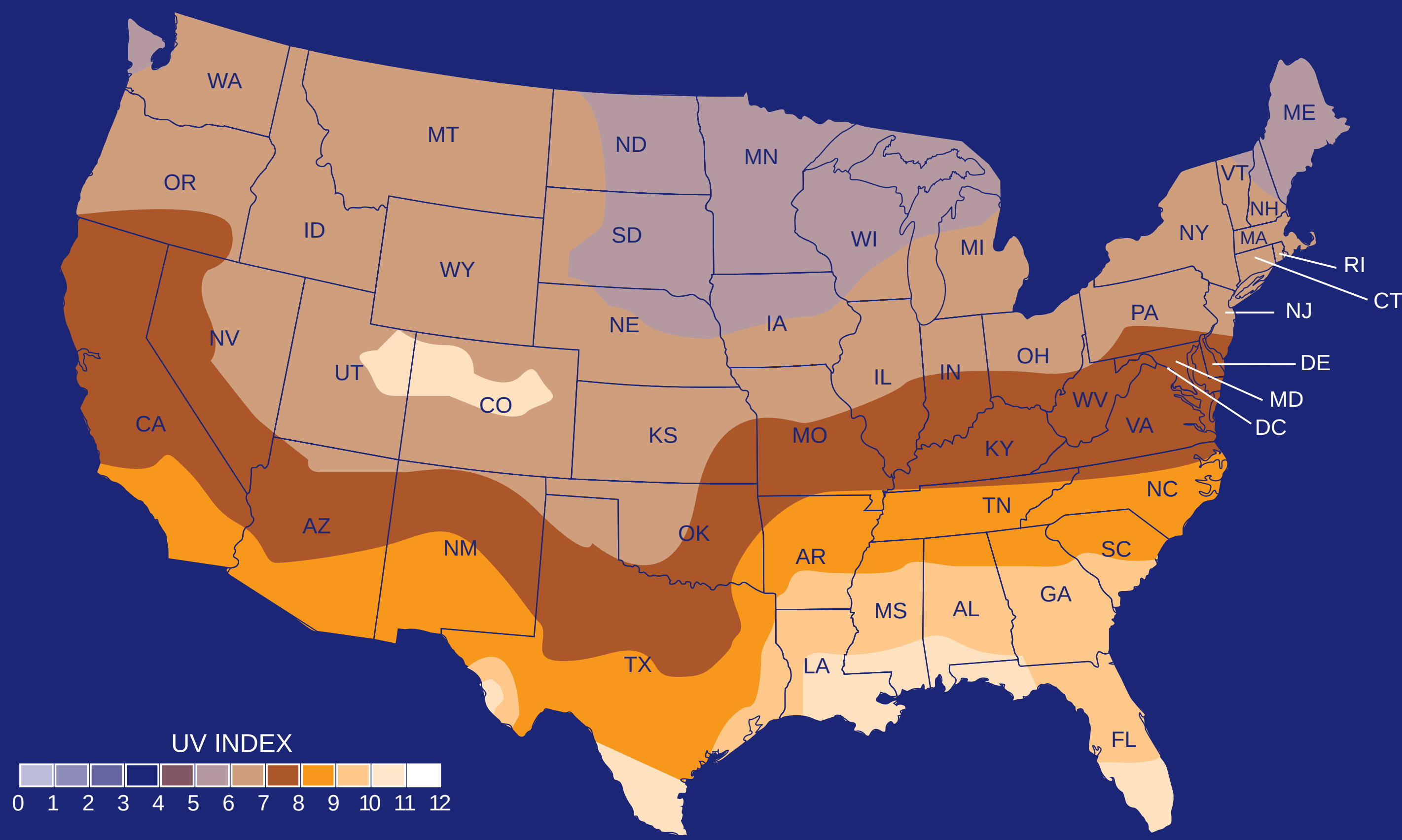
A new feature on the SunWise Web site can help protect you from overexposure to the sun, not just in summer, but all year long. Users can now search for the Ultraviolet (UV) Index by ZIP code at <www.epa.gov/sunwise/uvindex.html> and view the daily UV Index for their local area. “Prior to this, the National Weather Service (NWS) only issued a list of daily UV Indexes for 58 cities, and some major parts of the country were excluded. Now users can get the UV Index at their exact location, which is much more beneficial to them,” said Craig Long of NWS.

The UV Index was developed by NWS and EPA to predict UV radiation levels. Overexposure to the sun’s UV rays can cause sunburn and long-term effects such as skin cancer and cataracts. The UV Index reports daily UV forecasts on a 1 to 10+ scale that provides the expected risk of overexposure to the sun, with 0 indicating minimal risk and 10 indicating very high risk. It provides important information to help people plan outdoor activities in ways that prevent overexposure to the sun’s rays.

As a future project, the NWS and EPA are considering increasing the forecasted number of days, so users can plan outdoor activities several days in advance. For more information, contact Craig Long of NWS at 301 763-8071, ext. 7557.

UV Index Forecast for a Typical Day

Valid during the solar noon hour



New Tools for Teaching Kids to be SunWise

EPA's new SunWise Tool Kit is here! This collection of fun, developmentally appropriate activities combines education about sun protection and the environment with other aspects of learning. Teachers registered with the SunWise School Program receive a free tool kit with comprehensive, cross-curricular activities that focus on:

- The science behind ultraviolet (UV) radiation and stratospheric ozone
- The health risks of overexposure to UV radiation
- The steps you can take to protect yourself

The tool kit also contains a policy section that shows teachers and students how to encourage sun-safety activities outside of the classroom. These policy materials feature suggestions on sharing SunWise knowledge with the rest of the school, reaching out to families with sun-safe practices, forming community partnerships, and organizing sun-safe events. Stay tuned, as the tool kit will be available in Spanish within the coming year.

For more information on the SunWise Tool Kit, contact Linda Rutsch at 202 564-2261 or Kristin Kenausis at 202 564-2289. To join the SunWise School Program, please visit the Web site at <www.epa.gov/sunwise>.

EPA
United States
Environmental Protection Agency
(6205J)
Washington, DC 20460

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Penalty for Private Use
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MISSION: SUNWISE

Activity Book

About the SunWise School Program

To promote sun-safe behavior at an early age, the U.S. Environmental Protection Agency (EPA) developed the SunWise School Program, a free national environmental and health education program for young children. Through the use of classroom, school, and community components, SunWise promotes sun safety by teaching children and their caregivers how to protect themselves from overexposure to UV radiation.

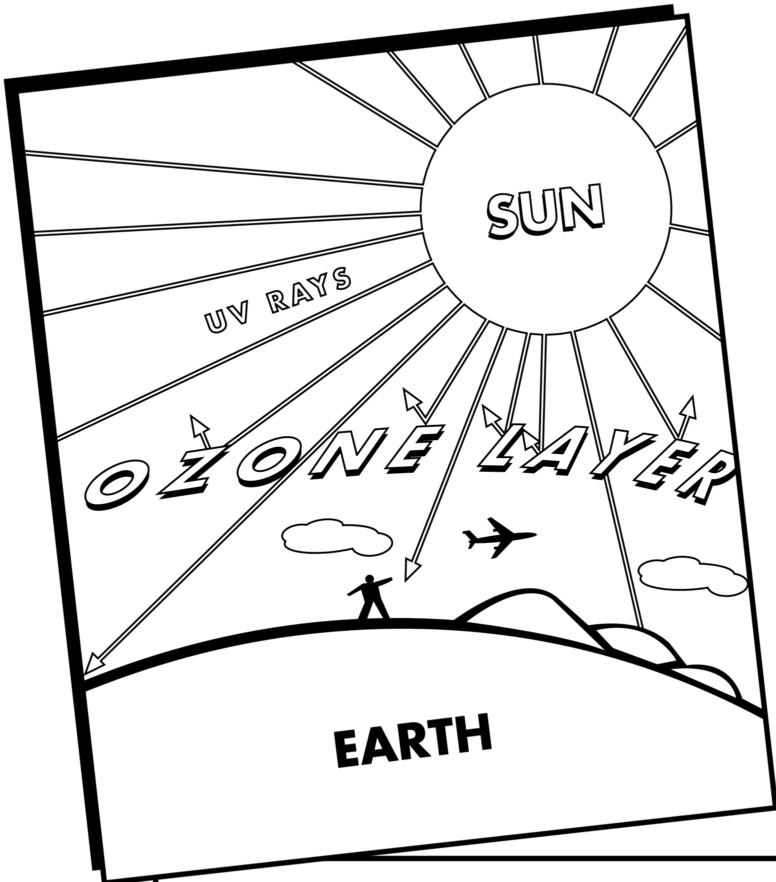
The program is designed for kindergarten through eighth-grade learning levels. Any K-8 school can participate.

By joining EPA's SunWise School Program, participants will have access to useful tools to help teach sun-safe behaviors in the classroom, such as:

- The SunWise Tool Kit - providing a range of cross-curricular lessons, activities, and background information for K-8 children.
- The SunWise Internet Learning Site (www.epa.gov/sunwise) - an interactive medium with web-based educational activities and resources.
- Additional materials, puzzles, posters and activities, such as the "Mission SunWise" storybook and activity book.

Register today to receive your free SunWise Tool Kit by visiting www.epa.gov/sunwise. Look for the "Join" icon in the "Educators" section.

The SunWise Club has a new Secret Mission!



CAN YOU FILL IN THE MISSING LETTERS?

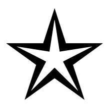
S U ____

O Z ____ N E

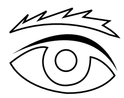
E ____ R ____ H

R ____ Y S

FILL IN THE MISSING WORDS:

The sun is a  ________ .

UV rays are outside even on  ________________ days.

UV rays can hurt your  __________ .

Too much sun can give you a  ____________________ .

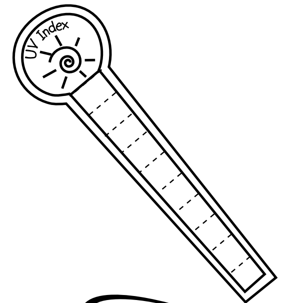
UNSCRAMBLE THE LETTERS TO READ AN IMPORTANT MESSAGE:

E H T Z N E O O A L Y R E L P H S E

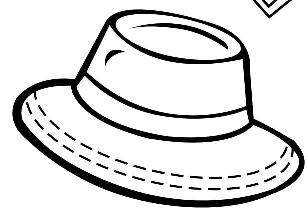
K O B L C V U Y R S A.

(SEE ANSWERS ON THE LAST PAGE)

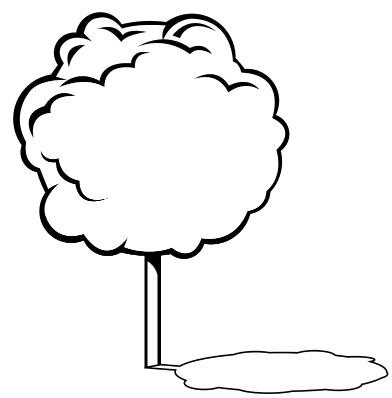
CAN YOU MATCH THE SUNWISE ACTION STEPS WITH THE RIGHT SUNWISE PICTURES?



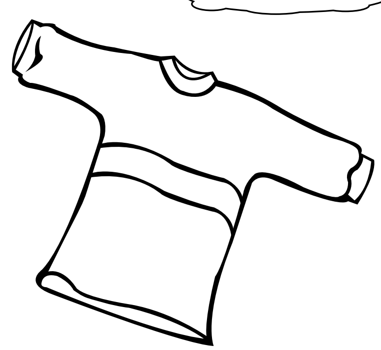
SLIP on a ________
… to cover as much skin on your body as you can.



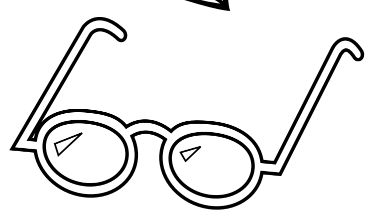
SLOP on ________
… on your face, arms, legs, and any other skin that the sun's UV rays can reach.



SLAP on a ________
… that will keep UV rays from reaching your face, ears and neck.



WRAP on ________
… to protect your eyes.

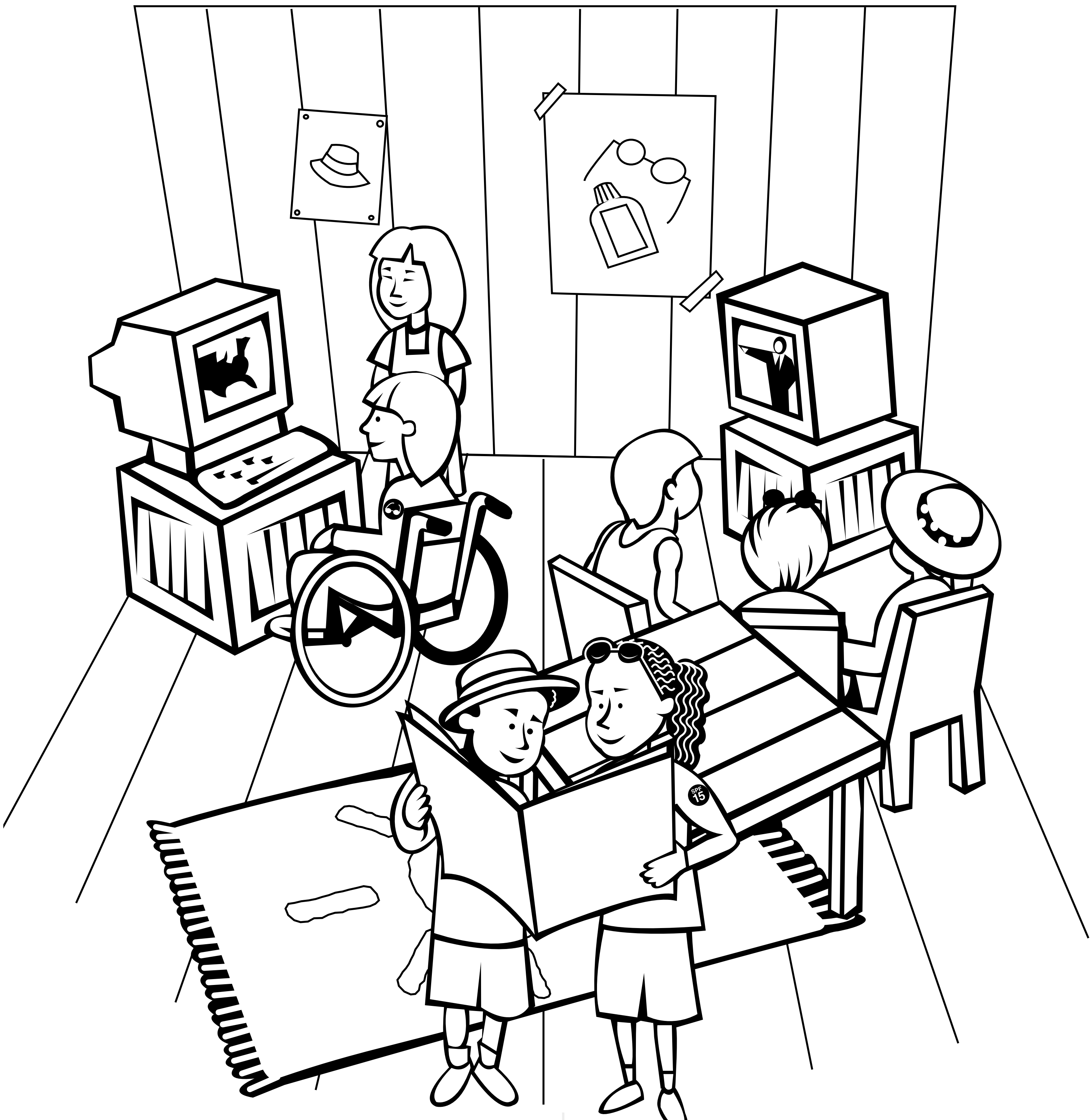


CHECK the __ _______
… to find the UV forecast

PLAY in the ______
… and stay out of the sun whenever possible

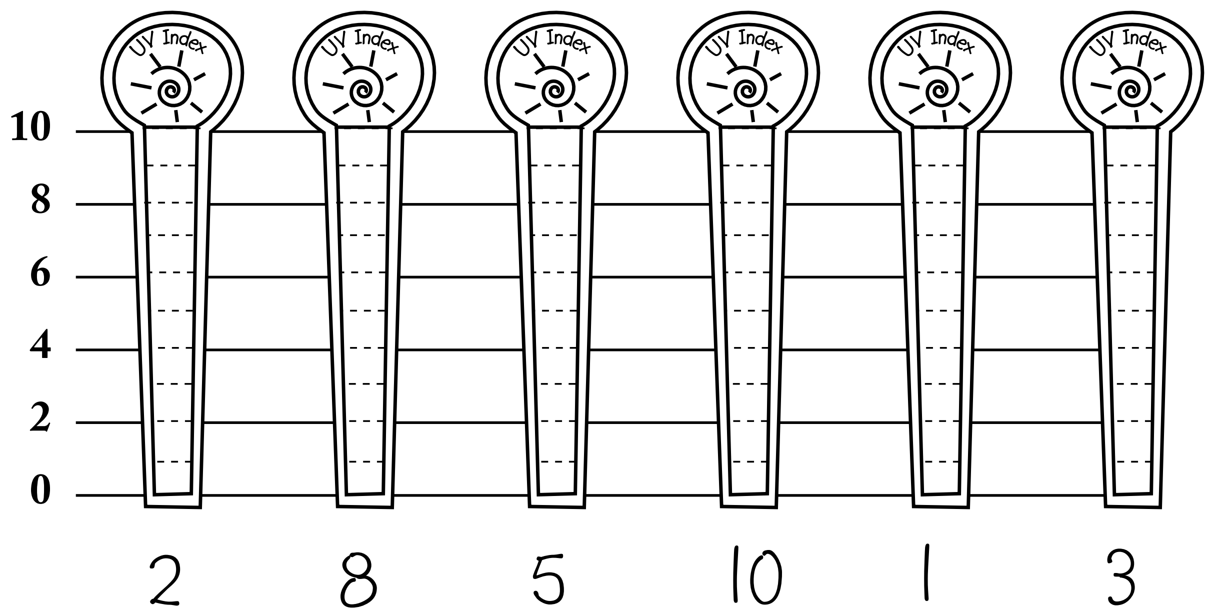
The children are checking the UV Index. The UV Index is a forecast of how strong the UV rays will be. It is reported on a scale of 0-10+. The higher the number, the stronger the rays will be, and the more we need to protect ourselves.

You can find the UV Index in many places. It is in the weather section of the newspaper and on TV, radio, and Internet weather reports.



UV Index

Index Number	Exposure Level
0-2	Minimal
3-4	Low
5-6	Moderate
7-9	High
10+	Very High



DIRECTIONS:

Color in each UV Index to match the number.

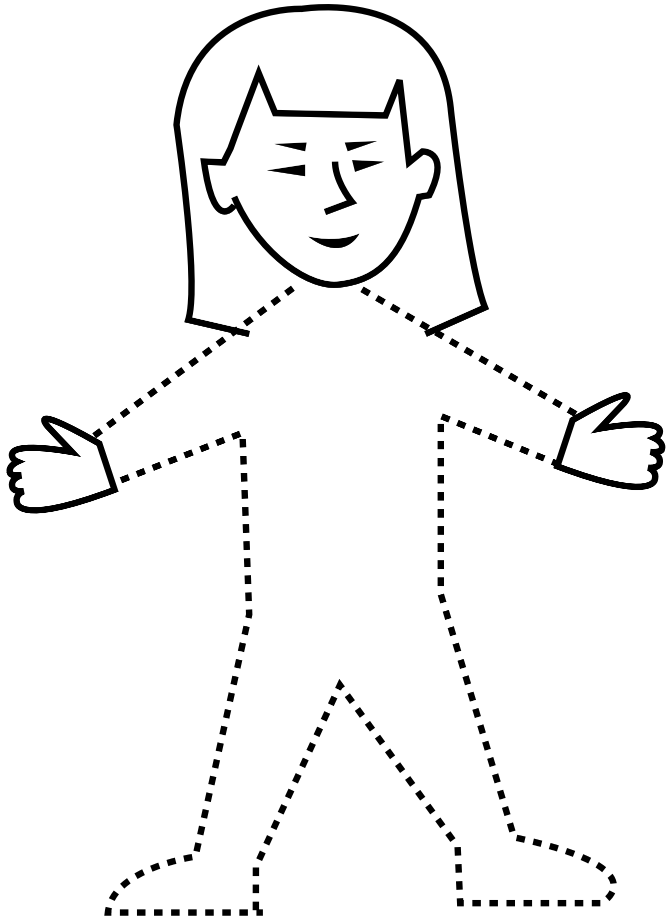
Circle the ones that are “HIGH” or “VERY HIGH.”

The higher the UV Index, the greater the need for skin and eye protection.

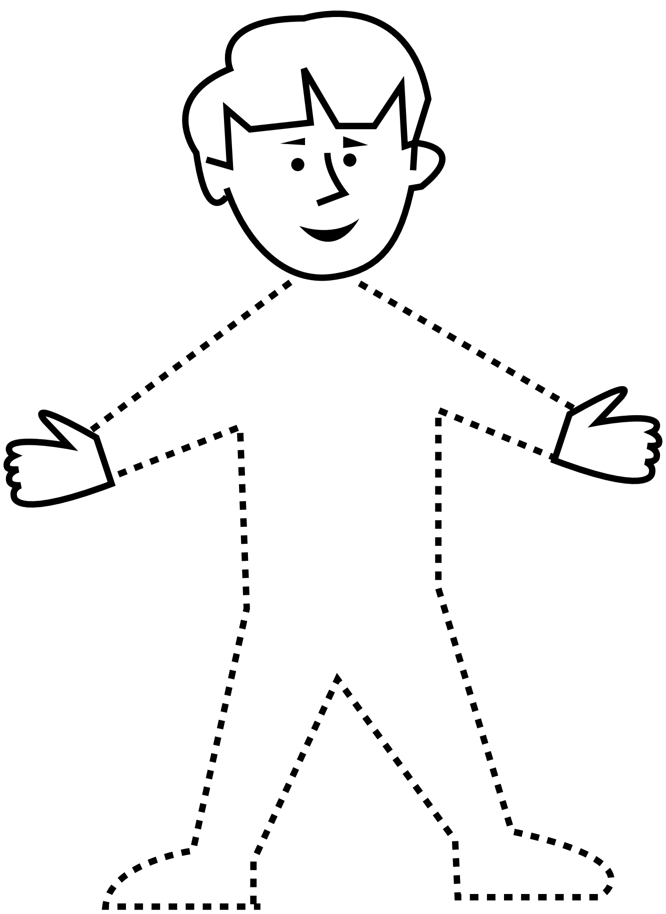
What’s the UV Index in YOUR neighborhood? Go to the SunWise website to find it! The website URL is www.epa.gov/sunwise

Carlos is trying to decide what to wear today. He wants to be SunWise, but needs your help! What clothes should he wear to be SunWise? Circle the best choices.

What would you wear to be SunWise? Draw your own SunWise outfits on Carlos and Lisa.



Lisa



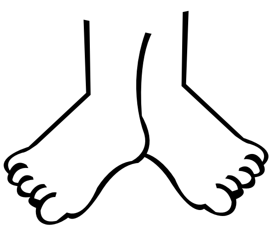
Carlos

SLOP ON SOME SUNSCREEN TO BE SUNWISE!

Sunscreen is a lotion you spread on your skin. Sunscreen helps block UV rays. Some sunscreens are more SunWise than others. Remember, you should always use sunscreen that is number 15 or higher.

Circle the SunWise sunscreen:

DO YOU PUT SUNSCREEN ON....

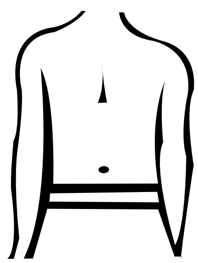


bare feet

YES NO

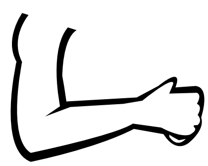
bare leg

YES NO



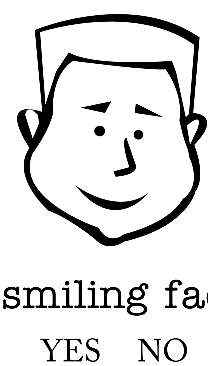
bare tummy

YES NO



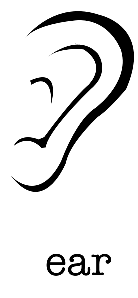
bare arm

YES NO



smiling face

YES NO

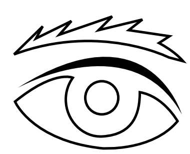


ear

YES NO

shoe

YES NO

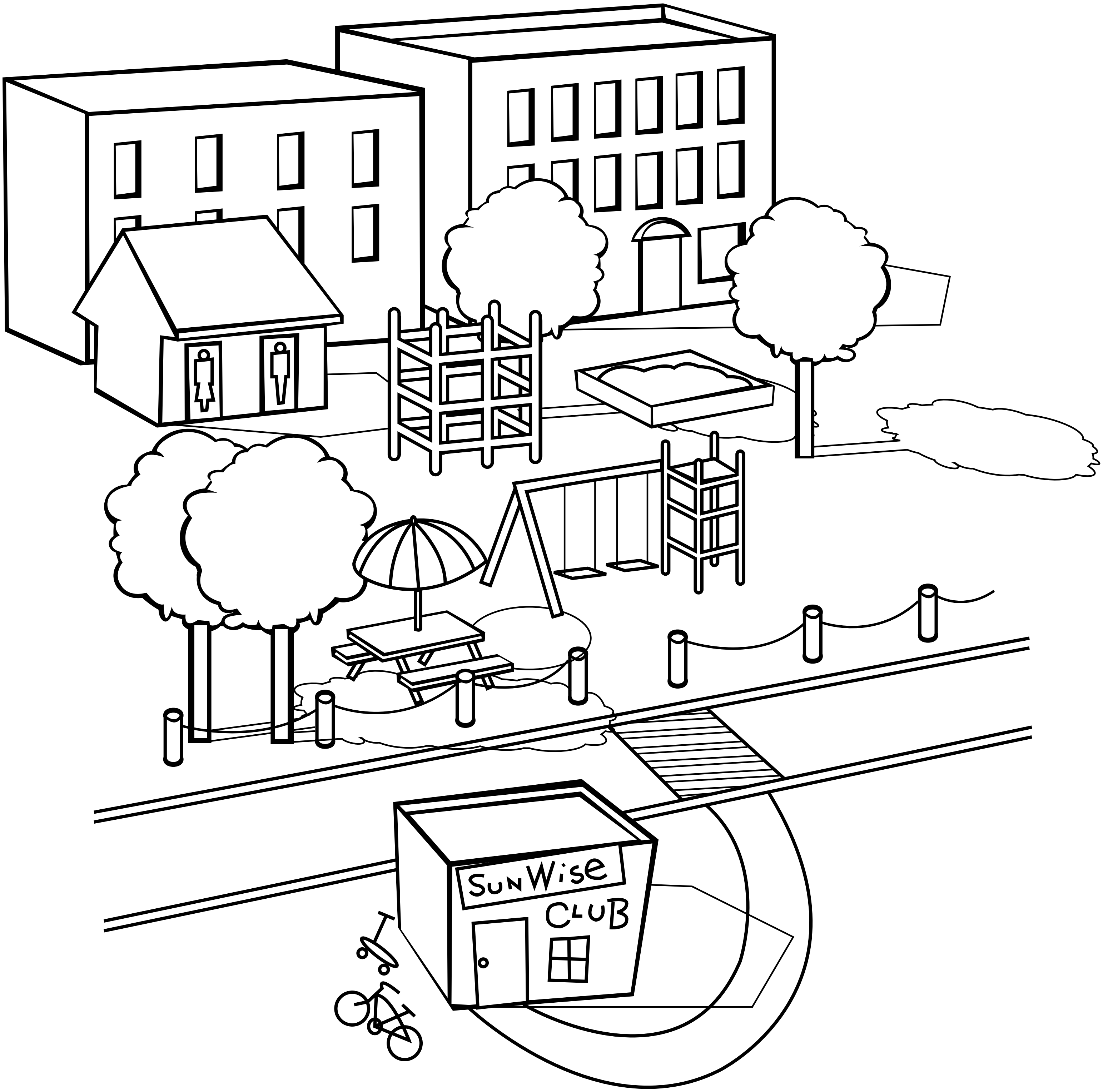


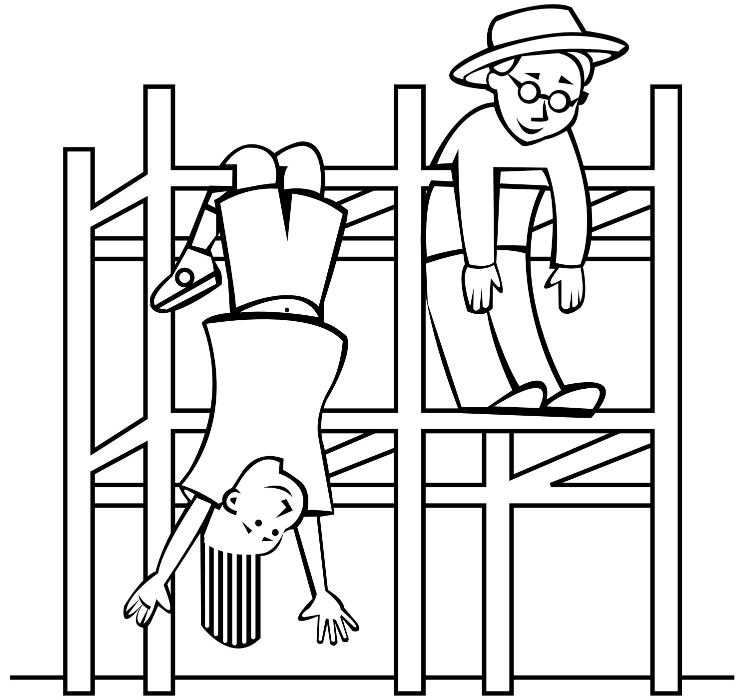
eyes

YES NO

Remember, when you're playing outside, try to play in the shade.

Circle the shady places in this picture.





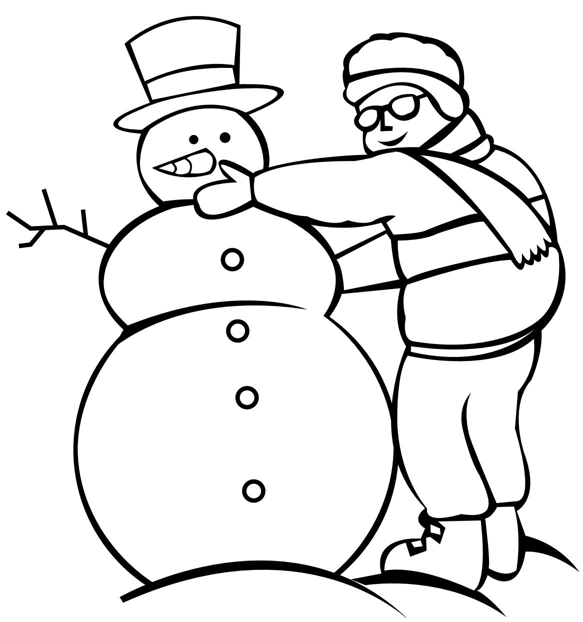
ARE THESE CHILDREN SUNWISE?

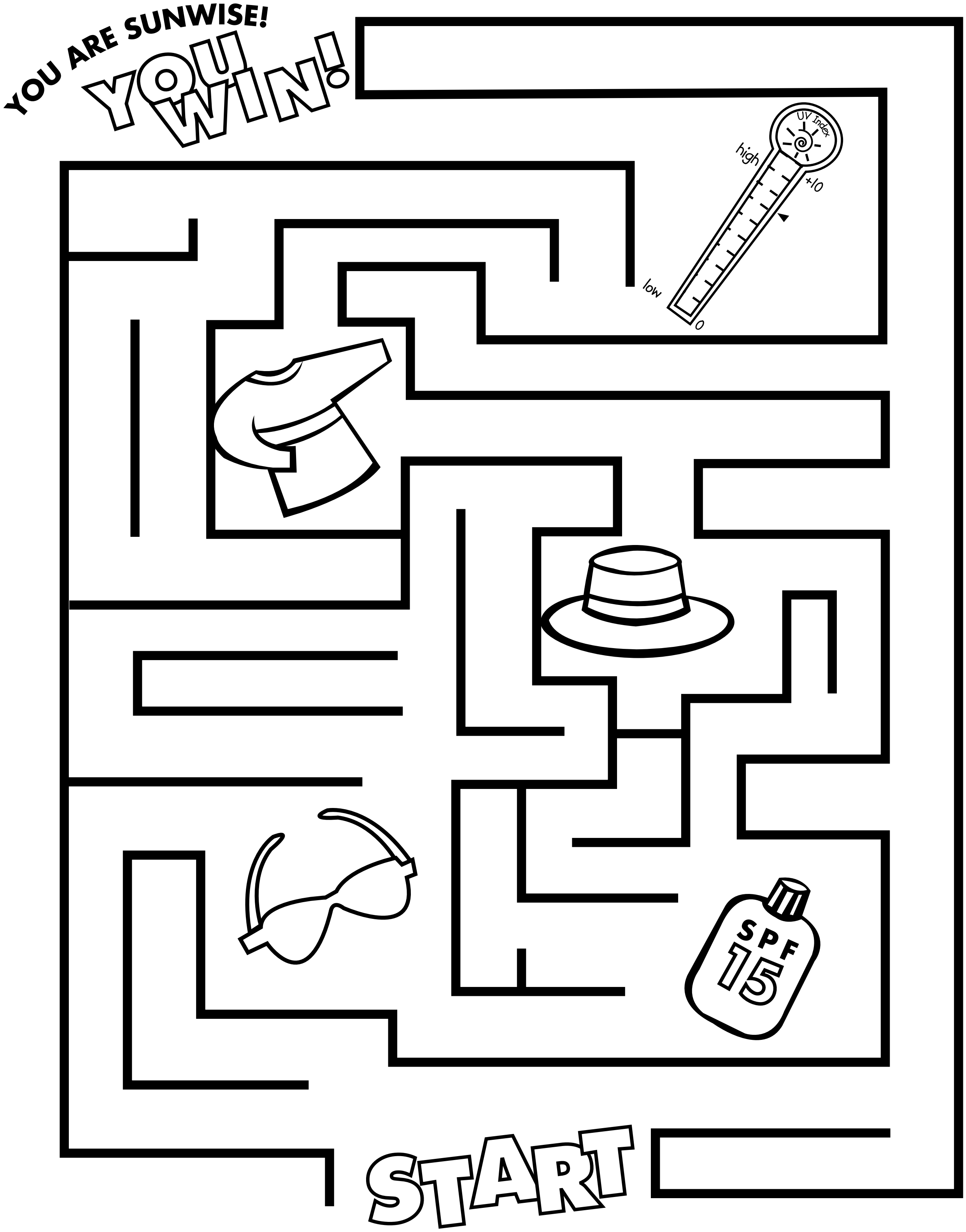
What do they need to make them SunWise?

Draw SunWise gear — hats, glasses and clothes — on the children.

Color in the areas where they should apply sunscreen.

Remember to be SunWise even on cloudy days!





DIRECTIONS:

Find your way through the maze, picking up all the SunWise gear on the way.

IT'S FUN AND EASY TO BE SUNWISE!

Tell your friends about ways to be SunWise.

Just remember SLIP! SLOP! SLAP! WRAP!,™ CHECK the UV INDEX and PLAY in the SHADE!

ANSWERS FOR PAGE 2

Missing words:

star
cloudy
eyes
sunburn

Missing letters:

sun
ozone
earth
rays

Unscrambled message:

The Ozone Layer Helps Block UV Rays.

The SunWise School Program would like to thank the American Cancer Society for their ongoing support and for allowing us to use their "SLIP! SLOP! SLAP! WRAP!"™ slogan.

United States
Environmental Protection
Agency

Air and Radiation
(6205J)

EPA 430-K-00002
April 2001
www.epa.gov/sunwise

EPA

Are YOU SunWise?

Join the kids in the SunWise Club and learn how to have safe fun in the sun!

Libro de actividades

¡MISIÓN SUNWISE:

Cómo te proteges del sol!

ACERCA DEL PROGRAMA ESCOLAR SUNWISE:

La Agencia Federal de Protección Ambiental (EPA – U.S. Environmental Protection Agency) creó el Programa Escolar SunWise para fomentar el cuidado de la piel y la protección del sol desde temprana edad. Éste es un programa nacional de educación de la salud y del medio ambiente sin costo alguno dirigido a los niños pequeños. El programa utiliza iniciativas educativas en los salones de clase, las escuelas y las comunidades, para enseñarles tanto a los niños como a las personas encargadas de su cuidado, como protegerse de la radiación de los rayos ultravioleta al exponerse demasiado al sol.

El programa se diseñó para estudiantes de kínder a octavo grado. Cualquier escuela de este tipo puede participar en el programa SunWise, ya sea con una clase, varias clases o todas las escuelas en general e inclusive los distritos escolares.

Las escuelas participantes que se unan al programa de la EPA, tendrán la oportunidad de usar diversos materiales educativos, que les indicarán como enseñarles a sus estudiantes a protegerse del sol y a cuidarse la piel; estos materiales son:

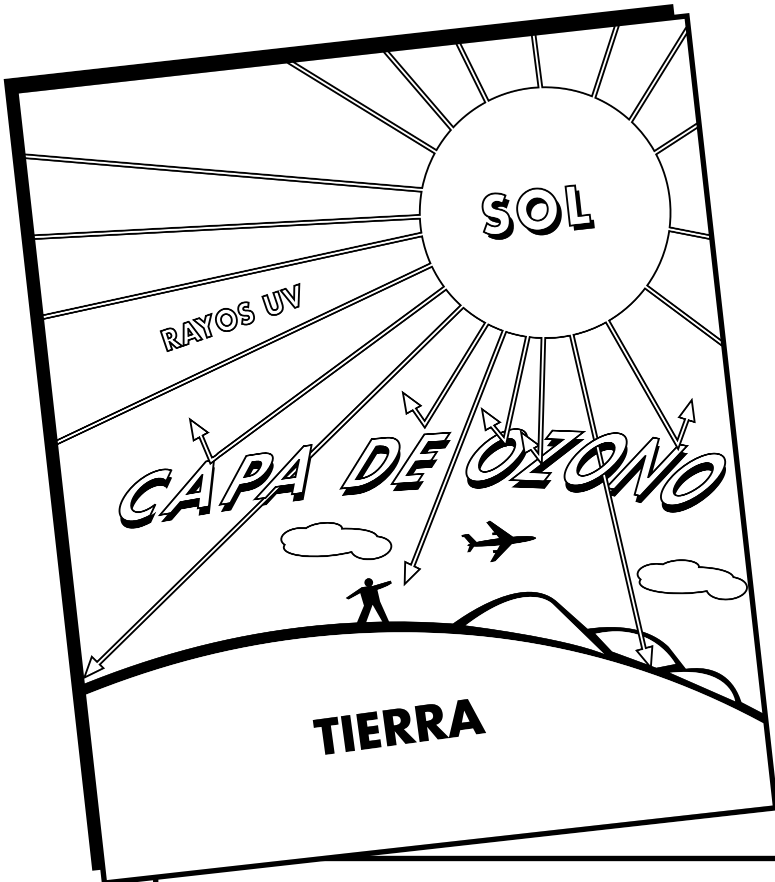
- La Guía de Actividades SunWise – contiene una gran variedad de lecciones extra curriculares, actividades para la clase e información adicional para los niños de kinder a octavo grado.

- La página Internet de aprendizaje SunWise (www.epa.gov/sunwise) –es un medio de aprendizaje interactivo con recursos y actividades educativas.

- Materiales adicionales, rompecabezas, carteles y actividades, tales como la "Misión SunWise" que tiene el libro para colorear y el libro de cuentos.

Visite la página Web www.epa.gov/sunwise e inscríbase hoy mismo para que reciba gratuitamente su "Guía de Actividades SunWise". Asegúrese de buscar la figura de la palabra "Join" (Únase) en la sección de "Educators" (Educadores).

¡El Club SunWise tiene una nueva misión secreta!



¿PUEDES COMPLETAR LAS LETRAS QUE FALTAN?

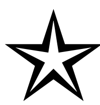
S O ____

O Z ____ N O

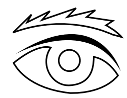
T I ____ R ____ A

R ____ Y ____ S

LLENA BLANCOS:

El Sol es una  ________ .

Los rayos ultravioleta están afuera aunque el día esté  ________ .

Los rayos ultravioleta te lastiman los  ________ .

Si te asoleas mucho te puedes  ________________ .

PON LAS LETRAS EN ORDEN Y LEE UN MENSAJE IMPORTANTE:

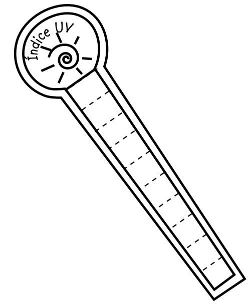
A L   A P C A   E D   Z N O O O   A D U A Y   A

I R E M P D I   S L O   S O Y A R

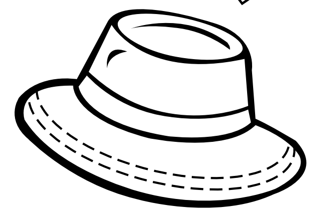
V L E A A U I O L T T R

BUSCA LAS RESPUESTAS EN LA ÚLTIMA PÁGINA

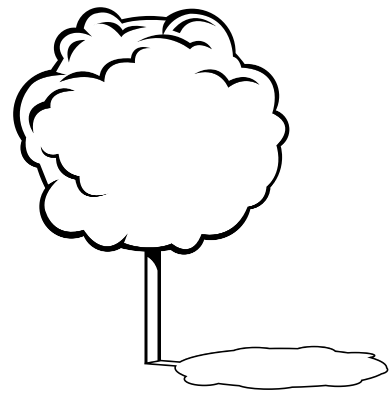
¿PODRÍAS ENCONTRAR LA FIGURA SUNWISE QUE CORRESPONDE A LAS INSTRUCCIONES DEL CLUB SUNWISE?



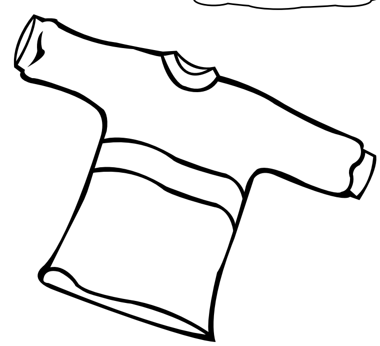
PONTE una ________
… para cubrirte la mayor parte del cuerpo.



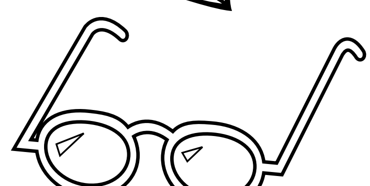
PONTE ________
… en la cara, brazos, piernas y en otra parte del cuerpo que no esté tapada por la ropa.



PONTE una __________
… para que los rayos ultravioleta no te lastimen la cara, oidos y cuello.



PONTE unos __________
… para protegerte los ojos.

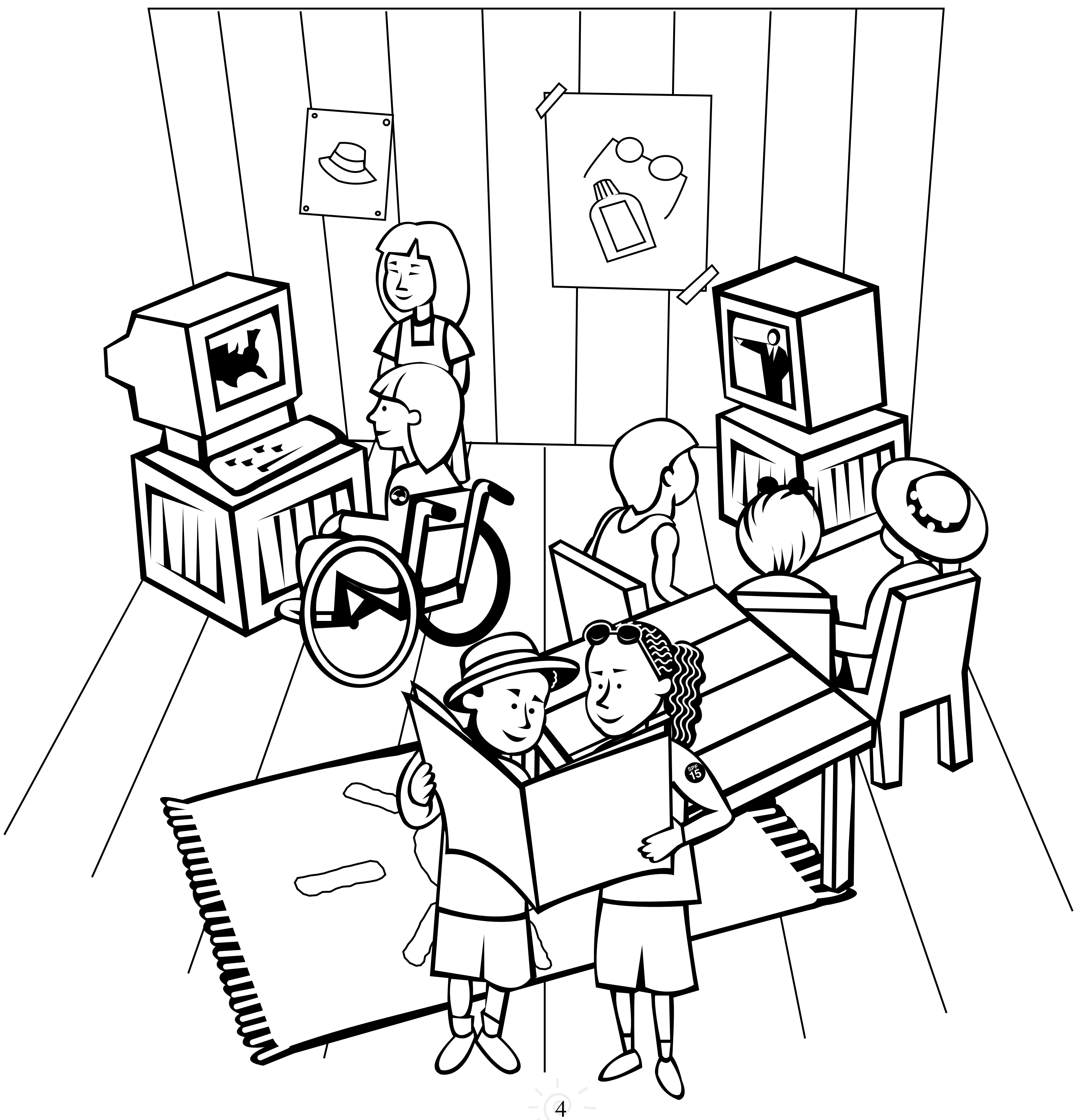


CHEQUEA el _________ ____
… para saber la intensidad de los rayos ultravioleta.

JUEGA en la __________
… y no te solees mucho.

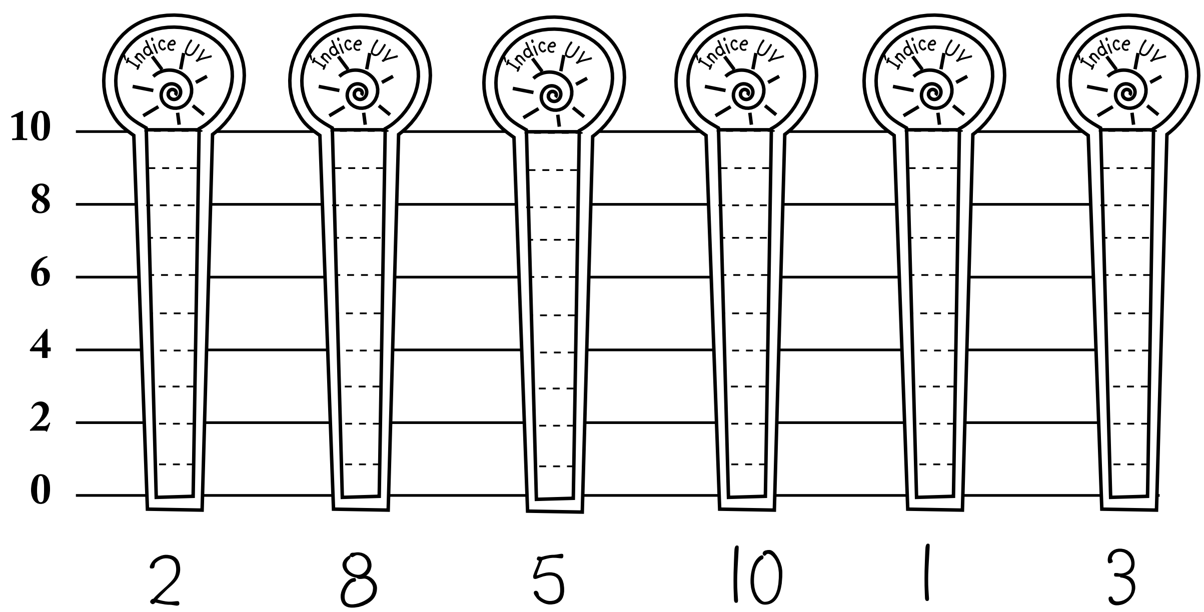
Los niños revisan el índice de los rayos ultravioleta. Este índice es un pronóstico de la intensidad de los rayos. El índice se mide en una escala de 0 a 10+. Entre más alto es el número, más fuerte son los rayos solares y nos debemos proteger más.

Puedes encontrar el índice de los rayos ultravioleta en muchos lugares. Está en la sección del estado del tiempo de los periódicos, y también en los informes del tiempo que se anuncian en la televisión, la radio y el Internet.



EL ÍNDICE UV

Número del Índice	Nivel de Exposición
0-2	Mínimo
3-4	Bajo
5-6	Moderado
7-9	Alto
10+	Muy alto



INSTRUCCIONES:

Colorea cada índice de los rayos ultravioleta que corresponda al número.

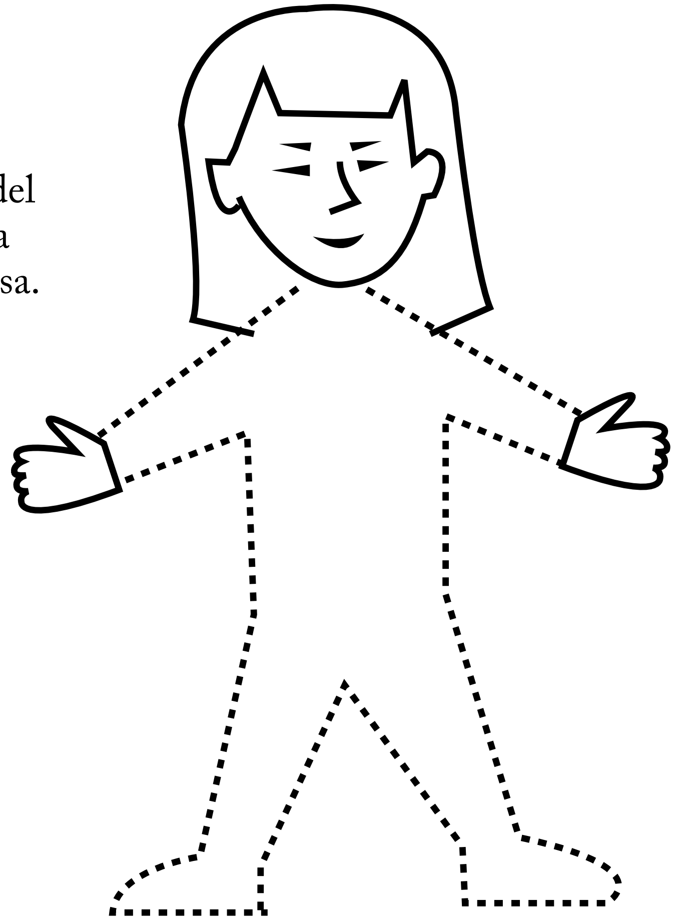
Ponle un círculo a los índices que indiquen "ALTO" o "MUY ALTO".

Entre más alto sea el índice ultravioleta, la necesidad de protegerse la piel y los ojos es mayor.

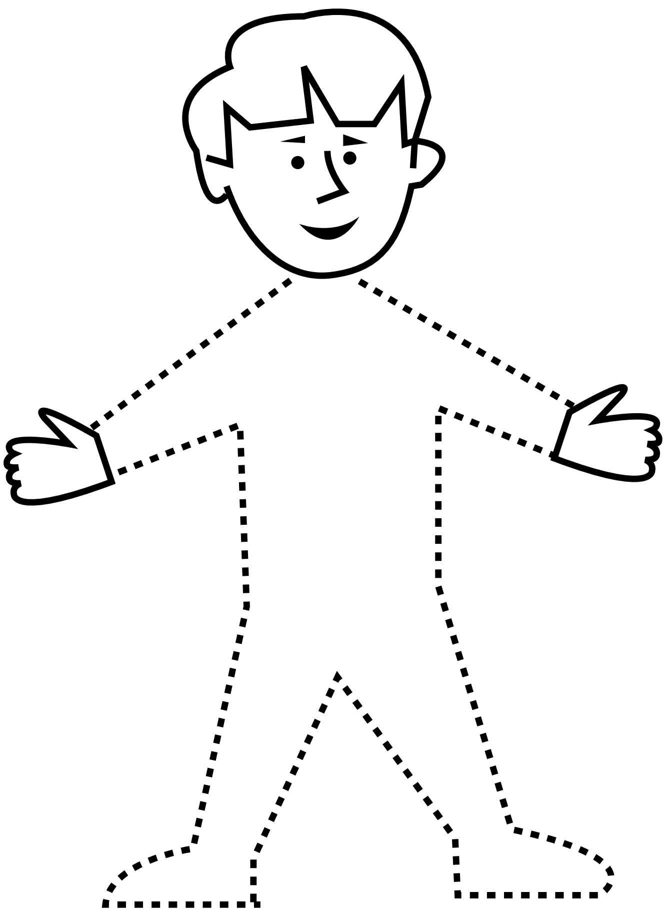
¿Cuál es el índice ultravioleta en tu comunidad? Visita la página Web de SunWise para encontrarlo. El sitio Web es www.epa.gov/sunwise

Carlos no sabe que ponerse el día de hoy. Él quiere protegerse del sol y hacer lo que el Club SunWise le dice, para eso necesita tu ayuda. ¿Podrías ayudarle a escoger la ropa adecuada? Haz un círculo a la ropa más apropiada.

¿Qué vestirías tú para protegerte del sol y seguir las instrucciones del Club SunWise? Dibuja tu propia ropa en las figuras de Carlos y Lisa.



Lisa



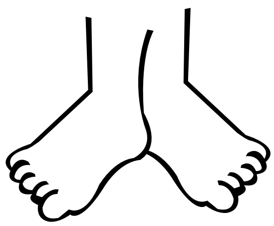
Carlos

¡PONTE UNA BUENA CANTIDAD DE PROTECTOR CONTRA EL SOL Y SIGUE LOS PASOS DEL CLUB SUNWISE!

El protector contra el sol es una crema que tiene una protección especial para el sol, te la puedes poner en la piel. Esta crema te ayuda a impedir los rayos ultravioleta. Algunos protectores te cuidan del sol más que otros, y el Club SunWise te recuerda que uses un protector número 15 o mayor que éste.

Ponle un círculo al protector SunWise:

¿TE PONES PROTECTOR EN....

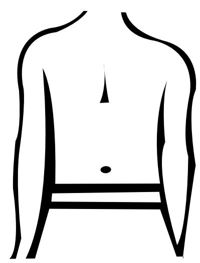


pies

SI   NO

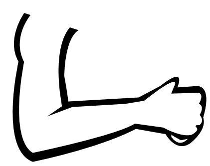
piernas

SI   NO



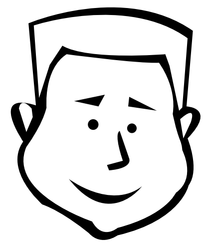
estomago/pecho

SI   NO



brazos

SI   NO



cara

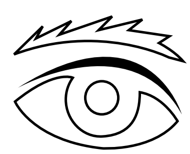
SI   NO

oidos

SI   NO

zapatos

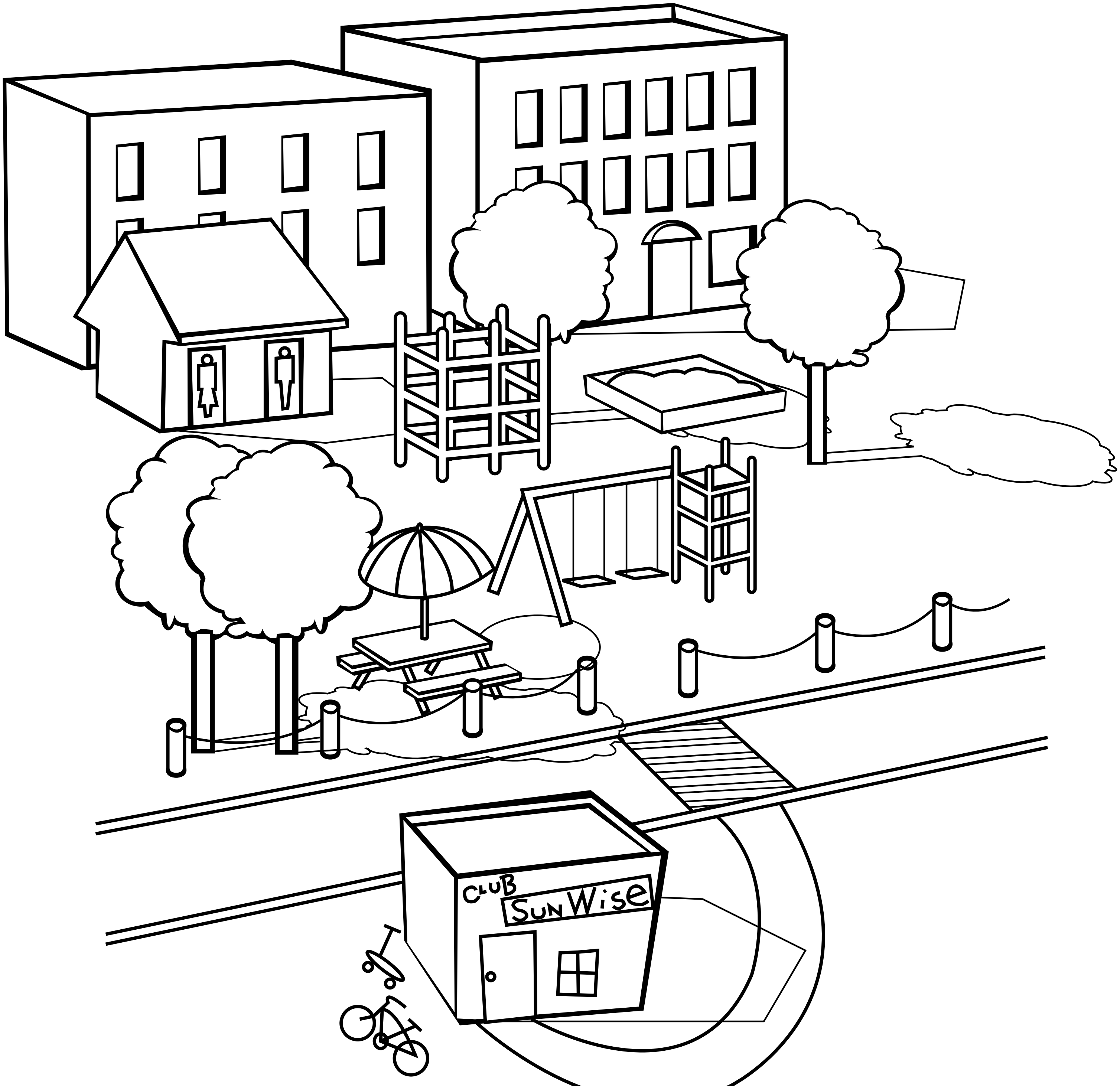
SI   NO

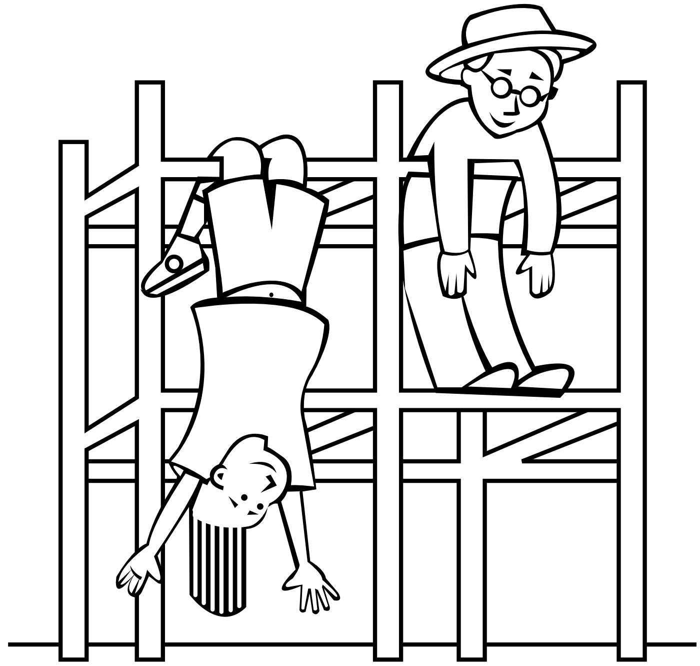


ojos

SI   NO

Recuerda, cuando juegues afuera, trata de hacerlo en la sombra.
Haz un círculo a las partes sombreadas de este dibujo.





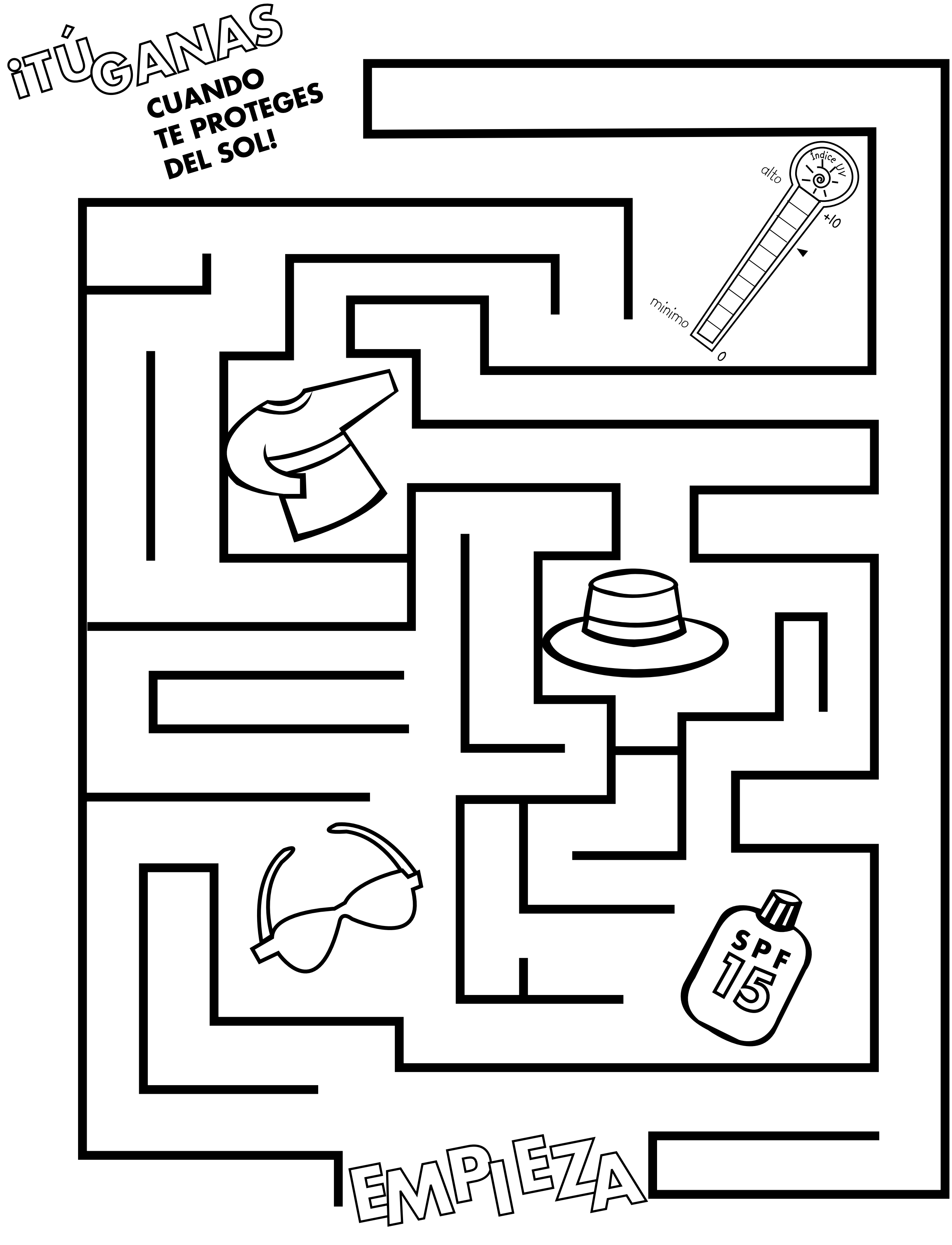
¿SE PROTEGEN CONTRA EL SOL ESTOS NIÑOS Y TIENEN EN CUENTA LO QUE EL CLUB SUNWISE LES DICE?

¿Qué es lo que se necesita para que se protejan del sol?

Díbujales a los niños artículos para protegerse del sol: Gorras, gafas de sol y ropa.

Colorea las partes del cuerpo en las cuales deben ponerse protector.

¡Recuerda protegerte del sol y hacer lo que el Club SunWise te dice inclusive en los días nublados!



INSTRUCCIONES:

Encuentra la salida del laberinto y escoge todas las cosas que necesitas para protegerte del sol.

¡Es muy fácil y divertido protegerse del sol y hacer lo que el Club SunWise nos dice!

Díle a tus amigos como pueden protegerse del sol.

Y recuerda: ¡PONTE UNA CAMISETA DE MANGA LARGA, PONTE PROTECTOR SOLAR, PONTE UNA GORRA y UNOS GAFAS DE SOL,™ REVISA el ÍNDICE ULTRAVIOLETA y JUEGA EN LA SOMBRA!

RESPUESTAS DE LA PÁGINA 2

Palabras que hacen falta:

estrella
nublado
ojos
quemar

Letras que faltan:

sol
ozono
tierra
rayos

Adivina el mensaje:
La capa de ozono ayuda a bloquear los rayos ultravioleta.

El Programa Escolar SunWise quisiera agradecerle a la Asociación Americana del Cancer (American Cancer Society) por su constante apoyo y por permitirnos usar su lema SLIP! SLOP! SLAP! WRAP!"™.

United States
Environmental Protection
Agency

Air and Radiation
(6205J)

EPA 430-K-01-007
April 2001
www.epa.gov/sunwise

¿sabe USTED protegerse del sol?

¡Únase a los niños del Club SunWise y aprenda tanto a protegerse del sol como a divertirse bajo el!

United States
Environmental Protection
Agency

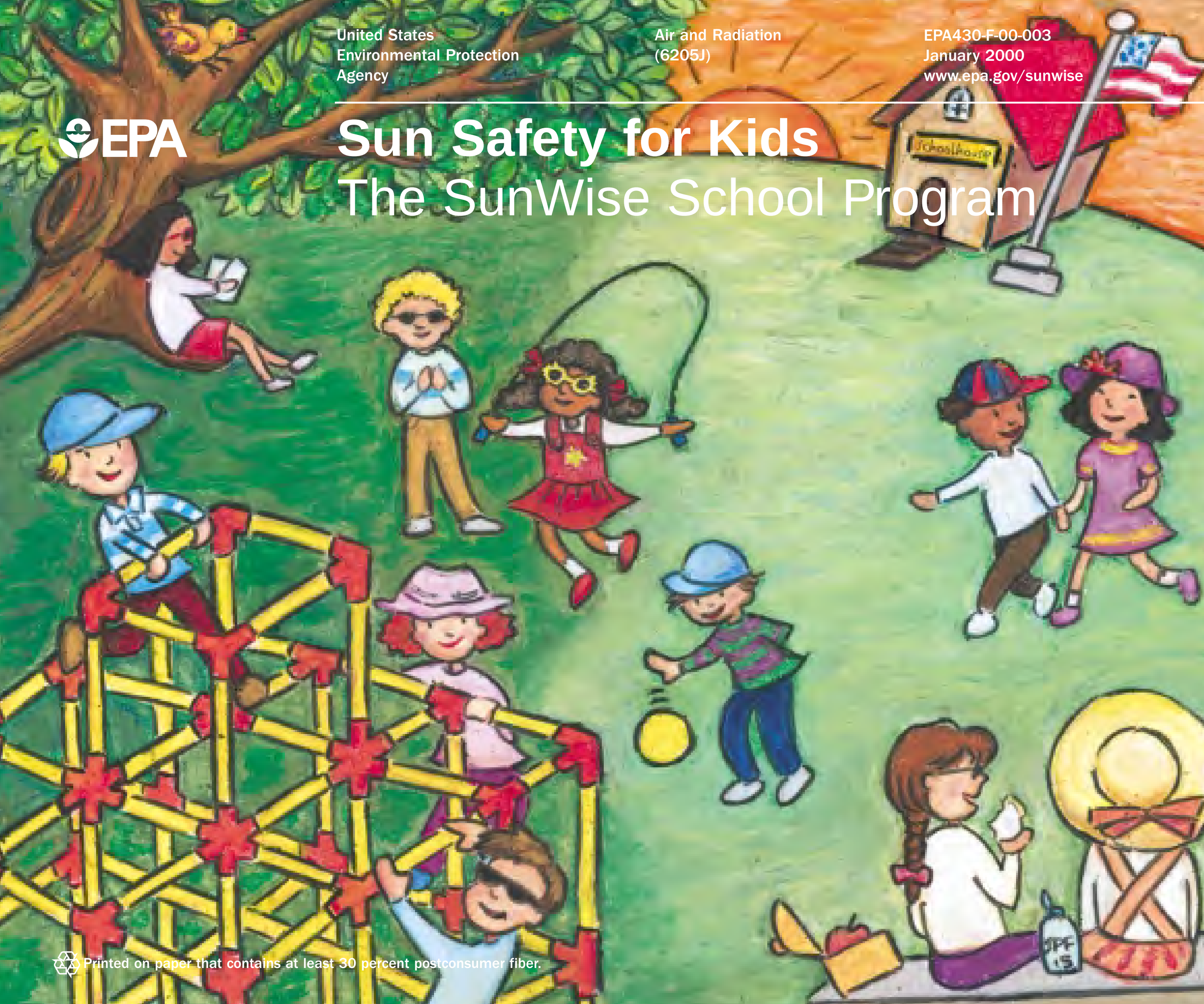
Air and Radiation
(6205J)

EPA430-F-00-003
January 2000
www.epa.gov/sunwise

EPA

Sun Safety for Kids

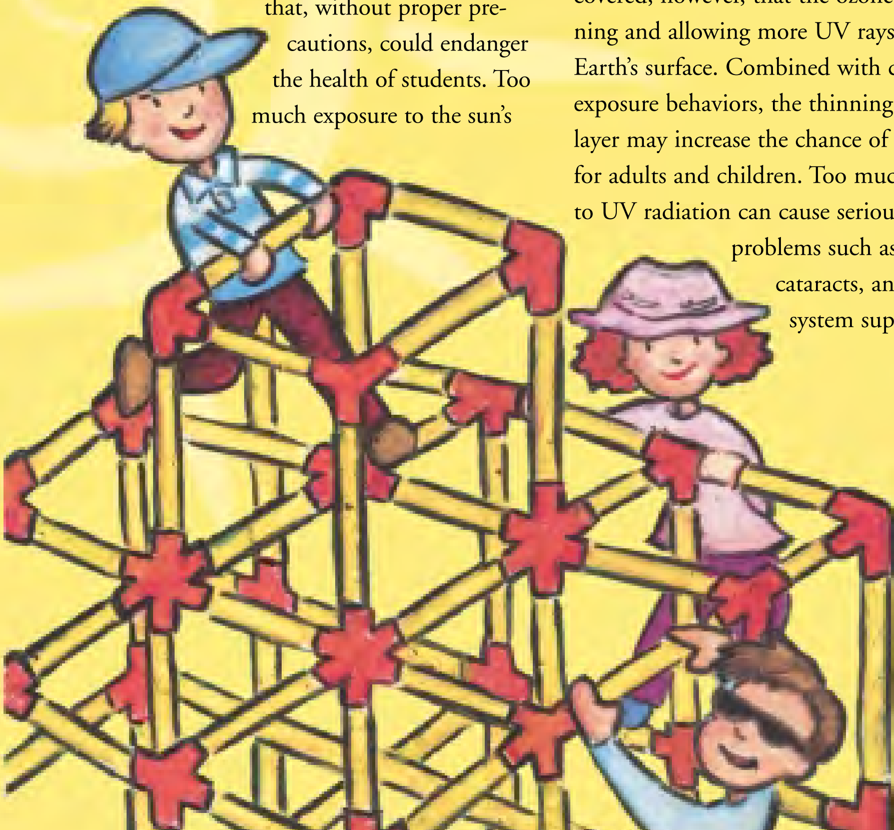
The SunWise School Program



The Sun, UV, and You

Day after day, as school bells echo through the hallways, millions of kids across the nation stream out of their classrooms and into sun-filled school yards, playgrounds, and sports fields. While this is a familiar childhood scene, it also is one that, without proper precautions, could endanger the health of students. Too much exposure to the sun's ultraviolet (UV) rays can be harmful to anyone's health—particularly that of a child.

In the atmosphere, the ozone layer forms a shield that protects the Earth from the sun's powerful UV radiation. Scientists have discovered, however, that the ozone layer is thinning and allowing more UV rays to reach the Earth's surface. Combined with current sun exposure behaviors, the thinning of the ozone layer may increase the chance of overexposure for adults and children. Too much exposure to UV radiation can cause serious health problems such as skin cancer, cataracts, and immune system suppression.



EPA's SunWise School Program

To promote sun-safe behavior at an early age, the U.S. Environmental Protection Agency (EPA) developed the SunWise School Program, a national environmental and health education program for young children. Through the use of classroom, school, and community components, SunWise promotes sun safety by teaching children and their caregivers how to protect themselves from overexposure to UV radiation.

The SunWise School Program builds upon traditional and innovative health and science practices already used by U.S. elementary and middle schools, focusing on simple steps students and teachers can take to prevent overexposure to the sun. While SunWise students learn about the environmental concepts related to sun protection, they also develop the ability to practice sustained health-enhancing behaviors.

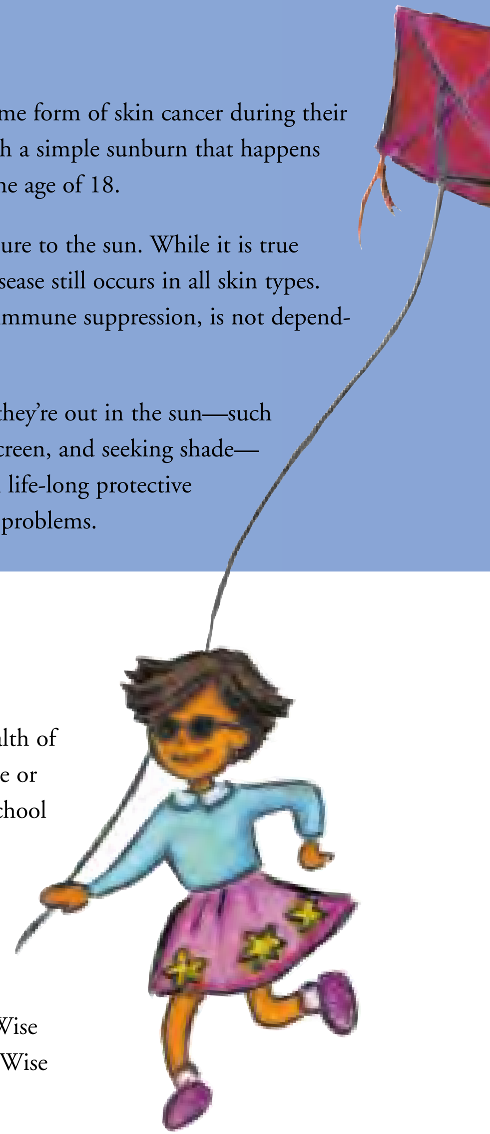
SunWise was developed in cooperation with schools and educators. Providing maximum flexibility, the program's elements can be used as stand-alone teaching tools or as supplements to existing school activities. The time commitment necessary to take part in SunWise is minimal, while the potential payoff is enormous.

Protecting the Children

According to the American Cancer Society, one in every five Americans will develop some form of skin cancer during their lifetime. This disease, one of the most serious UV-related health effects, can begin with a simple sunburn that happens years before skin cancer may develop. Most of a person's sun exposure occurs before the age of 18.

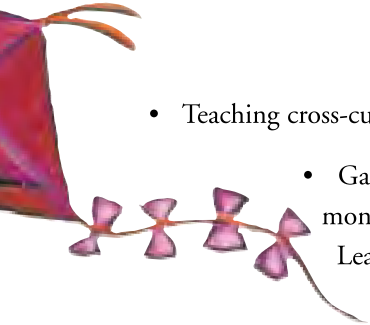
It is important to remember that children of all skin types need to be protected from overexposure to the sun. While it is true that the incidence of skin cancer is lower in dark-skinned individuals, the disease still occurs in all skin types. The risk of other UV-related health effects, such as eye damage and immune suppression, is not dependent upon skin type, and all children must be protected.

By teaching children to take some basic precautions when they're out in the sun—such as wearing protective clothing and sunglasses, using sunscreen, and seeking shade—teachers, nurses, parents, and other caregivers can instill life-long protective habits that reduce the risk of future UV-related health problems.



Becoming SunWise

SunWise is a fun and easy way to protect the health of children. Any school can participate, from single or multiple classrooms to entire schools, or even school districts. The program is designed for kindergarten through eighth-grade learning levels, with specific age-appropriate materials available for all learning levels. A random sample of participants will be asked to complete the *SunWise Student Survey* before and after implementing at least one of a range of SunWise activities. Following are some of the activities that SunWise schools can choose to undertake:

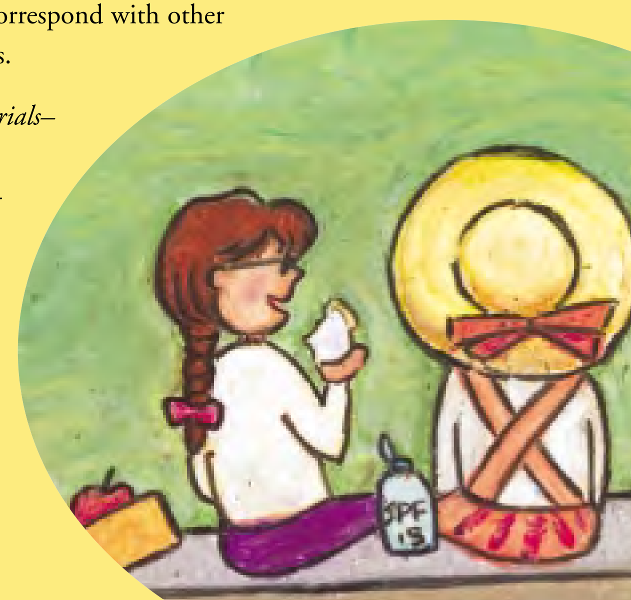


- Teaching cross-curricular classroom lessons and activities.
- Gathering UV ground data from hand-held monitors and using the SunWise Internet Learning Site to report and compare the findings to daily UV Index forecasts.
- Holding schoolwide sun safety events and assemblies.
- Improving school policies and structural designs to reduce students' exposure to the most intense UV rays and provide more shade structures on school grounds.
- Reaching out to the community by forming partnerships with local businesses and organizations or by hosting guest speakers.

Equipped to Be SunWise

By joining EPA's SunWise School Program, participants will have access to the following useful tools to help teach sun-safe behaviors in the classroom:

- *SunWise Tool Kit*–includes cross-curricular lessons designed for kindergarten through eighth-grade learning levels and features a range of activities and background information. Schools also will receive tools to help implement sun safety school policies, events, structural changes, and community partnerships.
- *The SunWise Internet Learning Site and UV Database*–is an interactive medium where students can report and interpret daily UV radiation levels using a hand-held UV monitoring device loaned to participating schools through the program, link to additional Web-based educational activities and resources, and correspond with other SunWise schools.
- *Additional Materials*–games, puzzles, incentives, Web-based activities, and other items are being developed.



Use the UV Index

Checking out television, radio, newspaper, and Internet weather forecasts in many cities across the country can now give you access to a powerful sun safety tool—the UV Index. The UV Index assigns a number to the next day's likely UV radiation levels and categorizes the level of exposure risk for people who plan to be outdoors.

The National Weather Service (NWS) calculates the UV Index so that the public can schedule outdoor activities to avoid dangerous overexposure to the sun. In addition to forecasts, you can find the daily UV Index on the SunWise Web site at <www.epa.gov/sunwise>. The UV Index predicts UV radiation levels on a 0 to 10+ scale in the following way:

Index Number	Exposure Level
0-2	Minimal
3-4	Low
5-6	Moderate
7-9	High
10+	Very High

While it is always important to take precautions against overexposure to the sun, both children and adults should take particular care to practice sun-safe behaviors when the UV Index is moderate or higher.

Take Action

Protect yourself and your children from overexposure to UV radiation. Taking the simple precautions listed below can ensure you enjoy safe fun in the sun.

Limit time in the midday sun as much as possible. The sun's UV rays are strongest between 10 a.m. and 4 p.m. To the extent you can, limit exposure to sun during those hours.

Watch for the UV Index. Always take precautions against overexposure, but take special care to adopt sun safety practices when the UV Index is moderate or higher.

Put on sunglasses. Sunglasses that provide 99 to 100 percent UVA and UVB protection will greatly reduce eye damage from sun exposure.

Wear a hat. A hat with a wide brim offers good sun protection for your eyes, ears, face, and the back of your neck.

Seek shade. Staying under cover or indoors is one of the best ways to protect yourself from the sun.

Protect other areas of your body with clothing. Wearing tightly-woven, loose-fitting, and full-length clothing is a good way to protect your skin from harmful UV rays.

Always use sunscreen. Apply a sunscreen with a sun protection factor of 15 or higher liberally, and reapply at least every 2 hours or after working, swimming, playing, or exercising outdoors. Consult your doctor about sunscreen use for children under 6 months.

Avoid sunlamps and tanning salons. The light source from sunbeds and sunlamps can damage the skin and unprotected eyes.

SunWise School Program

EPA's SunWise School Program is an Environmental Monitoring for Public Access and Community Tracking (EMPACT) project.

United States
Environmental Protection
Agency

Air and Radiation
6205J

EPA 430-K-00-005
May 2000
www.epa.gov/sunwise

EPA

The SunWise School Program Guide

Printed on paper that contains at least 30 percent postconsumer fiber.

Contents

"I have a vision of the Earth made green again through the efforts of children. I can see children of all nations planting trees and holding hands around the globe in celebration of the Earth as their home and all children, all people as their family."

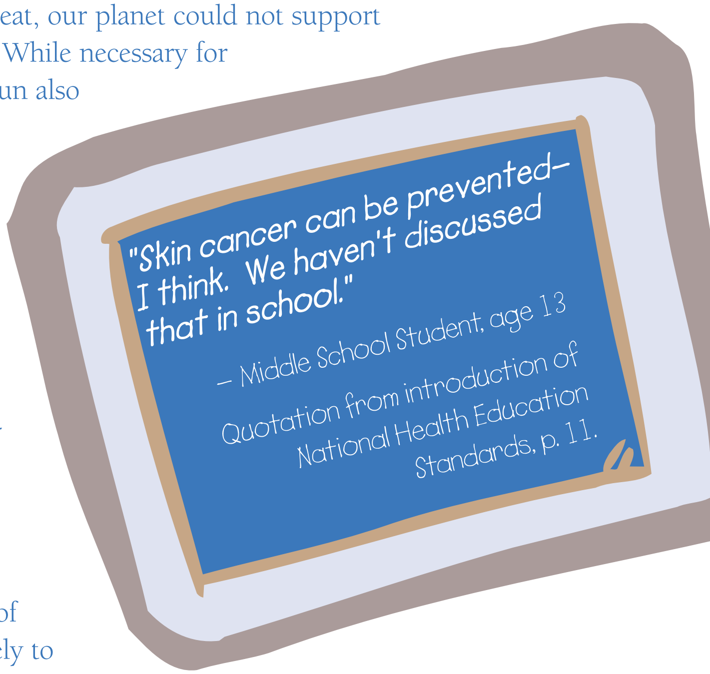
—Richard St. Barbe Baker

Introduction

Children spend lots of time outdoors during recess, physical education classes, after-school activities, and sports programs. While some exposure to sunlight can be enjoyable and healthy, too much can be dangerous. Overexposure to ultraviolet (UV) radiation can cause serious health effects, including skin cancer and other skin disorders, eye damage and cataracts, and immune system suppression. Currently, one in five Americans develops skin cancer during their lifetime. Every hour one person dies from this disease. The incidence of melanoma, the most serious type of skin cancer, is increasing faster than almost every form of cancer.[1]

You can make a difference! Children are of particular concern since most of the average person's lifetime sun exposure occurs before the age of 18. By educating ourselves and our children about UV-related health effects and the steps for sun protection, we can ensure a healthy future for the next generation.

Without the sun's light and heat, our planet could not support human, animal, or plant life. While necessary for our existence, however, the sun also can threaten our health with its UV radiation. UV radiation comes in several forms (i.e., UV-A, UV-B, and UV-C) that affect human health in different ways. In particular, we must protect ourselves from UV-A and UV-B, which penetrate the Earth's stratospheric ozone layer.



Due to the depletion of the ozone layer, increased levels of harmful UV radiation are likely to

[1] American Cancer Society, "Cancer Facts & Figures 1999."

reach the Earth. These heightened levels may cause the incidence and severity of UV-related health effects to rise, particularly given current sun-protection practices in the United States. Since the condition of the ozone layer is not expected to improve significantly until the middle of the 21st century, we need to change our sun behaviors now in order to protect our future health.

Many believe that only lighter-skinned people need to be concerned about the effects of overexposure to the sun. Though it is true that darker skin has more natural pigment, which acts as a protectant, the skin is still susceptible to many of the damaging effects of UV radiation. The incidence of skin cancer is lower in dark-skinned people, but it still occurs and is often not detected until later stages when it is more dangerous. The risk of other UV-related health effects, such as cataracts, premature aging of the skin, and immune suppression, is not dependent upon skin type.

The good news is that UV-related health effects are largely preventable by instituting sun-protection practices early and consistently. Schools and teachers can play a major role in protecting children by teaching sun safety behaviors.

To help educators raise sun safety awareness, the U.S. Environmental Protection Agency (EPA) has developed the SunWise School Program, a national education program for children in grades K through 8. SunWise Partner Schools sponsor classroom and schoolwide activities that raise children's awareness of stratospheric ozone depletion, UV radiation, and simple sun safety practices. SunWise is a collaborative effort of schools, communities, teachers, parents, health professionals, environmental

Skin cancer and other sun-related health effects are largely preventable.

groups, meteorologists, educational organizations, and others. With everyone's help, sun protection can grow beyond classrooms to the entire community.

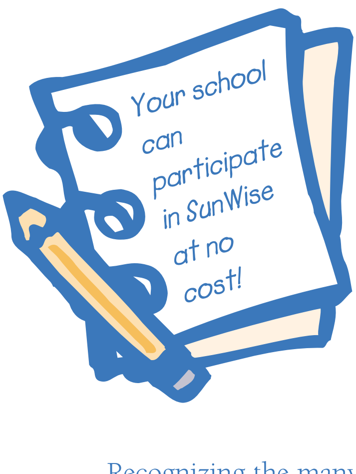
The SunWise School Program Guide is designed to provide school administrators, teachers, nurses, and other childhood caregivers with a general overview of SunWise and the components of the program. Additional brochures and fact sheets are available by calling EPA's Stratospheric Ozone Information Hotline at 800 296-1996 or by visiting the SunWise Web site at <www.epa.gov/sunwise>.

SunWise is intended to actively engage children in the learning process. Its dual focus on health and the environment will help children develop the skills necessary for sustained SunWise behavior and an appreciation for the environment around them.

The SunWise School Program

The SunWise School Program is an environmental and health education program that aims to teach children and their caregivers how to protect themselves from overexposure to the sun. Through the use of classroom-based, school-based, and community-based components, SunWise seeks to develop sustained sun-safe behaviors in schoolchildren.

The program's learning components build on a solid combination of traditional and innovative education practices already in use in many U.S. elementary and middle schools. Through the program, students and teachers will increase their awareness of simple steps they can take to protect themselves from overexposure to the sun. Students will demonstrate the ability to practice health-enhancing behaviors and reduce health risks. Children also will acquire scientific knowledge and develop an understanding of the environmental concepts related to sun protection.



The program encourages schools to provide a sun-safe infrastructure, including shade structures (e.g., canopies, trees) and policies (e.g., using hats, sunscreen, sunglasses) that promote sun protection in a school setting. Though based in schools, SunWise also supports community partnerships, such as inviting guest speakers to school assemblies, to enhance sun safety efforts.

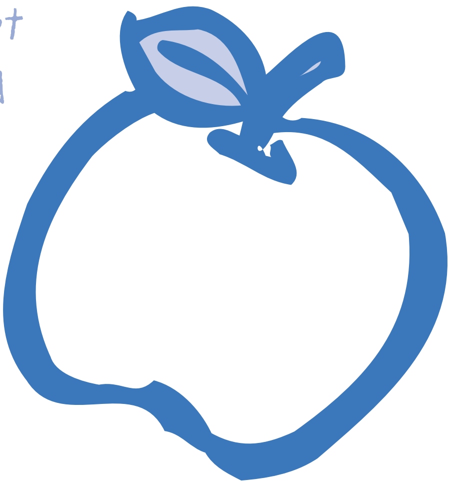
Recognizing the many issues schools are asked to address daily, SunWise has been developed with the needs of schools and educators in mind. The program is designed to provide maximum flexibility—elements can be used as stand-alone teaching tools or to complement existing school curricula. The time commitment necessary to implement SunWise is minimal, while the potential payoff in lower skin cancer rates—and other health benefits in the future—is high.

The SunWise School Program has been targeted for national implementation in the 2000-2001 school year. The components of the SunWise Program outlined below are available to Partner Schools free of charge.

SunWise School Program Components

Classroom	School	Community
✓ *SunWise Student Survey* ✓ Cross-Curricular Classroom Lessons ✓ Internet Learning, Including UV Measurement and Reporting ✓ Evaluation of SunWise School Program	✓ Suggestions for Infrastructure Enhancements (e.g., sun-safe policies and structures) ✓ Ideas for School-Based Sun Safety Activities (e.g., school assemblies) ✓ Evaluation of SunWise School Program	✓ Suggestions for Community Partnerships (e.g., guest speakers and business partnerships)

SunWise Lessons meet national science and health education standards.



How Do We Become a SunWise Partner School?

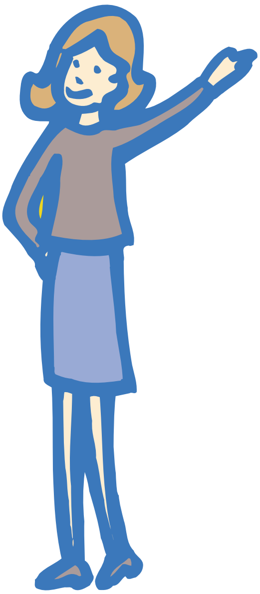
Becoming a SunWise Partner School is easy! Any elementary or middle school in the United States may participate in the SunWise School Program. A single classroom, multiple classrooms, a school, or an entire school district may join. To become a SunWise Partner School, you must:

1. **Register as a SunWise Partner School.** Educators are asked to complete the registration form located on the SunWise Web site at <www.epa.gov/ sunwise>. Printed copies also can be downloaded from the Web site. A hard copy can be found in the middle of this guide as well. EPA knows the registration form requires a substantial amount of information and appreciates your efforts to fill it out as completely as possible.

2. **A random sample of participants will be asked to complete the *SunWise Student Survey* before and after implementation of SunWise Activities.** This simple, 10-minute questionnaire, developed by Boston University's Skin Cancer Prevention Team, elicits basic information on attitudes and practices of children relating to sun exposure. This survey will provide information for evaluation purposes only. All personal information will remain confidential.

3. **Adopt at least one of the following supplemental SunWise Activities:**
   - ✓ Cross-curricular classroom lessons.
   - ✓ UV measurement and reporting on the Internet.
   - ✓ School infrastructure enhancements (school policy changes and/or sun-protection structures).
   - ✓ Community outreach (inviting guest speakers and forming business partnerships).

What Tools Are Available to SunWise Partner Schools?



Based on the activities you choose, you will receive, free of charge, materials and tools to help you implement SunWise in your classroom or school.

✓ SunWise Tool Kit

A Tool Kit containing cross-curricular classroom lessons and background information for K through 8th grade learning levels is available to all SunWise Partner Schools. The Tool Kit consists of a variety of fun, developmentally appropriate activities that combine education about sun protection and the environment with other aspects of learning.

Information for schools interested in promoting sun protection through infrastructure enhancements also is available in the Tool Kit. These materials feature suggestions on reaching out to schools and families with sun safety policies, forming community partnerships, making structural changes, and organizing sun safety events. The Tool Kit also includes an extensive list of other sun-protection resources.

✓ SunWise Internet Learning Site and UV Database

In order to make the best use of innovative educational and information-sharing technologies, EPA developed an Internet Learning Site as part of its main SunWise Program Web site. An easy-to-use, interactive medium for children, the Internet Learning Site features drop-down lists, check boxes, radio buttons, and eye-catching icons. Students and teachers can use the site to:

- Report and interpret daily measurements of UV radiation.
- Participate in online, interactive educational activities.
- Locate additional resources on sun protection, health, and the environment.

Through the Internet Learning Site, students can enter daily UV data, weather conditions, and information regarding daily sun-protection practices. The students' UV measurements will consist of:

- Community-specific UV Index data derived from the National Weather Service Web site.
- Actual data obtained from hand-held UV monitoring devices (lent to schools by the SunWise Program).

Once schools register, teachers will receive secure IDs for entering daily UV data on the Internet Learning Site.

How Will SunWise Be Evaluated?

The SunWise School Program recognizes a particular challenge in measuring the effectiveness of its effort to create sustained SunWise behavior, especially given the latency period associated with the onset of UV-related health effects. Therefore, the careful and consistent evaluation of program effectiveness through a variety of interim measurements—including input from educators and students—is integral to SunWise's success. In addition to the *SunWise Student Survey*, EPA plans to utilize other voluntary evaluation tools, including:

- ✓ **SunWise Parent Survey:** Research indicates that child behaviors are based, in large part, on modeling adult behaviors. If possible, randomly selected schools will ask parents to complete a simple, 10-minute take-home survey to identify their current sun safety practices and observed behavior of their children. (Note: Surveying is conducted for the sole purpose of evaluating the SunWise Program to help improve its messages and approaches. All personal information will remain anonymous and confidential.)
- ✓ **Teacher Evaluation of Classroom Activities:** Teachers will be asked to evaluate student receptivity to sun safety lessons and Internet learning. Teacher feedback about the usefulness of classroom and school materials will be vital to the refinement of sun safety education materials.
- ✓ **Teacher and School Administrator Evaluation of Infrastructure Improvements:** Teachers and school administrators will be asked to evaluate the practicality and success of proposed sun-protection policy changes, infrastructure enhancements, and the SunWise Program as a whole.

Why Should Schools Participate in SunWise?

Being a part of SunWise is a fun, easy, and effective way to protect the health of the children in your school. SunWise is a national education program designed to teach children not only about the health effects of overexposure to UV radiation and how to avoid them, but also about the environmental effects of ozone depletion. The program focuses on the whole spectrum of health effects, including skin cancer, eye damage, and other illnesses, and is appropriate for diverse school populations nationwide. Though based in schools, SunWise also encourages a sustained connection between schools and their communities. By participating in SunWise, children will enhance their creativity, critical thinking, data collection, reading, problem solving, decision-making, and communication skills.

EPA is currently exploring options for recognition incentives (e.g., stickers, bookmarks, water bottles, and more). Teachers also will receive a certificate acknowledging their accomplishment. Finally, the possibility of a *SunWise Helios Award for Sun-Protection Education* is currently being explored. This award would recognize innovative and exemplary efforts in the area of sun-protection education. Stay tuned for more information about this exciting possibility!

Be SunWise: Action Steps for Sun Protection

The SunWise School Program has developed a set of action steps for sun protection that can be used in the classroom, on the playground, or elsewhere to help reduce students' and adults' risk from UV radiation. With these steps, preventing overexposure to the sun is simple. You and your students should always take the following precautions:

✓ **Limit time in the midday sun.** The sun's UV rays are the strongest between 10 a.m. and 4 p.m. To the extent possible, limit exposure to the sun during these hours.

✓ **Watch for the UV Index.** This important resource helps you plan your outdoor activities in ways that prevent overexposure to the sun's rays. Developed by the National Weather Service and EPA, the UV Index is issued daily in selected cities across the country. The UV Index uses numbers to represent the likely level of UV exposure (Minimal: 0-2; Low: 3-4; Moderate: 5-6; High: 7-9; Very High: 10+). While you should always take precautions against overexposure, take special care to adopt sun safety practices when the UV Index predicts exposure levels of moderate or above.

✓ **Use shade wisely.** Seek shade when UV rays are the most intense, but keep in mind that shade structures (e.g., trees, umbrellas, canopies) do not offer complete sun protection. Students can easily remember the shadow rule: "Watch Your Shadow—No Shadow, Seek Shade!"[2]

✓ **Wear protective clothing.** A hat with a wide brim offers good sun protection for your eyes, ears, face, and the back of your neck.

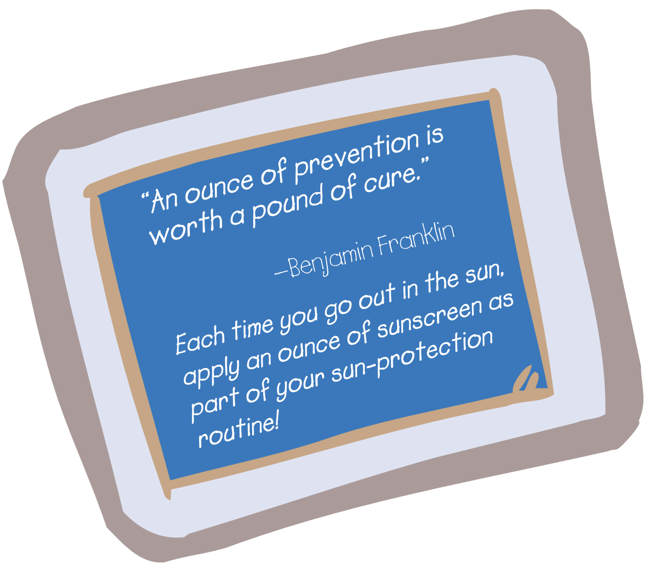
[2] Downham, T.F., "The shadow rule: A simple method for sun protection." In *Journal of the Southern Medical Association*, July 1998, 91:7, 619-623.

Sunglasses that provide 99 to 100 percent UV-A and UV-B protection will greatly reduce eye damage from sun exposure. Wrap-around sunglasses provide the most protection. Tightly woven, loose fitting clothes will provide additional protection from the sun.

✓ **Use sunscreen.** Apply a broad-spectrum sunscreen of SPF 15+ liberally and reapply every 2 hours, or after working, swimming, playing, or exercising outdoors.

✓ **Avoid sunlamps and tanning booths.** The light source from sunbeds and sun lamps damages the skin and unprotected eyes and is best avoided entirely.

Remember, everyday exposure counts! You don't have to be actively sunbathing to get a damaging dose of the sun—take care even when having lunch outside, going on school field trips, taking part in after-school activities, or participating in sports programs. Inform your friends and family about these simple sun safety steps. You could save a life!



Acknowledgments

The SunWise School Program would like to thank the many teachers, parents, communities, health professionals, educators, meteorologists, nonprofit organizations, environmental groups, scientists, and others who have helped make the SunWise vision a reality. Your commitment, energy, and dedication are truly remarkable, and the SunWise School Program sincerely appreciates your valuable efforts.

The SunWise School Program is one of several EPA EMPACT projects. SunWise would like to thank the EMPACT Program for its support and assistance. For information about the EMPACT Program, please call 202 564-6791 or visit the Web site at <www.epa.gov/empact>.

For More Information

For more information about EPA's SunWise School Program or sun protection, please contact any member of the SunWise staff (listed below) or visit the SunWise Web site at <www.epa.gov/sunwise>.

Maura Cantor, Director
Phone: 202 564-9096
E-mail: cantor.maura@epa.gov

Linda Rutsch, Schools Coordinator
Phone: 202 564-2261
E-mail: rutsch.linda@epa.gov

Kelly Davis, Web Manager
Phone: 202 564-2303
E-mail: davis.kelly@epa.gov

Kevin Rosseel, Communications Manager
Phone: 202 564-9731
E-mail: rosseel.kevin@epa.gov

Kristin Kenausis, Education Coordinator
Phone: 202 564-2289
E-mail: kenausis.kristin@epa.gov

Mailing address for all staff:

U.S. EPA/SunWise School Program
1200 Pennsylvania Avenue, NW. (6205J)
Washington, DC 20460

For courier or overnight deliveries, please send to:

U.S. EPA/SunWise School Program
501 3rd Street, NW.
Washington, DC 20001

Additional Sun-Protection Resources

Please contact the following organizations for additional information on sun protection:

American Academy of Dermatology
930 North Meacham Road
P.O. Box 4014
Schaumburg, IL 60173-4965
888 462-DERM (462-3376)
www.aad.org

American Cancer Society
1599 Clifton Road, NE.
Atlanta, GA 30329-4251
800 ACS-2345 (227-2345)
www.cancer.org

Boston University Medical Center
Skin Oncology, Cancer Prevention & Control Center
720 Harrison Avenue, DOB-801A
Boston, MA 02118
617 638-7131

Centers for Disease Control and Prevention
Division of Cancer Prevention and Control
4770 Buford Highway
Chamblee, GA 30341
770 488-4751
www.cdc.gov/cancer

National Association of Physicians for the Environment
6410 Rockledge Drive, Suite 412
Bethesda, MD 20817-1809
301 571-9790
www.napenet.org

National Safety Council
Environmental Health Center
1025 Connecticut Avenue, NW.
Suite 1200
Washington, DC 20036
800 557-2366 #2
www.nsc.org/ehc/sunsafe.htm

The Skin Cancer Foundation
245 Fifth Avenue
Suite 1403
New York, NY 10016
212 725-5176
www.skincancer.org

EPA
United States
Environmental Protection Agency
(6205J)
Washington, DC 20460

The completed registration form
can be mailed or faxed to:

Linda Rutsch
SunWise School Program
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW. (6205J)
Washington, DC 20460

Fax Number: 202 565-2065

Fold Here

Mailing Instructions

Carefully remove the entire form from the booklet and fold it as indicated above, with the address visible. To ensure the form remains folded during shipment, secure it with a piece of tape.
No postage is necessary.

SunWise School Program Identification

Please assign an identification name for each class that will be participating. **If you plan to register more than one class, please submit a separate registration form for each participating class.** You are free to pick any name, using numeric and/or alpha characters, but it should not exceed 6 characters. Upon receipt of this form, SunWise will provide you with a confirmation of your registration, as well as a computer-generated Class ID, which you will need for data entry purposes on the SunWise Internet Learning Site.

Identification Name ______________________________Number of Students in Class ____________________

Grade Level of Class_____________________

SunWise School Program Guide

Registration Form

Registering for the SunWise School Program is easy! Simply review the program requirements and the activities described on this form, then choose the activities in which you would like to participate. We'll send you everything you need. Please fill out this form completely and use the self-addressed cover to mail it back to EPA. You also can register through the SunWise Web site at <www.epa.gov/sunwise>. Thanks for your participation!

Participant Requirements

1. Complete and return this self-addressed form.
2. Adopt at least one of the SunWise activities described on this form.

Registration:

For 2000-2001 school year:
Registration opens **March 1, 2000** and closes **February 28, 2001.**

For 2001-2002 school year:
Registration opens **March 1, 2001** and closes **February 28, 2002.**

If you have any questions about this form or about SunWise, please call Linda Rutsch at 202 564-2261.

About Your School

School Name: ______________________________

Street Address: ______________________________

City: ____________________ State: __________ ZIP Code: __________

Web site address: ____________________ Phone: ____________________

Principal's Name: ______________________________

School District Name: ______________________________

Does Your School Have Videoconferencing Capability? ❑ Yes ❑ No

School Type: (check all that apply) ❑ Elementary ❑ Middle ❑ Grades 1-8 ❑ Other ❑ Year-Round School ❑ Public School ❑ Private School

Number of Students in School (Estimate): ______________

About Yourself

Name: ______________________________

E-mail: ____________________ Phone: ____________________

For what school year are you registering? ❑ 2000-2001 ❑ 2001-2002

Average Class Size: ❑ 1-15 ❑ 16-25 ❑ 26-30 ❑ 31+

Grades You Teach: ❑ K ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 ❑ 7 ❑ 8

Subjects You Teach: ❑ Science ❑ Math ❑ Health ❑ English ❑ Social Studies ❑ Physical Education ❑ Geography ❑ Other

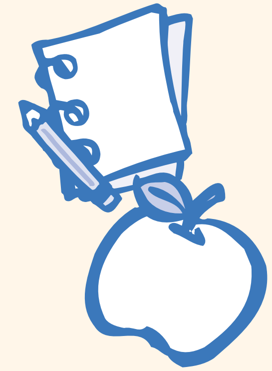
Have you taught or worked in the following areas (check all that apply)?

❑ Sun Protection ❑ Environmental Issues ❑ World Wide Web

SunWise Activities

Please indicate below which SunWise activities you would like to implement in your classroom or school. For more information on each activity, **see the descriptions below**. Please choose at least one activity but feel free to implement as many as you like. Remember, all materials and tools will be provided to you **free of charge**.

- Cross-Curricular Classroom Lessons ❑
- Reporting of the UV Index on the Internet Learning Site ❑
- Reporting of UV Ground Data (via Hand-Held Monitor) on the Internet Learning Site ❑
- Infrastructure Enhancements: Policy Changes ❑
- Infrastructure Enhancements: Shade Structures ❑
- Community Partnerships ❑
- Schoolwide Sun Safety Activities ❑



Cross-Curricular Classroom Lessons
A SunWise Tool Kit includes cross-curricular lessons that focus on UV radiation effects, risk factors for overexposure, and sun-protection habits. Activities are included for K-3rd, 4th-6th, and 7th-8th grade learning levels.

Reporting the UV Index or UV Ground Data on the Internet Learning Site
This interactive, easy-to-use EPA Web site is fun and colorful. Teachers and students can use the site to report and interpret daily UV data and weather conditions. EPA also lends hand-held UV monitoring devices to schools for data collection.

Infrastructure Enhancements—Policy Changes
Simple improvements such as rescheduling recesses during a time of day with lower UV radiation levels, or requiring students to wear hats, sunscreen, or eye protection, are described in the SunWise Tool Kit.

Infrastructure Enhancements—Shade Structures
Ideas for infrastructure improvements, such as the addition of trees, canopies, or other shade structures, are included in the Tool Kit, and EPA is available to advise participants.

Community Partnerships
Schools can work with local organizations, such as nurseries or television stations, to show students how sun safety practices extend beyond the classroom.

Schoolwide Sun Safety Activities
Classes can use SunWise Program knowledge to share sun safety messages with the whole school. Suggestions for schoolwide events are included in the Tool Kit.

¡MISIÓN SUNWISE:

Cómo te proteges del sol!

ACERCA DEL PROGRAMA ESCOLAR SUNWISE:

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- La Guía de Actividades SunWise – contiene una gran variedad de lecciones extra curriculares, actividades para la clase e información adicional para los niños de kinder a octavo grado.
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"¡Bienvenidos al club SunWise!", dijo Amy.

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"¡Nosotros nos divertimos mucho! Tenemos misiones y aventuras secretas, que cuando las terminamos obtenemos premios fabulosos", dijo Brian.

"¿Cuál es nuestra misión secreta de hoy?", preguntó Sam.

"Nuestra misión de hoy es ayudar a que Carlos y Lisa se protejan del sol y sigan con atención lo que el Club SunWise les dice, cuando ellos aprendan como protegerse del sol, obtendremos nuestro premio", dijo Amy.

"¿Por qué debo protegerme del sol?", preguntó Lisa.

"El Sol es una estrella", dijo Erin. "Ayuda mucho a las plantas y a los animales de la tierra".

"El Sol nos da luz para que podamos ver, nos mantiene calientitos y ayuda a que las plantas crezcan".

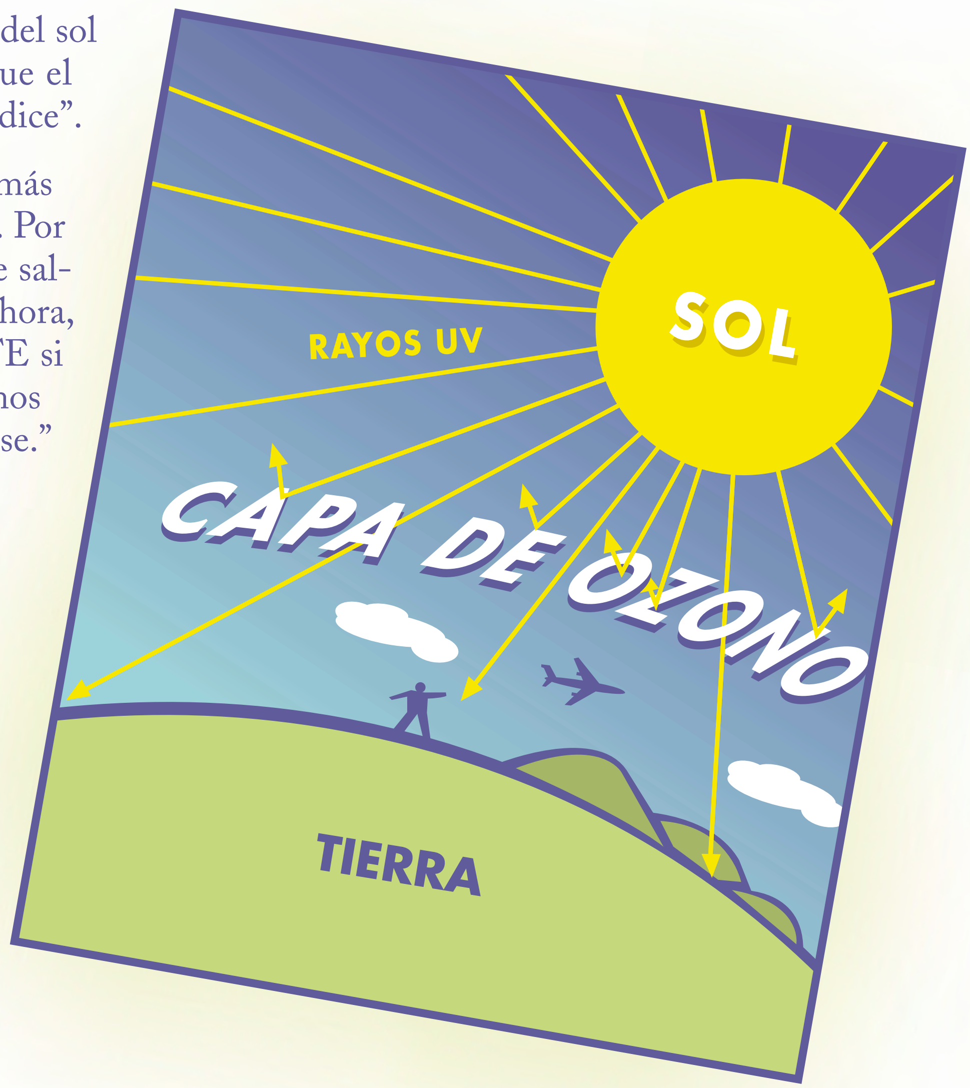
"Pero, si nos asoleamos mucho nos puede hacer daño, aunque el sol es muy importante para todos".

"Debemos protegernos de los rayos del sol llamados RAYOS ULTRAVIOLETA. Estos rayos también se llaman rayos UV".

“¡Claro!”, dijo Amy, “tú no puedes ver ni sentir los rayos UV, pero siempre están ahí, inclusive en los días nublados. Los rayos UV pueden lastimarte la piel y los ojos, sin importar que tu piel sea clara u oscura. Los rayos UV pueden hacerte mucho daño”.

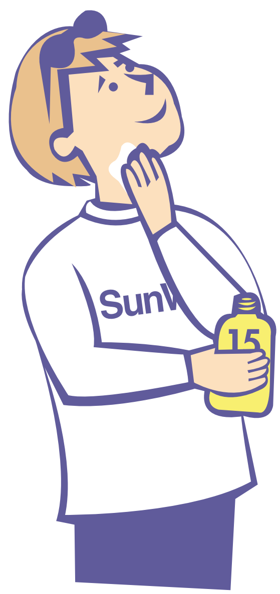
“El cielo tiene un escudo protector llamado la CAPA DE OZONO. Esta capa no deja que los rayos UV lleguen a la tierra. Se parece a un paraguas para la lluvia. Pero, la capa de ozono no puede bloquear todos los rayos UV. Por eso, es importante que nos protejamos del sol y que hagamos lo que el Club SunWise nos dice”.

“Los rayos UV son más fuertes al medio día. Por eso, no es bueno que salgamos a jugar a esa hora, ESPECIALMENTE si no hacemos lo que nos dice el Club SunWise.”



"OK" dijo Carlos, "ya sé por qué necesito protegerme del sol. Pero, ¿cómo hago lo que me dice el Club SunWise y cómo me protejo de los rayos UV?"

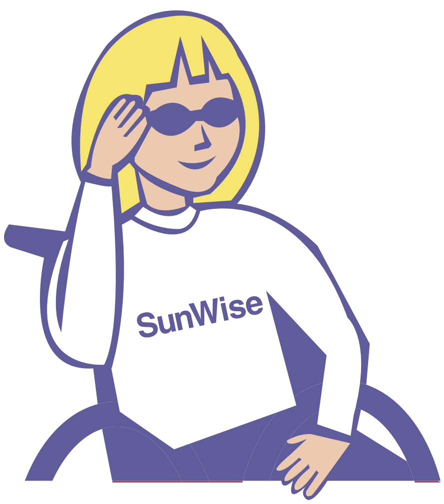
"¡Eso es muy fácil!", dijo Kelly. Todo lo que tienes que hacer es acordarte de lo siguiente: ¡PONTE UNA CAMISETA DE MANGA LARGA, PONTE PROTECTOR CONTRA EL SOL, PONTE UNA GORRA Y UNOS ANTEOJOS DE SOL,™ REVISA el índice de los rayos UV y JUEGA en la SOMBRA!"

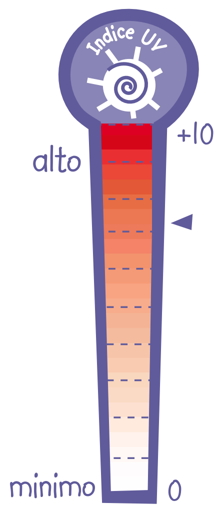


"PONTE una camiseta de manga larga y unos pantalones para que te cubra casí todo el cuerpo", dijo Sam.

"PONTE protector contra el sol que tenga un SPF de 15 o mayor que éste. Póntelo en la cara, brazos, piernas y en cualquier otra parte del cuerpo que quede al sol", dijo Brian. Y recuerda, "póntelo varias veces".

"PONTE la gorra más adecuada. Un buen sombrero te protegerá la cara, los oidos y el cuello de los rayos UV", dijo Erin.



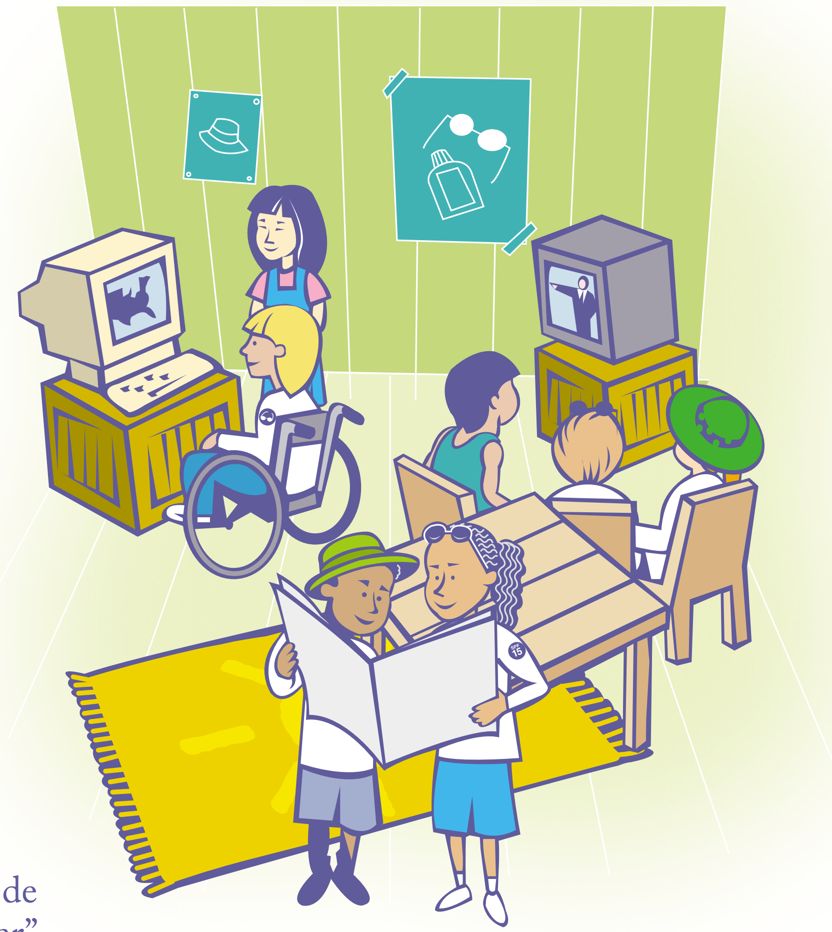


"PONTE unos gafas de sol. Los gafas de sol te protegen los ojos", dijo Kelly.

"!CHEQUEA el índice UV, ya que te mostraremos como hacerlo! El índice UV te indica la intensidad de los rayos UV para el día", dijo Sam.

"Y JUEGA en la SOMBRA. Si estás en la sombra, estarás protegido de los rayos ultravioleta", dijo Brian.

"Si sigues cada uno de los pasos del Club SunWise te ganarás una insignia. Si te ganas varias podrás entrar a nuestro club", dijo Kelly. "¡Nosotros te ayudaremos!"



"Debemos revisar el índice UV antes de que salgamos a jugar", dijo Brian.

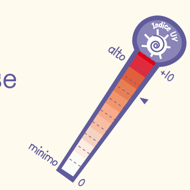
"¿Qué es el índice UV?", preguntó Lisa.

"El índice UV es una predicción de la intensidad de los rayos UV. Así como podemos predecir si va a llover o a nevar, también podremos saber la intensidad de los rayos UV. El índice UV se mide en una escala de 0 a 10+. Entre más alto es el número, más fuerte son los rayos solares que caen sobre la tierra y por eso tenemos que protegernos más del sol", dijo Amy.

EL ÍNDICE UV

Número del Índice	Nivel de Exposición
0-2	Mínimo
3-4	Bajo
5-6	Moderado
7-9	Alto
10+	Muy alto

Entre más alto sea el índice ultravioleta, la necesidad de protegerse y de seguir los pasos del Club SunWise es más importante.



"Puedes encontrar el índice UV en muchos lugares. Está en la sección del estado del tiempo del periódico y también en los informes del tiempo que se anuncian por la televisión y la radio. Si visitas la página Web del Club SunWise www.epa.gov/sunwise podrás encontrarlo allí también".

"Si chequeas el índice UV todos los días, te ganarás una insignia del Club SunWise", agregó Brian.

"¿Qué tal si me pongo ésto?", preguntó Carlos. "¿Me protegerá del sol como dice el Club SunWise?"

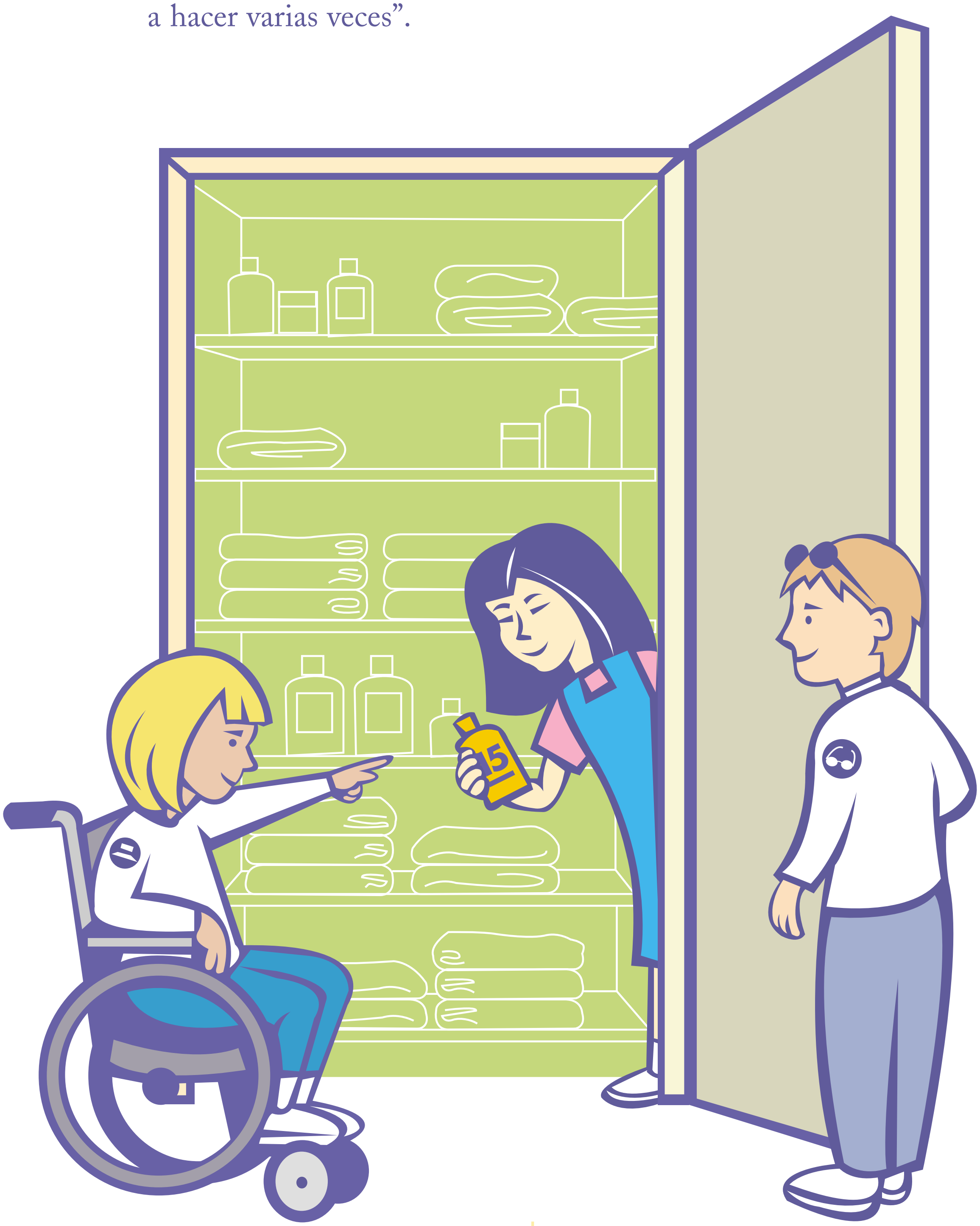
"Está bien", dijo Amy, "pero ÉSTA es mucho mejor".

Recuerda, para que sigas los pasos del Club SunWise, debes cubrirte la mayor parte del cuerpo. ¿Qué otra clase de ropa es la más adecuada?

"Es hora de PONERTE protector contra el sol", dijo Kelly.

"¡Aquí está el que mi mamá usa!. ¿Qué indica el número 15?", preguntó Lisa.

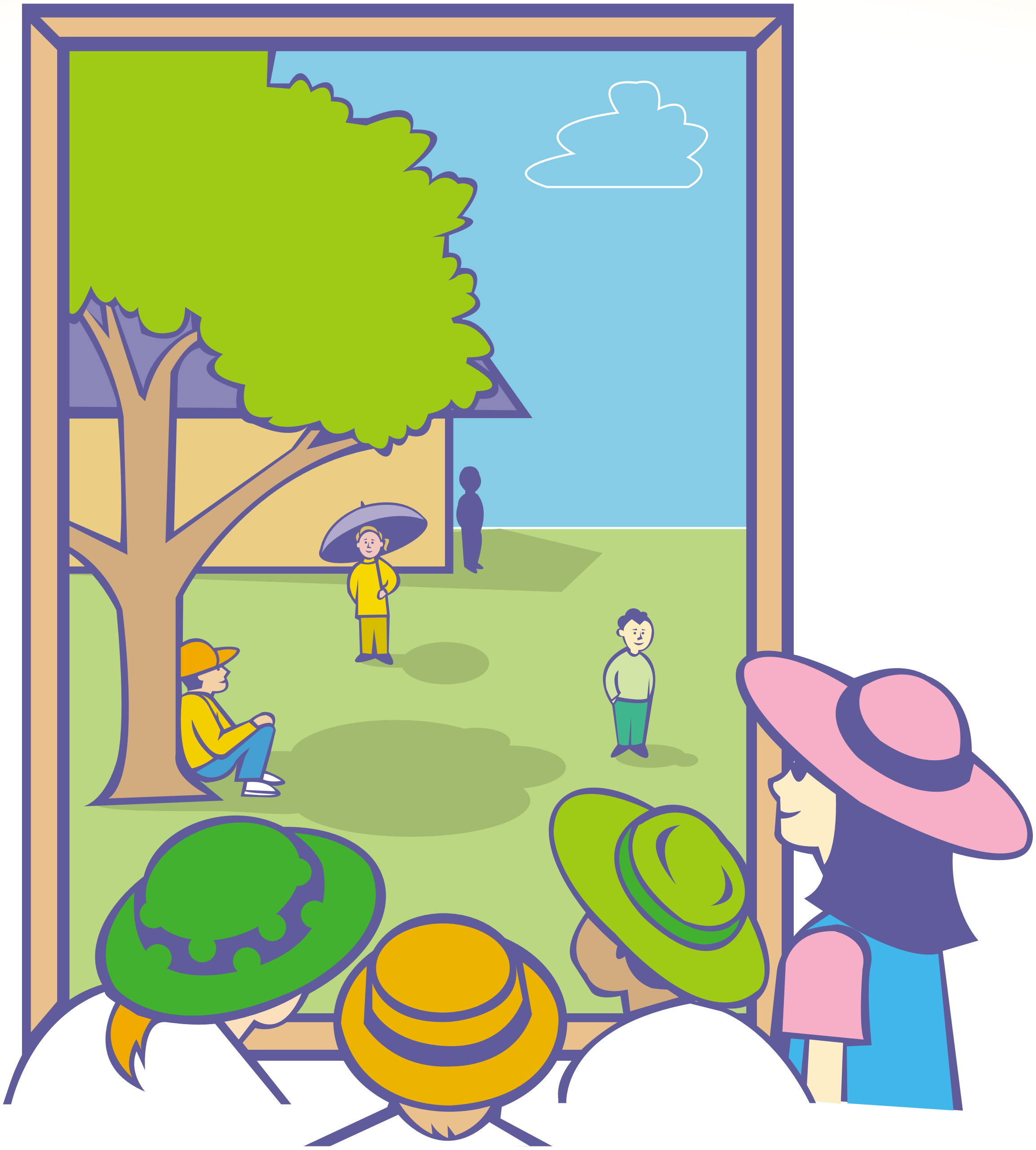
"Los números que aparecen en el protector te indican la protección que esta crema te dará. Siempre debes usar un protector número 15 o más alto. El protector que te PONGAS te ayudará a cuidarte la piel de los rayos UV", dijo Sam. "Recuerda, tienes que PONERTE bastante y volverlo a hacer varias veces".



"Es hora de PONERTE una gorra y unos gafas de sol. ¿Qué clase de gorra me debo poner?", preguntó Carlos.

"Escoge una gorra que te cubra la cabeza, la cara y el cuello del sol", dijo Kelly.

¿Cuál gorra crees tú que es la más apropiada?



"Trata de jugar en la sombra cuando estés afuera", dijo Sam.

"¿Sabes una forma de indicar si los rayos del sol son muy fuertes?", preguntó Kelly. "Es cuando tu sombra es más pequeña que tu cuerpo".

"¿Puedes encontrar las partes sombreadas de este dibujo?", preguntó Erin. Puedes ganarte una insignia si las encuentras todas".

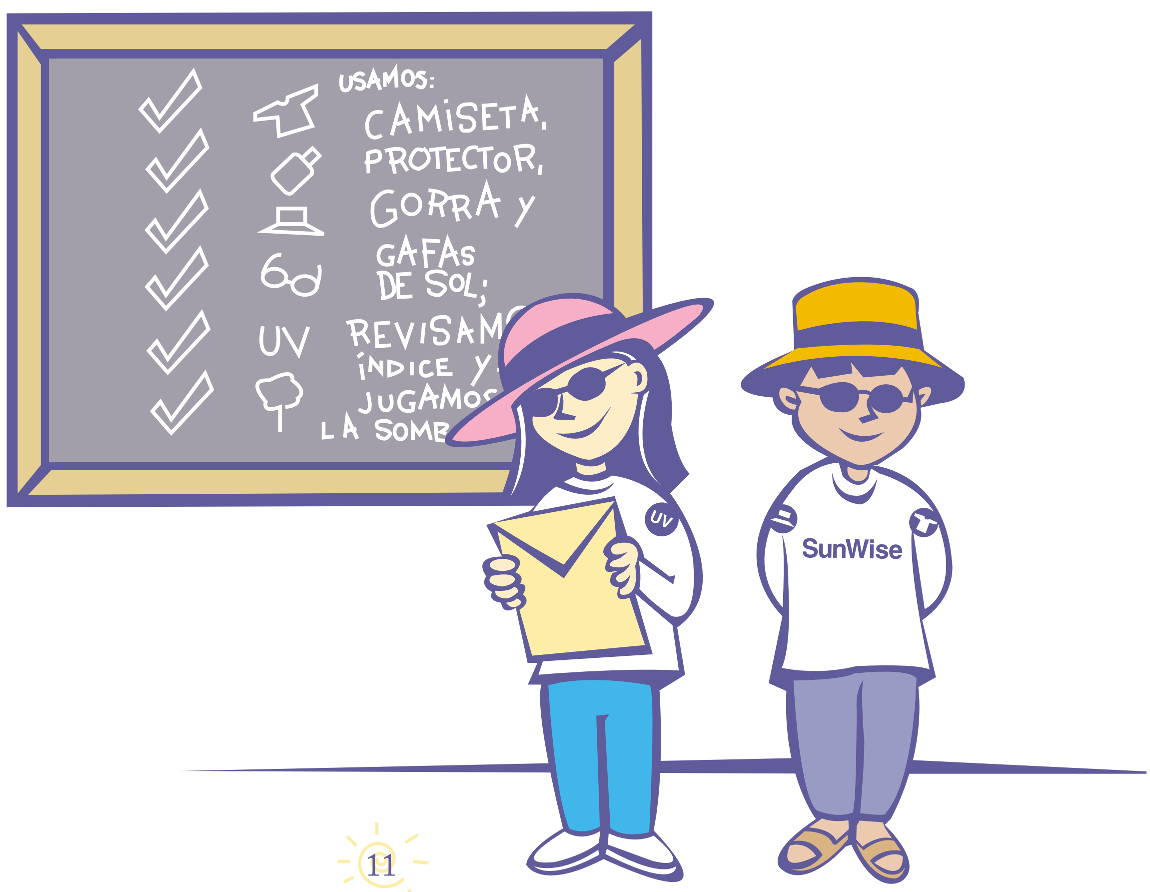
“OK, Lisa y Carlos, ¿cómo han seguido los pasos del Club SunWise? ¿cuántas insignias han ganado?”, preguntó Brian.

“¡Cada uno ganó 6 insignias!”, dijo Lisa.

- “Nos PUSIMOS camisetas de manga larga y pantalones,
- nos PUSIMOS protector contra el sol,
- nos PUSIMOS gorras que nos cubrieron la cara y el cuello,
- nos PUSIMOS unos gafas de sol,
- CHEQUEAMOS el índice UV y
- JUGAMOS en la sombra”.

“Ya sabemos como protegernos del sol y hacemos lo que el Club SunWise nos dice”, dijo Carlos.

“¡Y terminamos nuestra misión secreta!”, dijo Amy. “Me pregunto ¿cuál será nuestro premio?”



"Nuestro premio es: ¡Un paseo al parque de diversiones!", dijo Amy.

"¡Lisa y Carlos!: Bienvenidos al Club SunWise", dijo Erin.

"¡Gracias!", dijeron Lisa y Carlos.

"Todos los niños pueden unirse al Club SunWise. Lo único que tienes que hacer es protegerte del sol y hacer lo que el Club SunWise te dice", dijo Brian.

"Recuerda: ¡Ponte una camiseta de manga larga, ¡ponte protector, ¡ponte una gorra y unos gafas de sol,™ ¡chequea el índice UV y juega en la sombra!", dijo Sam.

El Programa Escolar SunWise quisiera agradecerle a la Asociación Americana del Cancer (American Cancer Society) por su constante apoyo y por permitirnos usar su lema SLIP! SLOP! SLAP! WRAP!™

SLIP! SLOP! SLAP! WRAP!™ es un lema registrado por la American Cancer Society, Inc.

United States
Environmental Protection
Agency

Air and Radiation
(6205J)

EPA 430-K-01-006
April 2001
www.epa.gov/sunwise

EPA

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Este librito le presenta al niño conceptos básicos acerca del sol y lo que debe hacer para protegerse de éste. A los niños les encantará formar parte del Club SunWise ya que podrán mostrarles a sus amigos lo que deben hacer para protegerse del sol.

La ¡Misión SunWise! cuyos libros para colorear y de actividades forman parte del Programa Escolar SunWise sin costo alguno para niños pequeños, de la Agencia Federal de Protección Ambiental. Para mayor información sobre el Club SunWise visite nuestra página Web www.epa.gov/sunwise.

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"¡Nosotros nos divertimos mucho! Tenemos misiones y aventuras secretas, que cuando las terminamos obtenemos premios fabulosos", dijo Brian.

"¿Cuál es nuestra misión secreta de hoy?", preguntó Sam.

"Nuestra misión de hoy es ayudar a que Carlos y Lisa se protejan del sol y sigan con atención lo que el Club SunWise les dice, cuando ellos aprendan como protegerse del sol, obtendremos nuestro premio", dijo Amy.

"¿Por qué debo protegerme del sol?", preguntó Lisa.

"El Sol es una estrella", dijo Erin. "Ayuda mucho a las plantas y a los animales de la tierra".

"El Sol nos da luz para que podamos ver, nos mantiene calientitos y ayuda a que las plantas crezcan".

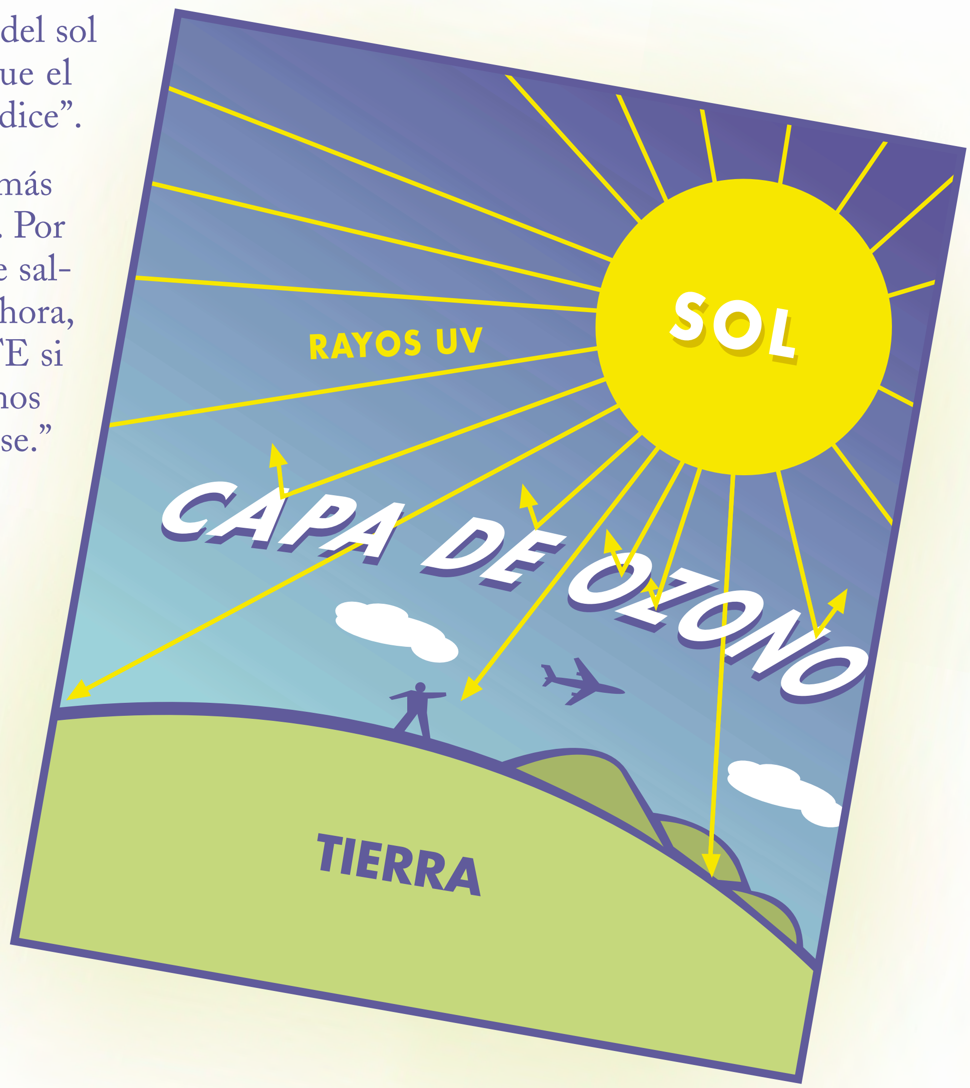
"Pero, si nos asoleamos mucho nos puede hacer daño, aunque el sol es muy importante para todos".

"Debemos protegernos de los rayos del sol llamados RAYOS ULTRAVIOLETA. Estos rayos también se llaman rayos UV".

“¡Claro!”, dijo Amy, “tú no puedes ver ni sentir los rayos UV, pero siempre están ahí, inclusive en los días nublados. Los rayos UV pueden lastimarte la piel y los ojos, sin importar que tu piel sea clara u oscura. Los rayos UV pueden hacerte mucho daño”.

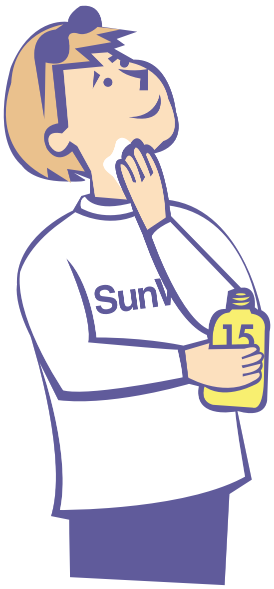
“El cielo tiene un escudo protector llamado la CAPA DE OZONO. Esta capa no deja que los rayos UV lleguen a la tierra. Se parece a un paraguas para la lluvia. Pero, la capa de ozono no puede bloquear todos los rayos UV. Por eso, es importante que nos protejamos del sol y que hagamos lo que el Club SunWise nos dice”.

“Los rayos UV son más fuertes al medio día. Por eso, no es bueno que salgamos a jugar a esa hora, ESPECIALMENTE si no hacemos lo que nos dice el Club SunWise.”



"OK" dijo Carlos, "ya sé por qué necesito protegerme del sol. Pero, ¿cómo hago lo que me dice el Club SunWise y cómo me protejo de los rayos UV?"

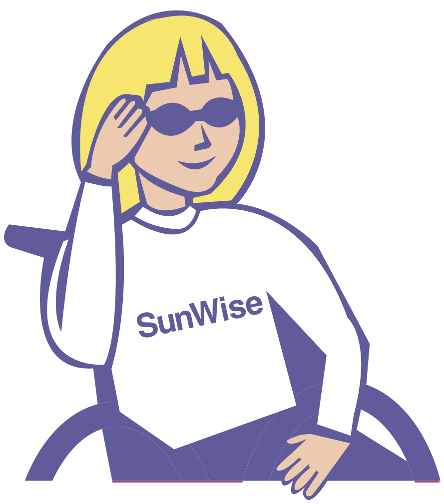
"¡Eso es muy fácil!", dijo Kelly. Todo lo que tienes que hacer es acordarte de lo siguiente: ¡PONTE UNA CAMISETA DE MANGA LARGA, PONTE PROTECTOR CONTRA EL SOL, PONTE UNA GORRA Y UNOS ANTEOJOS DE SOL,™ REVISA el índice de los rayos UV y JUEGA en la SOMBRA!"

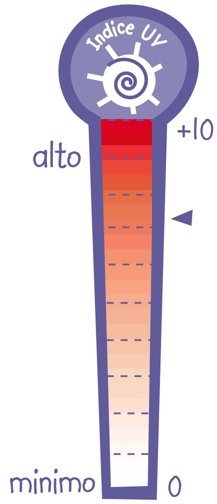


"PONTE una camiseta de manga larga y unos pantalones para que te cubra casí todo el cuerpo", dijo Sam.

"PONTE protector contra el sol que tenga un SPF de 15 o mayor que éste. Póntelo en la cara, brazos, piernas y en cualquier otra parte del cuerpo que quede al sol", dijo Brian. Y recuerda, "póntelo varias veces".

"PONTE la gorra más adecuada. Un buen sombrero te protegerá la cara, los oidos y el cuello de los rayos UV", dijo Erin.



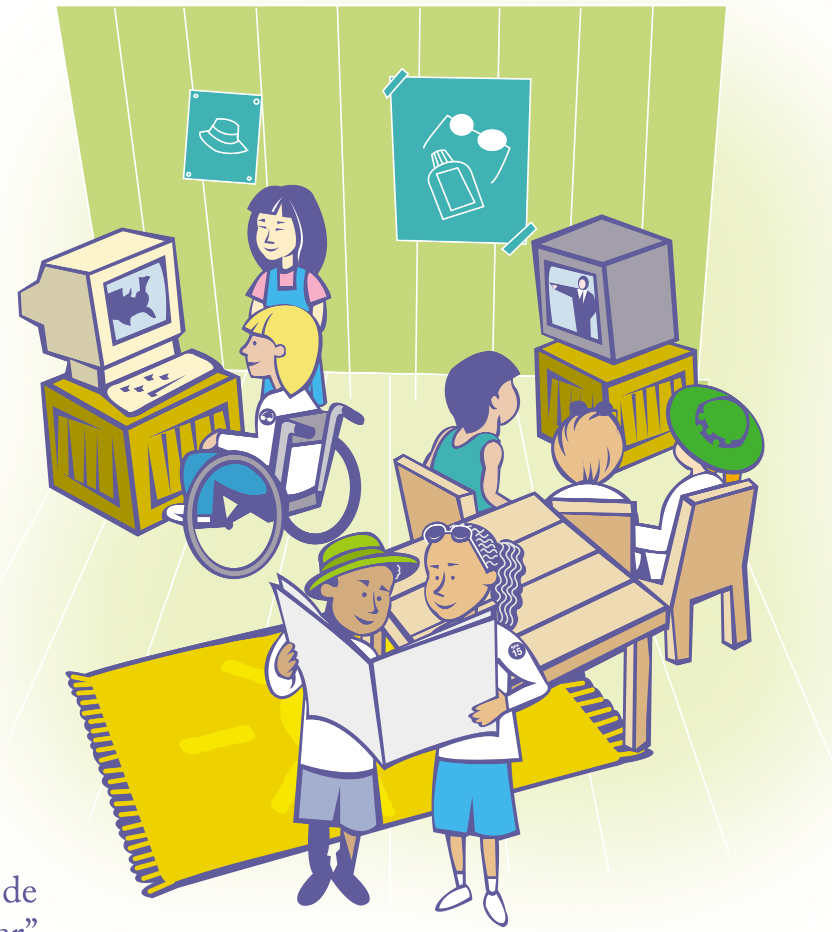


"PONTE unos gafas de sol. Los gafas de sol te protegen los ojos", dijo Kelly.

"!CHEQUEA el índice UV, ya que te mostraremos como hacerlo! El índice UV te indica la intensidad de los rayos UV para el día", dijo Sam.

"Y JUEGA en la SOMBRA. Si estás en la sombra, estarás protegido de los rayos ultravioleta", dijo Brian.

"Si sigues cada uno de los pasos del Club SunWise te ganarás una insignia. Si te ganas varias podrás entrar a nuestro club", dijo Kelly. "¡Nosotros te ayudaremos!"



"Debemos revisar el índice UV antes de que salgamos a jugar", dijo Brian.

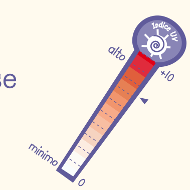
"¿Qué es el índice UV?", preguntó Lisa.

"El índice UV es una predicción de la intensidad de los rayos UV. Así como podemos predecir si va a llover o a nevar, también podremos saber la intensidad de los rayos UV. El índice UV se mide en una escala de 0 a 10+. Entre más alto es el número, más fuerte son los rayos solares que caen sobre la tierra y por eso tenemos que protegernos más del sol", dijo Amy.

EL ÍNDICE UV

Número del Índice	Nivel de Exposición
0-2	Mínimo
3-4	Bajo
5-6	Moderado
7-9	Alto
10+	Muy alto

Entre más alto sea el índice ultravioleta, la necesidad de protegerse y de seguir los pasos del Club SunWise es más importante.



"Puedes encontrar el índice UV en muchos lugares. Está en la sección del estado del tiempo del periódico y también en los informes del tiempo que se anuncian por la televisión y la radio. Si visitas la página Web del Club SunWise www.epa.gov/sunwise podrás encontrarlo allí también".

"Si chequeas el índice UV todos los días, te ganarás una insignia del Club SunWise", agregó Brian.

"¿Qué tal si me pongo ésto?", preguntó Carlos. "¿Me protegerá del sol como dice el Club SunWise?"

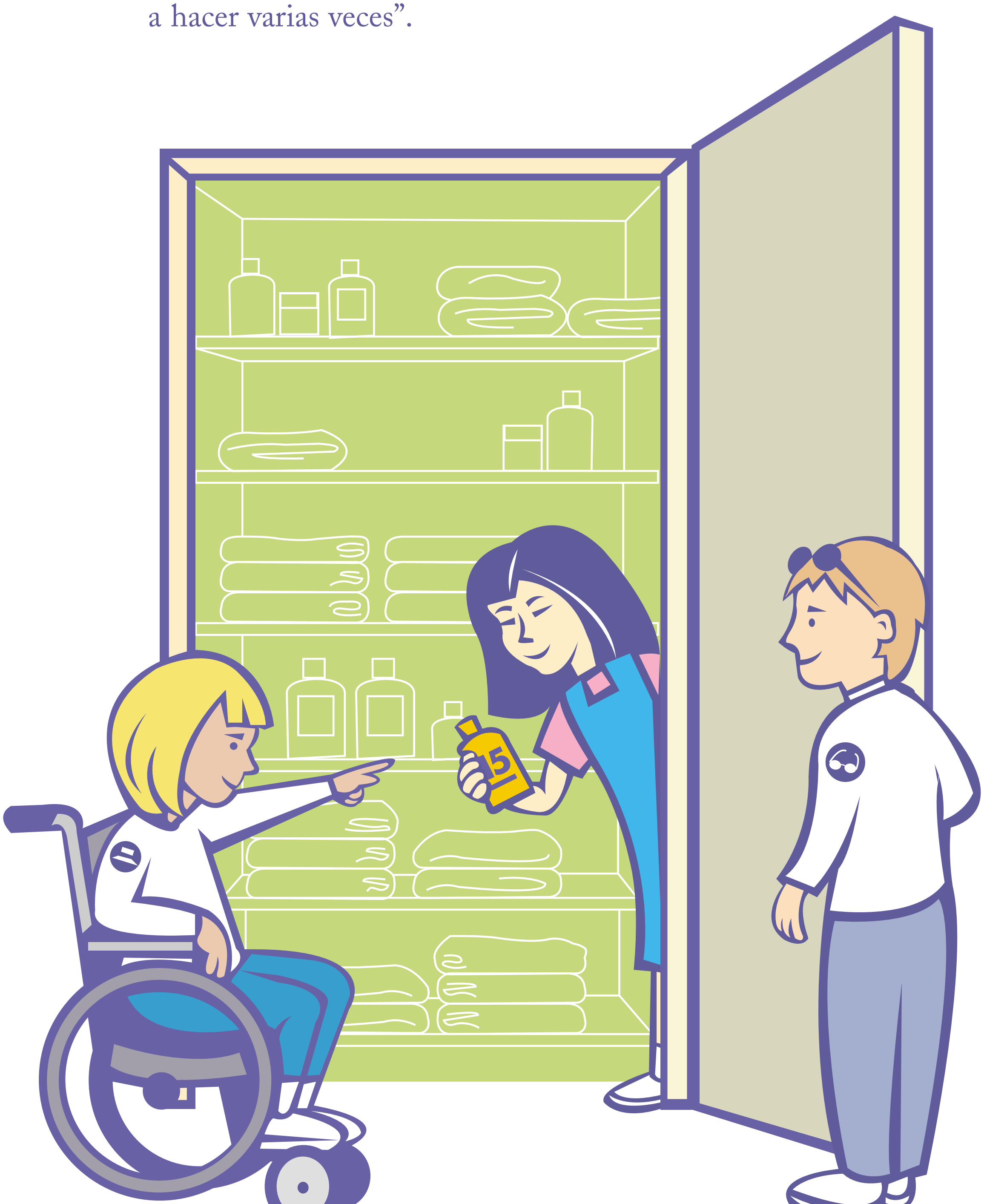
"Está bien", dijo Amy, "pero ÉSTA es mucho mejor".

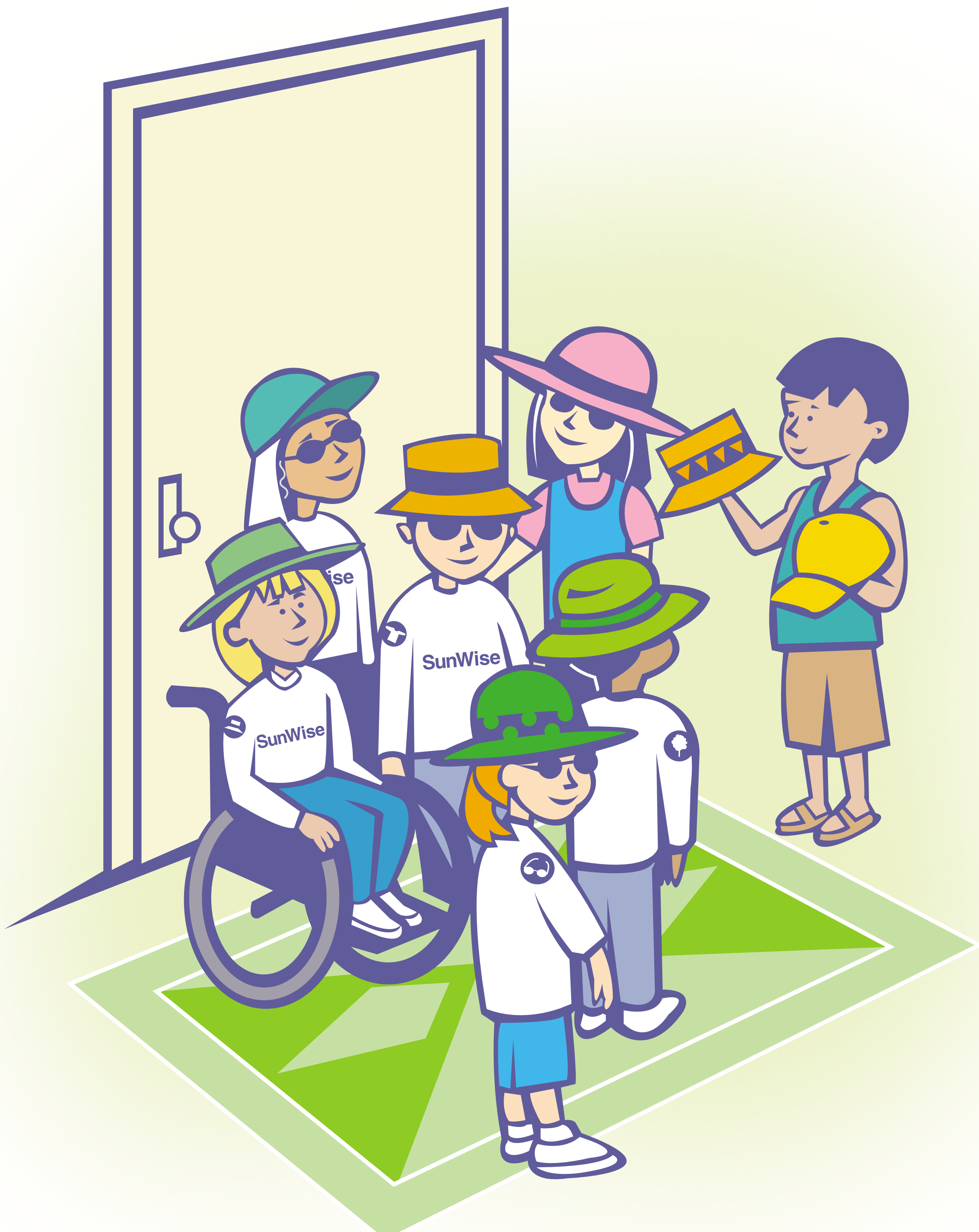
Recuerda, para que sigas los pasos del Club SunWise, debes cubrirte la mayor parte del cuerpo. ¿Qué otra clase de ropa es la más adecuada?

“Es hora de PONERTE protector contra el sol”, dijo Kelly.

“¡Aquí está el que mi mamá usa!. ¿Qué indica el número 15?”, preguntó Lisa.

“Los números que aparecen en el protector te indican la protección que esta crema te dará. Siempre debes usar un protector número 15 o más alto. El protector que te PONGAS te ayudará a cuidarte la piel de los rayos UV”, dijo Sam. “Recuerda, tienes que PONERTE bastante y volverlo a hacer varias veces”.

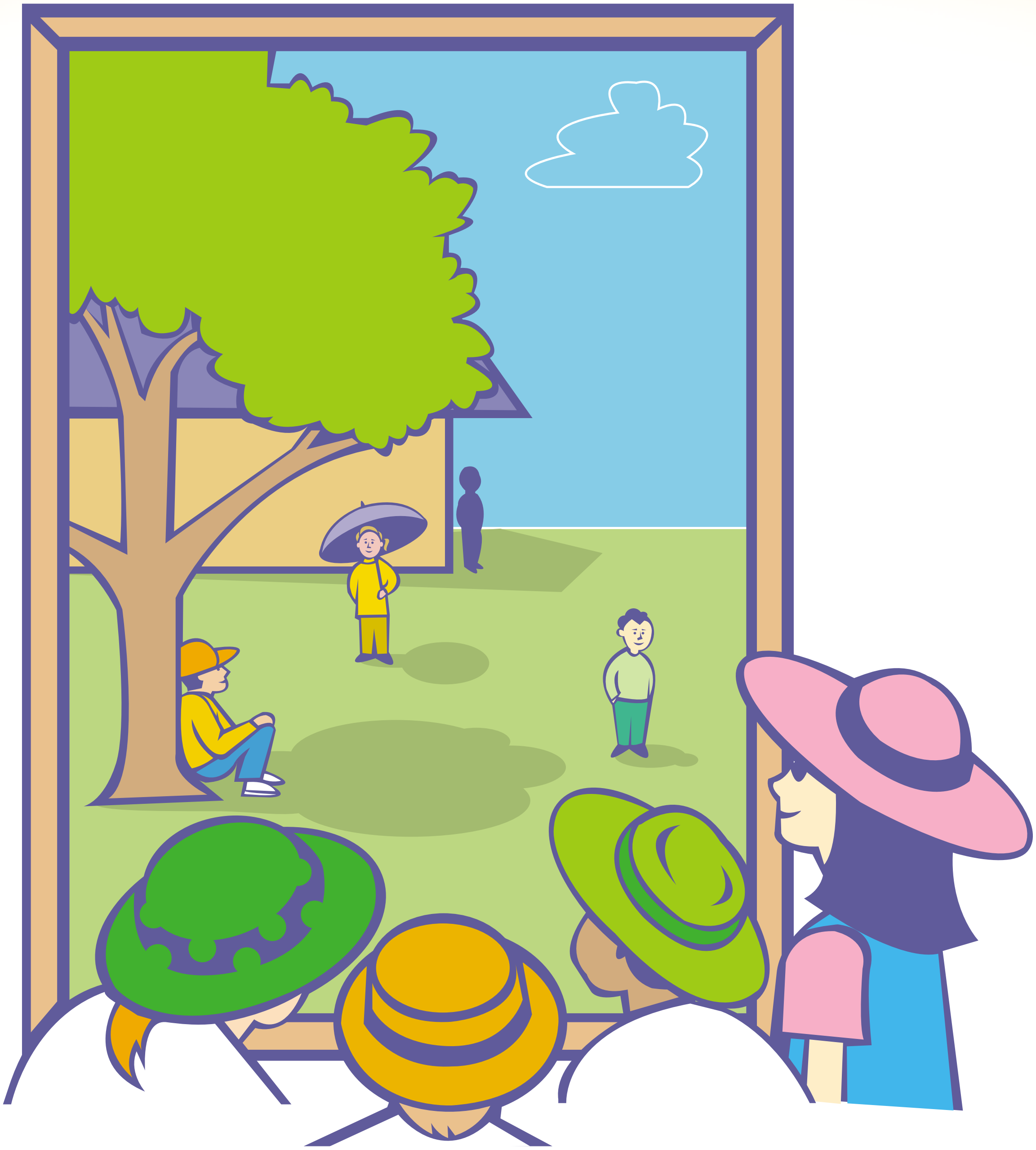




"Es hora de PONERTE una gorra y unos gafas de sol. ¿Qué clase de gorra me debo poner?", preguntó Carlos.

"Escoge una gorra que te cubra la cabeza, la cara y el cuello del sol", dijo Kelly.

¿Cuál gorra crees tú que es la más apropiada?



"Trata de jugar en la sombra cuando estés afuera", dijo Sam.

"¿Sabes una forma de indicar si los rayos del sol son muy fuertes?", preguntó Kelly. "Es cuando tu sombra es más pequeña que tu cuerpo".

"¿Puedes encontrar las partes sombreadas de este dibujo?", preguntó Erin. Puedes ganarte una insignia si las encuentras todas".

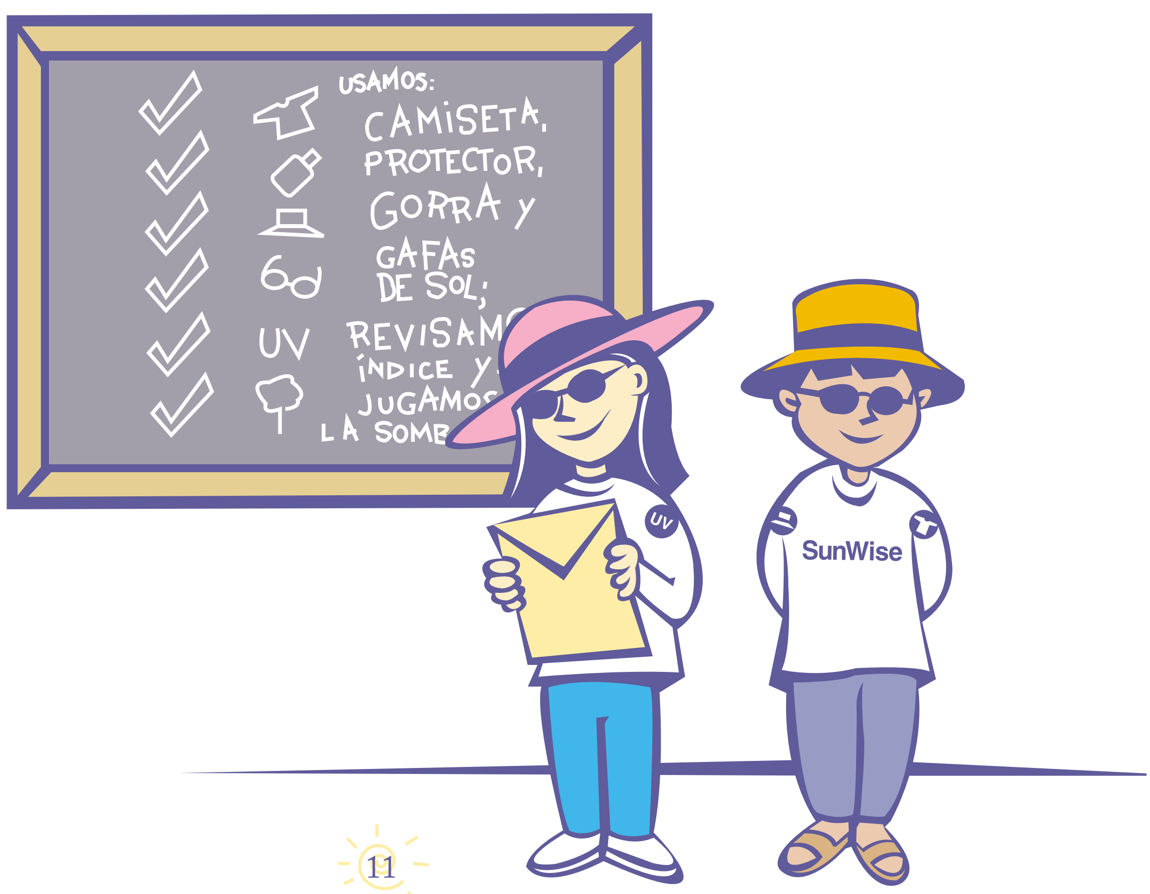
"OK, Lisa y Carlos, ¿cómo han seguido los pasos del Club SunWise? ¿cuántas insignias han ganado?", preguntó Brian.

"¡Cada uno ganó 6 insignias!", dijo Lisa.

- "Nos PUSIMOS camisetas de manga larga y pantalones,
- nos PUSIMOS protector contra el sol,
- nos PUSIMOS gorras que nos cubrieron la cara y el cuello,
- nos PUSIMOS unos gafas de sol,
- CHEQUEAMOS el índice UV y
- JUGAMOS en la sombra".

"Ya sabemos como protegernos del sol y hacemos lo que el Club SunWise nos dice", dijo Carlos.

"¡Y terminamos nuestra misión secreta!", dijo Amy. "Me pregunto ¿cuál será nuestro premio?"



"Nuestro premio es: ¡Un paseo al parque de diversiones!", dijo Amy.

"¡Lisa y Carlos!: Bienvenidos al Club SunWise", dijo Erin.

"¡Gracias!", dijeron Lisa y Carlos.

"Todos los niños pueden unirse al Club SunWise. Lo único que tienes que hacer es protegerte del sol y hacer lo que el Club SunWise te dice", dijo Brian.

"Recuerda: ¡Ponte una camiseta de manga larga, ¡ponte protector, ¡ponte una gorra y unos gafas de sol,™ ¡chequea el índice UV y juega en la sombra!", dijo Sam.

El Programa Escolar SunWise quisiera agradecerle a la Asociación Americana del Cancer (American Cancer Society) por su constante apoyo y por permitirnos usar su lema SLIP! SLOP! SLAP! WRAP!™

United States
Environmental Protection
Agency

Air and Radiation
(6205J)

EPA 430-K-01-006
April 2001
www.epa.gov/sunwise

EPA

El sol es una estrella que ayuda a darle vida a las plantas y a los animales de la tierra. El sol nos proporciona la luz para que podamos ver, nos mantiene calientitos y ayuda a que las plantas crezcan. Necesitamos el sol, pero si nos exponemos demasiado a éste nos puede hacer daño.

Este librito le presenta al niño conceptos básicos acerca del sol y lo que debe hacer para protegerse de éste. A los niños les encantará formar parte del Club SunWise ya que podrán mostrarles a sus amigos lo que deben hacer para protegerse del sol.

La ¡Misión SunWise! cuyos libros para colorear y de actividades forman parte del Programa Escolar SunWise sin costo alguno para niños pequeños, de la Agencia Federal de Protección Ambiental. Para mayor información sobre el Club SunWise visite nuestra página Web www.epa.gov/sunwise.

EPA United States
Environmental Protection
Agency

Summertime Safety

Keeping Kids Safe from Sun and Smog

If you spend time with kids in the summer, you want to keep them safe while providing fun outdoor experiences. Did you know that overexposure to the sun and air pollution can pose serious health effects, especially to children? You can take several simple actions to protect kids—and yourself.

Ozone:
"Good up high, bad nearby."

What's the Problem?

Ozone can be protective or harmful, depending on where it is found in the atmosphere. Ozone is a naturally occurring gas in the upper atmosphere (the stratosphere) that protects us from the sun's ultraviolet (UV) radiation. Several chemicals released over time, however, have reduced the amount of stratospheric ozone left to protect us. *Paying attention to the summer sun is more important than ever.*

Ozone at ground-level (the troposphere) is formed from pollutants emitted by cars, power plants, refineries, and other sources. Ground-level ozone is a primary component of a chemical soup known as "smog." Smog can be particularly high in the summer. *Your chances of being affected by ground-level ozone increase the longer you are active outdoors or the more strenuous the activity.*

Health Effects

Overexposure to UV radiation can cause sunburns now, but can also lead to skin cancer, cataracts, and premature aging of the skin. Because kids spend so much time in the sun, and because even one or two blistering sunburns can double the risk of some skin cancers, protecting kids from the sun is especially important.

Kids and teenagers who are active outdoors—especially those with asthma or other respiratory problems—are particularly sensitive to ground-level ozone. Ozone can cause coughing, throat irritation, and pain when taking a deep breath. It can also reduce lung function, inflame the linings of the lungs, and even trigger asthma attacks the day after ozone levels are high. Repeated inflammation over time may permanently scar lung tissue.

Check your daily UV Index and Air Quality Index (below), and follow the simple steps on the back of this fact sheet to protect kids' health.

UV Index

UV Index Number	Exposure Level
0 to 2	Minimal
3 to 4	Low
5 to 6	Moderate
7 to 9	High
10+	Very high

Air Quality Index (AQI)*

AQI Number	Health Concern	Color Code
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for sensitive groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very unhealthy	Purple

* Although ozone reports are primarily made for metropolitan areas, ozone can be carried by the wind to rural areas, where it can cause health problems.

The UV Index

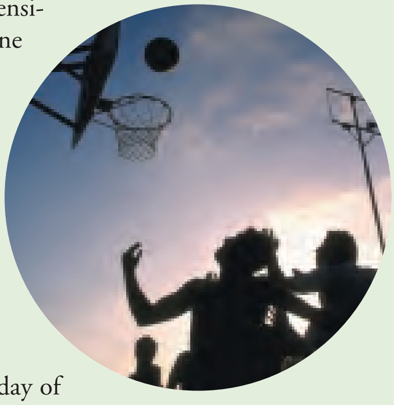
Developed in partnership with the National Weather Service, the UV Index provides a daily forecast of the expected risk of overexposure to the sun. The Index predicts UV intensity levels on a scale of 0 to 10+, where 0 indicates a minimal risk of overexposure, and 10+ means a very high risk.

Actions You Can Take

- ***When the UV Index is "high" or "very high"*: Limit outdoor activities between 10 am and 4 pm,** when the sun is most intense.
- **Seek shade.** When possible, conduct activities in a shaded area. Rotate players to allow breaks in the shade.
- **Apply sunscreen.** Twenty minutes before going outside, liberally apply a broad-spectrum sunscreen with a Sun Protection Factor (SPF) of at least 15. Reapply every two hours or after swimming or sweating.
- **Require hats and sunglasses.** Encourage kids to find a hat they like and wear it. Wide brim hats offer the most sun protection. Teach kids to wear sunglasses with 99 to 100 percent UV-A and UV-B protection.
- **Encourage t-shirts instead of tank tops.**

The Air Quality Index

The Air Quality Index (AQI) is a scale used by state and local air agencies to report how clean or polluted the air is. Ground-level ozone is one pollutant reported. An AQI of 100 or less (green or yellow) is considered satisfactory for most people. Air quality values above 100 (orange, red, and purple) are considered unhealthy, first for sensitive groups, but then for everyone as the AQI gets higher.



Actions You Can Take

- ***When the AQI reports unhealthy levels,* limit physical exertion outdoors.** In many places, ozone peaks in mid-afternoon to early evening. Change the time of day of strenuous outdoor activity to avoid these hours, or reduce the intensity of the activity.
- **Pay attention to symptoms.** Know how to recognize symptoms of respiratory discomfort, such as coughing, wheezing, and breathing difficulty, and reduce exposure if these occur.
- **Rotate players in physically exerting games.** Rest players to reduce exertion.
- **Provide alternative activities.** Allow kids that have asthma or other respiratory problems to participate in activities that are less physical when pollution levels are high. If pollution levels are particularly high, move physical activities indoors where the air is filtered by an air conditioning system.
- **Be vigilant about asthma management.** People with asthma should have adequate medication on hand and follow their asthma management plans.

>> To find the UV Index...

Visit EPA's UV Index Web Page
www.epa.gov/sunwise/uvindex.html
Search by zip code for your local UV Index. View a daily UV Index color-coded map of the United States or a daily Index map of 58 specific monitoring locations.

Check local newspapers or listen to local radio and TV weather forecasts.

>> To find the Air Quality Index...

Visit EPA's AIRNOW Web Page
www.epa.gov/airnow/
Choose your state and local area for real-time animated maps, forecasts, and previous day's peak ozone level.

Check local newspapers or listen to local radio and TV weather forecasts.

Contact your state or local environmental or health department to ask if you can receive fax or e-mail alerts if the AQI forecast is for unhealthy air.

Office of Air and Radiation (6205J)
EPA430-F-02-015
www.epa.gov
May 2002

United States Environmental Protection Agency
Air and Radiation 6205J
EPA430-F-99-026
September 1999
www.epa.gov/sunwise

EPA

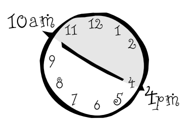
Action Steps for Sun Protection

While some exposure to sunlight can be enjoyable, too much can be dangerous. Overexposure to ultraviolet (UV) radiation in sunlight can result in a painful sunburn. It can also lead to more serious health effects, including skin cancer, premature aging of the skin, and other skin disorders; cataracts and other eye damage; and immune system suppression. Children are particularly at risk of overexposure, since most of the average person's lifetime exposure occurs before the age of 18.

Be SunWise

Most people are not aware that skin cancer, while largely preventable, is the most common form of cancer in the United States, with more than one million cases reported annually. By following a number of simple steps, you can still enjoy your time in the sun while protecting yourself from overexposure.

In cooperation with a number of leading public health organizations, the U.S. Environmental Protection Agency (EPA) is providing these action steps to help you and your family be "SunWise." Other than staying indoors, no single step can fully protect from overexposure to UV radiation, so use as many of the following actions as possible.

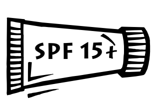


Limit Time in the Midday Sun

The sun's rays are strongest between 10 a.m. and 4 p.m. Whenever possible, limit exposure to the sun during these hours.

Seek Shade

Staying under cover is one of the best ways to protect yourself from the sun. Remember the shadow rule: "Watch Your Shadow—No Shadow, Seek Shade!"



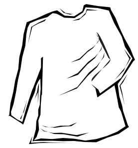
Always Use Sunscreen

A broad spectrum sunscreen with a Sun Protection Factor (SPF) of at least 15 blocks most UV radiation. Apply sunscreen liberally on exposed skin and reapply every 2 hours when working or playing outdoors. Even waterproof sunscreen can come off when you towel off sweat or water.

Wear a Hat

A hat with a wide brim offers good sun protection for your eyes, ears, face, and the back of your neck—areas particularly prone to overexposure to the sun.

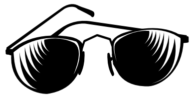
The UV Index provides numeric values and describes a person's likelihood of exposure to the sun's harmful rays.



Cover Up

Wearing tightly woven, loose-fitting, and full-length clothing is a good way to protect your skin from the sun's UV rays.

Wear Sunglasses That Block 99 to 100 Percent of UV Radiation



Sunglasses that provide 99 to 100 percent UVA and UVB protection will greatly reduce sun exposure that can lead to cataracts and other eye damage. Check the label when buying sunglasses.

Avoid Sunlamps and Tanning Salons

The light source from sunbeds and sunlamps damages the skin and unprotected eyes. It's a good idea to avoid artificial sources of UV light.

Watch for the UV Index

The UV Index provides important information to help you plan your outdoor activities in ways that prevent overexposure to the sun. Developed by the National Weather Service (NWS) and EPA, the UV Index is issued daily in selected cities across the United States.

Special Considerations for Children

Although many of the sun's effects do not appear until later in life, recent medical research shows that it is very important to protect children and young adults from overexposure to UV radiation. Because children tend to spend more time in the sun than adults, be careful to keep young children protected from overexposure, and consult your physician about sun protection for children under 6 months of age.

EPA's SunWise School Program

In response to the serious public health threat posed by overexposure to UV radiation, EPA is working with schools and communities across the nation through the SunWise School Program. SunWise teaches children in elementary school and their caregivers how to protect themselves from overexposure to the sun.

For More Information

To learn more about UV radiation, the action steps for sun protection, and the SunWise School Program, call EPA's Stratospheric Ozone Information Hotline at 800 296-1996, or visit our Web site at <www.epa.gov/sunwise>.

EPA
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Environmental Protection
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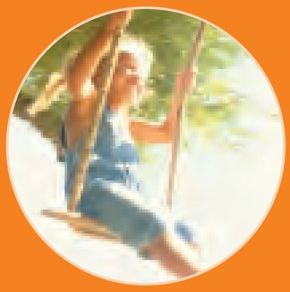
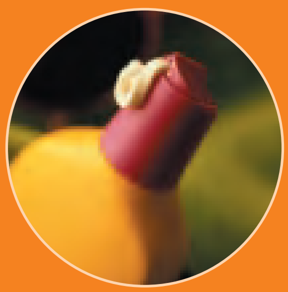
Air and Radiation
(6205J)

EPA430-F-01-015
May 2001

Sun screen!

The Burning Facts





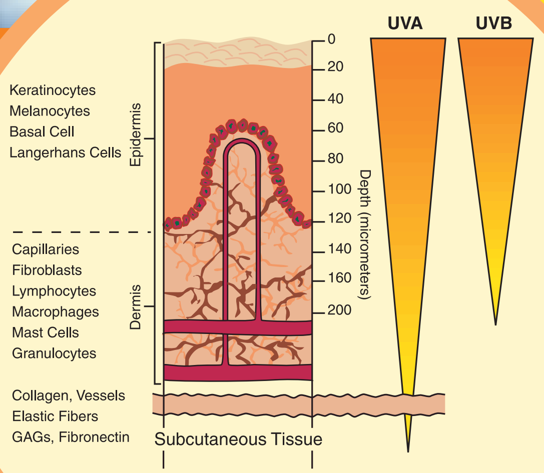
Although the sun is necessary for life, too much sun exposure can lead to adverse health effects, including skin cancer. More than 1 million people in the United States are diagnosed with skin cancer each year, making it the most common form of cancer in the country, but it is largely preventable through a broad sun protection program. Ninety percent of skin cancers are linked to sun exposure.[1]

By themselves, sunscreens might not be effective in protecting you from the most dangerous forms of skin cancer. However, sunscreen use is an important part of your sun protection program. Used properly, certain sunscreens help protect human skin from some of the sun's damaging ultraviolet (UV) radiation. But according to recent surveys, most people are confused about the proper use and effectiveness of sunscreens.[2] The purpose of this fact sheet is to educate you about sunscreens and other important sun protection measures so that you can protect yourself from the sun's damaging rays.

Printed on paper that contains at least 50 percent postconsumer fiber.

How Does UV Radiation Affect My Skin? What Are the Risks?

UV rays can have a number of harmful effects on the skin. The two types of UV radiation that can affect the skin, UVA and UVB, have both been linked to skin cancer and a weakening of the immune system. They also contribute to both premature aging of the skin and cataracts (a condition that impairs eyesight), and cause skin color changes.



Penetration of UV Into the Skin

UVA Rays

UVA rays, which are not absorbed by the ozone layer, penetrate deep into the skin and heavily contribute to premature aging. Up to 90 percent of the visible skin changes commonly attributed to aging are caused by sun exposure.[3]

UVB Rays

These powerful rays, which are partially absorbed by the ozone layer, mostly impact the surface of the skin and are the primary cause of sunburn. Because of the thinning of the ozone layer, the effects of UVB radiation will pose an increased threat until the layer is restored in approximately 50 years.

[1] American Cancer Society, "Cancer Facts and Figures 1999."

[2] IARC Working Group (2001) Sunscreens (IARC Handbooks of Cancer Prevention, Vol. 5), Lyon, International Agency for Research on Cancer, pp. 23-52.

[3] Taylor, C.R. et al, *Photoaging/ Photodamage and Photoprotection,* J Am Acad Dermatol, 1990: 22: 1-15.

[4] Stern RS, Weinstein MC, Baker SG. Risk reduction for nonmelanoma skin cancer with childhood sunscreen use. *Arch Dermatol.* 1986: 122: 537-545.

[5,6] American Academy of Pediatrics, *Ultraviolet Light: A Hazard to Children,* Pediatrics, 1999: 104: 328-333.

[7] IARC Working Group (2001) Sunscreens (IARC Handbooks of Cancer Prevention, Vol. 5), Lyon, International Agency for Research on Cancer, pp. 148-149.

Are Some People Predisposed to Adverse Health E

Everybody, regardless of race or ethnicity, is subject to the potential adverse effects of overexposure to the sun. Some people might be more vulnerable to certain conditions, however.

Skin Type

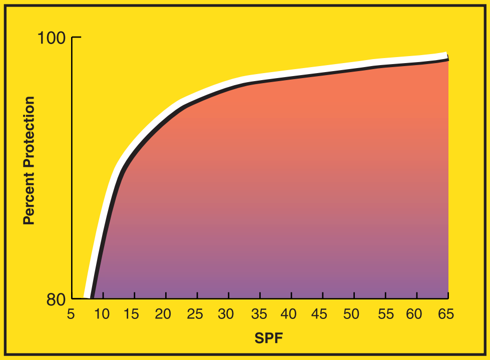
Skin type affects the degree to which some people burn and the time it takes them to burn. The Food and Drug Administration (FDA) classifies skin type on a scale from 1 to 6. Individuals with lower number skin types (1 and 2) have fair skin and tend to burn rapidly and more severely. Individuals with higher number skin types (5 and 6), though capable of burning, have darker skin and do not burn as easily.

How Do Sunscreens Work?
What Is the Sun Protection Factor (SPF)?

Sunscreens protect your skin by absorbing and/or reflecting UVA and UVB rays. The FDA requires that all sunscreens contain a Sun Protection Factor (SPF) label. The SPF reveals the relative amount of sunburn protection that a sunscreen can provide an average user (tested on skin types 1, 2, and 3) when correctly used.

Sunscreens with an SPF of at least 15 are recommended. You should be aware that an SPF of 30 is not twice as protective as an SPF of 15; rather, when properly used, an SPF of 15 protects the skin from 93 percent of UVB radiation, and an SPF 30 sunscreen provides 97 percent protection (see chart to the right).

SPF vs. UVB protection



Although the SPF ratings found on sunscreen packages apply mainly to UVB rays, many sunscreen manufacturers include ingredients that protect the skin from some UVA rays as well. **These "broad-spectrum" sunscreens are highly recommended.**

ffects Resulting From Sun Exposure?

The same individuals who are most likely to burn are also most vulnerable to skin cancer. Studies have shown that individuals with large numbers of freckles and moles also have a higher risk of developing skin cancer. Although individuals with higher-number skin types are less likely to develop skin cancer, they should still take action to protect their skin and eyes from overexposure to the sun. Some dark-skinned individuals can and do get skin cancer.

Additional factors

Certain diseases, such as lupus, can also make a person more sensitive to sun exposure. Some medications, such as antibiotics and antihistamines and even certain herbal remedies, can cause extra sensitivity to the sun's rays. Discuss these issues with your physician.

What Are the Active Ingredients in Sunscreen?

Chemical (Organic) Ingredients

Broad-spectrum sunscreens often contain a number of chemical ingredients that absorb UVA and UVB radiation. Many sunscreens contain UVA-absorbing **avobenzone** or a **benzophenone** (such as dixoybenzone, oxybenzone, or sulisobenzone), in addition to UVB-absorbing chemical ingredients (some of which also contribute to UVA protection). In rare cases, chemical ingredients cause skin reactions, including acne, burning, blisters, dryness, itching, rash, redness, stinging, swelling, and tightening of the skin. Consult a physician if these symptoms occur. These reactions are most commonly associated with para-aminobenzoic acid (PABA)-based sunscreens and those containing benzophenones. Some sunscreens also contain alcohol, fragrances, or preservatives, and should be avoided if you have skin allergies.

Physical (Inorganic) Ingredients

The physical compounds titanium dioxide and zinc oxide reflect, scatter, and absorb both UVA and UVB rays. These ingredients, produced through chemical processes, do not typically cause allergic reactions. Using new technology, the particle sizes of zinc oxide and titanium dioxide have been reduced, making them more transparent.

Summary

All of the previously mentioned chemical and physical ingredients have been approved by the FDA. The following table lists these ingredients and includes information regarding the type and amount of ray protection that they provide and their class.

FDA Monograph Sunscreen Ingredients	Amount of Ray Protection		Chemical (C) or Physical (P)
	UVA	UVB	
Aminobenzoic acid (PABA)	○	●	C
Avobenzone	●	◔	C
Cinoxate	◔	●	C
Dioxybenzone	◐	●	C
Homosalate	○	●	C
Menthyl anthranilate	◐	●	C
Octocrylene	◔	●	C
Octyl methoxycinnamate	◔	●	C
Octyl salicylate	○	●	C
Oxybenzone	◐	●	C
Padimate O	○	●	C
Phenylbenzimidazole	○	●	C
Sulisobenzone	◐	●	C
Titanium dioxide	◐	●	P
Trolamine salicylate	○	●	C
Zinc Oxide	●	●	P

Protection Level: ● = extensive ◐ = considerable ◔ = limited ○ = minimal

How Can I Maximize My Sun Protection?

Because the active sunscreen ingredients will not usually block out the complete spectrum of UVA and UVB rays, sunscreens by themselves might not offer enough protection to prevent skin cancer and some of the other sun-related ailments. To thoroughly protect yourself, you should take as many of the following **action steps** as you can:

- Limit time in the strong, midday sun between 10 a.m. and 4 p.m.
- Seek shade.
- Wear sunglasses with 99-100 percent UVA and UVB protection.
- Wear tightly woven, long-sleeve clothing.
- Wear a wide brim hat.
- Apply broad-spectrum sunscreen rated SPF 15 or higher.

Can I Get a Tan Without the Sun?

Sunless tanners and bronzers are applied to the skin like a cream and can provide a temporary, artificial tan. The only color additive currently approved by FDA for this purpose is dihydroxyacetone (DHA). Application can be difficult, and areas of the skin can react differently, resulting in an uneven appearance.

Bronzers stain the skin temporarily, and they can generally be removed with soap and water. They may streak after application and can stain clothes. Sunless tanners and bronzers might not contain active sunscreen ingredients. Read their labels to find out if they provide any sun protection.

How Can I Protect My Kids?

Children

An estimated 80 percent of a person's sun exposure occurs before age 18.[4] For this reason, it is important that children be protected from overexposure. Many parents do not properly apply sunscreen on their children. Sunscreen should be applied and reapplied to all exposed areas. Blistering sunburns during childhood significantly increase the risk of developing skin cancer later in life.[5] Encourage your children to take all sun safety action steps.

Babies

Keep babies out of direct sunlight. The American Academy of Pediatrics recommends using sunscreen on infants for small areas such as the face and back of hands where protection from clothing is inadequate.[6]

SunWise School Program

SunWise a school program that **radiates** good ideas

In response to the serious public health threat raised by overexposure to UV radiation, EPA is working with schools and communities across the nation through the SunWise School Program. SunWise aims to teach children in elementary and middle school and their caregivers how to protect themselves from overexposure to the sun. For more information, go to the SunWise Web site at <http://www.epa.gov/sunwise>.

Is a Suntan Healthy?

There is no such thing as a healthy suntan. Any change in your natural skin color is a sign of skin damage. Every time your skin color changes after sun exposure, your risk of developing sun-related ailments increases.

Will Sun Protection Deprive Me of Vitamin D?

Sun exposure is not required to get a sufficient amount of vitamin D. Most people get an adequate amount of vitamin D in their diets. If you are concerned about not getting enough vitamin D, consider taking a multivitamin or drinking vitamin D-fortified milk daily.

Are Tanning Lotions Safe?

The FDA considers it an important public health issue that users of suntanning products be told when the products do not contain a sunscreen and thus, do not protect against sunburn or other harmful effects to the skin. The FDA requires that all such products carry the following label:

"**Warning**–This product does not contain a sunscreen and does not protect against sunburn. Repeated exposure of unprotected skin while tanning may increase the risk of skin aging, skin cancer, and other harmful effects to the skin even if you do not burn."

(Title 21 of the Code of Federal Regulations, Section 740.19)

How Does the Outside Environment Influence Exposure?

The intensity of the sun's UV rays reaching the Earth's surface varies and should be considered when you plan outdoor activities. The National Weather Service issues the UV Index, a daily forecast of UV intensity.

The UV Index	
Index Number	Exposure Level
0 to 2	Minimal
3 to 4	Low
5 to 6	Moderate
7 to 9	High
10+	Very High

You can obtain your local UV Index forecast daily from local weather stations or newspapers. The U.S. Environmental Protection Agency's Web site provides daily local UV forecasts for your ZIP code. The address is <http://www.epa. gov/sunwise/ uvindex.html>. The higher the UV Index forecast, the stronger the sun will be and the greater the need to follow all the sun protection action steps.

In general, UV strength is greatest from 10 a.m. to 4 p.m. during sunny summer days. Up to 80 percent of UV rays pass through clouds, however, meaning that sunburn is possible on cloudy days as well. UV exposure is greater at low latitudes (nearer to the equator) and/or high altitudes. Snow, water, and sand also increase sun exposure by reflecting incoming UV rays, making it especially important for skiers, boaters, and beachcombers to wear clothing and hats and apply sunscreen.

How Do I Apply Sunscreen?

Use a broad-spectrum sunscreen with an SPF rating of 15 or higher. Apply sunscreen 20 minutes before going out into the sun (or as directed by the manufacturer) to give it time to absorb into your skin. Apply it well and regularly—about 1 ounce every 2 hours (or as directed by the manufacturer)—and more often if you are swimming or perspiring. A small tube containing between 3 and 5 ounces of sunscreen might only be enough for one person during a day at the beach.

Do not forget about lips, ears, feet, hands, bald spots and the back of the neck. In addition, apply sunscreen to areas under bathing suit straps, necklaces, bracelets, and sunglasses. Keep sunscreen until the expiration date or for no more than 3 years, because the sunscreen ingredients might become less effective over time.

According to the FDA, "water resistant" sunscreens must maintain their SPFs after 40 minutes of water immersion, while "very water resistant" sunscreens must maintain their SPF after 80 minutes of water immersion. Either type of water-resistant sunscreen must be reapplied regularly, as heavy perspiration, water, and towel drying remove the sunscreen's protective layer.

Is Sunscreen Fail-Safe?

Using sunscreen does not mean it is safe to spend more time in the sun, especially when the UV Index is high. Although a sunscreen with an SPF of 30 offers protection from sunburn, it does not block all of the sun's damaging rays. In fact, there is no evidence that sunscreens protect you from malignant melanoma, the deadliest form of skin cancer. There is only limited evidence that sunscreens protect you from several other types of skin cancer.[7] To fully protect yourself, remember to seek shade, avoid peak hours of sun exposure, and wear protective clothing in addition to applying sunscreen.

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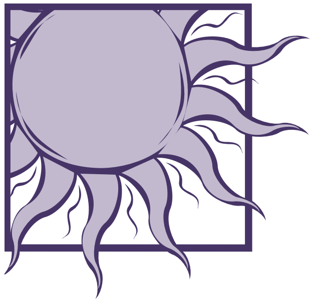
The Sun, UV, and You

A Guide to SunWise Behavior

Printed on paper that contains at least 30 percent postconsumer fiber.



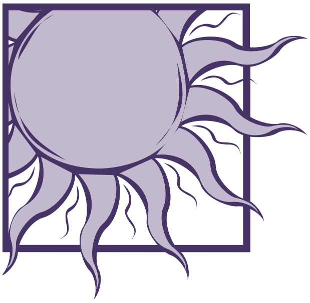
While some exposure to sunlight is enjoyable, too much can be dangerous and cause immediate effects like blistering sunburns and long-term problems like skin cancer and cataracts. Overexposure also causes wrinkling and aging of the skin. Scientists are concerned that ultraviolet (UV) radiation might even impair the human immune system.

The U.S. Environmental Protection Agency (EPA) prepared this booklet to help you understand the risks from overexposure to the sun's harmful UV rays and how to protect yourself and your loved ones from UV radiation.

This booklet presents the following information:

- The science behind UV radiation and stratospheric ozone.
- The health risks from overexposure to UV radiation.
- The steps you can take to protect yourself and your children.
- What the UV Index is and how you can use it.
- Details about EPA's SunWise School Program.
- Where to get more information about the UV Index and ways to protect yourself from the sun.

We hope you find this booklet useful and that you will use the information provided to help you be SunWise!



UV Radiation

The sun gives out energy over a broad spectrum of wavelengths. UV radiation, which has a shorter wavelength than either visible blue or violet light, is responsible for sunburn and other adverse health effects. Fortunately for life on earth, stratospheric ozone screens most harmful UV radiation. What gets through the ozone layer, however, can cause the following health problems, particularly for people who spend substantial time outdoors:

- Skin cancer and other skin disorders
- Cataracts and other eye damage
- Immune suppression

Because of these adverse health effects, you should limit your exposure to UV radiation and protect yourself when working, playing, or exercising outdoors.

Types of UV Radiation

Scientists have classified UV radiation into three types: UVA, UVB, and UVC.

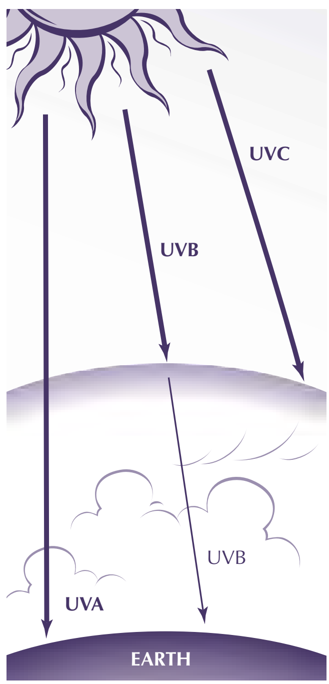
The stratospheric ozone layer absorbs some but not all of these types of UV radiation:

UVA
Not absorbed by the ozone layer

UVB
Partially absorbed by the ozone layer

UVC
Completely absorbed by oxygen and ozone in the atmosphere

UVA and especially UVB penetrate into the skin and eyes, and can cause the adverse health effects listed above.



UV Levels Depend on a Number of Factors

Stratospheric Ozone

The ozone layer absorbs most of the sun's harmful UV rays, but its thickness varies depending on the time of year and changing weather patterns. The ozone layer has thinned in certain areas due to the emission of ozone-depleting chemicals.

Time of Day

The sun is at its highest in the sky around noon. At that time, the sun's rays have the least distance to travel through the atmosphere, and UVB levels are at their highest. In the early morning and late afternoon, the sun's rays pass obliquely through the atmosphere, and the intensity of UVB is greatly reduced. UVA levels are not sensitive to ozone and vary throughout the day much like visible sunlight does.

Time of Year

The sun's angle varies with the seasons, causing the intensity of UV rays to vary. UV intensity tends to be highest during the summer months.

Latitude

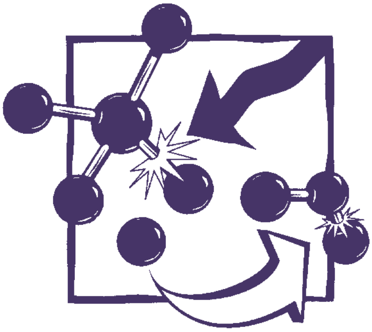
The sun's rays are strongest at the equator where the sun is most directly overhead and where UV rays must travel the least distance through the atmosphere. Ozone also is naturally thinner in the tropics as compared to the mid- and high-latitudes, so there is less ozone to absorb the UV radiation as it passes through the atmosphere. At higher latitudes the sun is lower in the sky, so UV rays must travel a greater distance through ozone-rich portions of the atmosphere and in turn expose those latitudes to less UV radiation.

Altitude

UV intensity increases with altitude because there is less atmosphere to absorb the damaging rays.

Weather Conditions

Cloud cover reduces UV levels, but not completely. Depending on the thickness of the cloud cover, it is possible to burn on a cloudy day even if it does not feel very warm.



Ozone Depletion

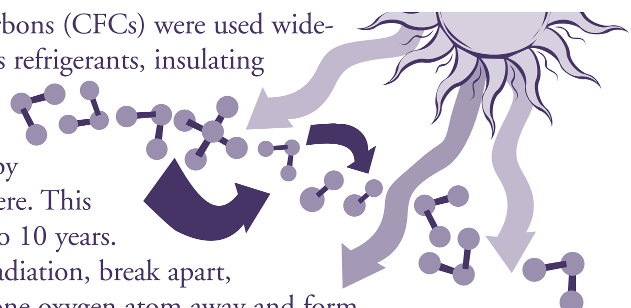
The ozone layer forms a thin shield in the stratosphere, protecting life on earth from the sun's harmful UV rays. In the 1980s, scientists began accumulating evidence that the ozone layer was being depleted. Depletion of the ozone layer can result in increased UV radiation reaching the earth's surface, which can lead to a greater chance of overexposure to UV radiation and consequent health effects including skin cancer, cataracts, and immune suppression.

How Stratospheric Ozone Protects Us

Ozone is a naturally occurring gas that is found in two layers in the atmosphere. In the layer surrounding the earth's surface—the troposphere—ground-level or "bad" ozone is an air pollutant that damages human health and vegetation and is a key ingredient of urban smog. The troposphere extends up to the stratosphere, which is where the "good" ozone protects life on earth by absorbing some of the sun's ultraviolet rays. Stratospheric ozone is most concentrated between 6 to 30 miles above the earth's surface.

Ozone is formed when oxygen molecules absorb UV radiation and split apart into two oxygen atoms (O), which combine with other oxygen molecules (O_2) to form ozone molecules (O_3). Ozone also is broken apart as it absorbs UV radiation. In this way, UV radiation helps sustain the natural balance of ozone in the stratosphere, while ozone in turn absorbs UV radiation, protecting life on earth from harmful radiation.

How Ozone Is Depleted



Until recently, chlorofluorocarbons (CFCs) were used widely in industry and elsewhere as refrigerants, insulating foams, and solvents. They migrate into the upper atmosphere after use, carried by air currents into the stratosphere. This process can take as long as 5 to 10 years. These chemicals absorb UV radiation, break apart, and react with ozone, taking one oxygen atom away and forming highly reactive chlorine monoxide. Chlorine monoxide in turn breaks down O_3 again by pulling away a single oxygen atom, creating two O_2 molecules, and allowing the chlorine to move freely to another ozone molecule. In this way, each chlorine atom acts as a catalyst, repeatedly combining with and breaking apart as many as 100,000 ozone molecules during its stratospheric life.

Other compounds also damage the ozone layer in much the same way as do CFCs. These ozone-depleting substances include pesticides such as methyl bromide, halons used in fire extinguishers, and methyl chloroform used in industrial processes.

What Is Being Done About Ozone Depletion

Countries around the world have recognized the threats posed by ozone depletion and have responded by adopting the Montreal Protocol on Substances That Deplete the Ozone Layer. Parties to this treaty, including the United States, are phasing out the production and use of ozone-depleting substances.

Effect of Ozone Depletion on UV Radiation Levels

Current studies predict that CFC levels in the atmosphere should peak by around 2000 and should fall to pre-1980 levels by about 2050. As international control measures reduce the release of CFCs and other ozone-depleting substances, natural atmospheric processes will repair the ozone layer. Until that time, we can expect increased levels of UV radiation at the earth's surface. These increased UV radiation levels can lead to a greater chance of overexposure to UV radiation and the consequent health effects.

Health Effects From Overexposure to the Sun

Americans love the sun and spend a great deal of time outside—working, playing, exercising—often in clothing that exposes a lot of skin to the sun. Most people are now aware that too much sun has been linked to skin cancer. However, few know the degree of risk posed by overexposure, and fewer are aware that the risks go beyond skin cancer. Recent medical research has shown that overexposure to the sun's UV radiation can contribute to serious health problems. Each year, for example, more than 1 million cases of skin cancer are diagnosed in the United States, and one person dies every hour from melanoma or nonmelanoma skin cancer.

This section provides a quick overview of the major problems linked to excess UV exposure: skin cancer (i.e., melanoma, basal cell carcinoma, and squamous cell carcinoma); other skin problems; cataracts and other eye damage; and immune system suppression. Understanding these risks and taking a few sensible precautions described in this booklet will help you to enjoy the sun while lowering your chances of sun-related health problems later in life.

A Word About Risk

Overexposure to UV radiation poses the risk of serious health effects for everyone, but not everyone is equally at risk. For example, you may be at greater risk of contracting skin cancer if your skin always burns, or burns easily, and if you have blond or red hair, or blue, green, or gray eyes. Other factors indicating an increased risk of skin cancer include: a history of blistering sunburns in early childhood, usually from acute sun overexposure; the presence of many moles; or a family history of skin cancer. Also, people who work or otherwise spend a large amount of time outdoors (i.e., chronic exposure to the sun) may be at higher risk of health effects. It's a good idea to remember that anyone can contract skin cancer, and that all people, no matter what skin type, are equally at risk of eye damage.

Melanoma

Melanoma, the most serious form of skin cancer, also is one of the fastest growing types of cancer in the United States. Many scientists believe there might be a link between childhood sunburns and malignant melanoma later in life. Melanoma cases in this country have more than doubled in the past 2 decades; according to the American Cancer Society, about 44,200 new cases of melanoma and 7,300 deaths are currently reported each year.

Cure Rate

Melanoma can spread to other parts of the body quickly, but when detected in its earliest stages it is almost always curable. If not caught early, melanoma is often fatal.

Warning Sign

Melanoma begins as an uncontrolled growth of pigment-producing cells in the skin. This growth leads to the formation of dark-pigmented malignant moles or tumors, called melanomas. Melanomas can appear suddenly without warning but also can develop from or near a mole. For this reason, it is important to know the location and appearance of moles on the body so any change will be noticed. Melanomas are found most frequently on the upper backs of men and women, and the legs of women, but can occur anywhere on the body. Be aware of any unusual skin condition, especially a change in the size or color of a mole or other darkly or irregularly pigmented growth or spot; scaliness, oozing, bleeding, or change in the appearance of a bump or nodule; spread of pigment from the border into surrounding skin; and change in sensation including itchiness, tenderness, or pain.

Nonmelanoma Skin Cancers

Unlike melanoma, nonmelanoma skin cancers are rarely fatal. Nevertheless, they should not be taken lightly. Untreated, they can spread and cause more serious health problems. An estimated 1 million Americans will develop nonmelanoma skin cancers this year, while 1,900 will die from the disease.

There are two primary types of nonmelanoma skin cancers:

Basal Cell Carcinomas are tumors of the skin that usually appear as small, fleshy bumps or nodules on the head and neck but can occur on other skin areas as well. It is the most common skin cancer found among fair-skinned people. Basal cell carcinoma does not grow quickly and rarely spreads to other parts of the body. It can, however, penetrate below the skin to the bone and cause considerable local damage.

Squamous Cell Carcinomas are tumors that might appear as nodules or as red, scaly patches. The second most common skin cancer found in fair-skinned people, squamous cell carcinoma is rarely found in darker-skinned people. This cancer can develop into large masses, and unlike basal cell carcinoma, it can spread to other parts of the body.

Cure Rate

These two nonmelanoma skin cancers have cure rates as high as 95 percent if detected and treated early. The key is to watch for signs and to detect the cancer in its early stages.

Warning Sign

Basal cell carcinoma tumors usually appear as slowly growing, raised, translucent, pearly nodules that, if untreated, might crust, discharge pus, and sometimes bleed. Squamous cell carcinomas usually are raised, red or pink scaly nodules, or wart-like growths that form pus in the center. They typically develop on the edge of the ears, the face, lips, mouth, hands, and other exposed areas of the body.

Actinic Keratoses

These sun-induced skin growths occur on body areas exposed to the sun. The face, hands, forearms, and the "V" of the neck are especially susceptible to this type of blemish. They are premalignant, but if left untreated, actinic keratoses can become malignant. Look for raised, reddish, rough-textured growths. See a dermatologist promptly if you notice these growths.

Premature Aging of the Skin

Chronic exposure to the sun causes changes in the skin called actinic (or solar) degeneration. Over time, the skin becomes thick, wrinkled, and leathery. Since it occurs gradually, often manifesting itself many years after the majority of a person's exposure to the sun, this condition is often regarded as unavoidable, a normal part of growing older. With proper protection from UV radiation, however, premature aging of the skin can be substantially avoided.

Cataracts and Other Eye Damage

Cataracts are a form of eye damage, a loss of transparency in the lens that clouds vision. Left untreated, cataracts can rob people of vision. Research has shown that UV radiation increases the likelihood of certain cataracts. Although curable with modern eye surgery, cataracts diminish the eyesight of millions of Americans and necessitate billions of dollars of eye surgery each year. Other kinds of eye damage include: pterygium (tissue growth on the white of the eye that can block vision), skin cancer around the eyes, and degeneration of the macula (the part of the retina near the center, where visual perception is most acute). All of these problems could be lessened with proper eye protection from UV radiation.

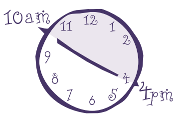
Immune Suppression

Scientists have found that sunburn can alter the distribution and function of disease-fighting white blood cells in humans for up to 24 hours after exposure to the sun. Repeated exposure to UV radiation might cause more long-lasting damage to the body's immune system. Mild sunburns can suppress immune functions in people of all skin types.

Action Steps for Sun Protection

Be SunWise

Protecting yourself from overexposure to UV radiation is simple if you take the precautions listed below.



Limit Time in the Midday Sun as Much as Possible

The sun's UV rays are strongest between 10 a.m. and 4 p.m. To the extent you can, limit exposure to the sun during these hours.

Watch for the UV Index

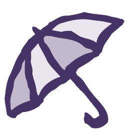
The UV Index provides important information to help you plan your outdoor activities in ways that prevent overexposure to the sun's rays. Developed by the National Weather Service (NWS) and EPA, the UV Index is issued daily in selected cities across the United States.

Wear Sunglasses That Block 99 to 100 Percent of UV Radiation

Sunglasses that provide 99 to 100 percent UVA and UVB protection will greatly reduce sun exposure that can lead to cataracts and other eye damage. Check the label when buying sunglasses.

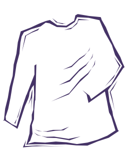
Wear a Hat

A hat with a wide brim offers good sun protection for your eyes, ears, face, and the back of your neck—areas particularly prone to overexposure to the sun.



Seek Shade

Staying under cover is one of the best ways to protect yourself from the sun.



Protect Other Areas of Your Body With Clothing During Prolonged Periods in the Sun

Tightly-woven, loose-fitting, and full-length clothes are best for protection of exposed skin.

Always Use a Sunscreen When Outside

A sunscreen with a sun protection factor (SPF) of at least 15 blocks most harmful UV radiation. Apply sunscreen liberally and reapply every 2 hours when working, playing, or exercising outdoors. Even waterproof sunscreen can come off when you towel off sweat or water. Consult your physician about sunscreen use on children under 6 months of age. Also use lip balm of SPF 15.

Avoid Sunlamps and Tanning Salons

The light source from sunbeds and sunlamps damages the skin and unprotected eyes. It's a good idea to avoid artificial sources of UV light.

The UV Index Describes the Next Day's Likely Levels of the Intensity of UV Rays. The Index Predicts UV Levels on a 0 to 10+ Scale in the Following Way:

INDEX NUMBER	INTENSITY LEVEL
0 to 2	Minimal
3 to 4	Low
5 to 6	Moderate
7 to 9	High
10+	Very High

While always taking precautions against overexposure, take special care to adopt the safeguards recommended above when the UV Index predicts exposure levels of moderate or higher.

Some medications cause serious sun sensitivity, as do some diseases such as lupus erythematosus. The UV Index is *not* intended for use by seriously sun-sensitive individuals. Consult your doctor about additional precautions you might need to take.

How NWS Calculates the UV Index

The National Weather Service uses a computer model to calculate the next day's UV levels for selected cities across the United States. The model takes into account a number of factors including the amount of ozone and clouds overhead, latitude, elevation, and time of year.

To compute the UV Index forecast, the model first calculates a UV dose rate, or amount of UV radiation to which a person will be exposed at the next day's solar noon (when the sun is highest in the sky) under "clear sky" (no clouds) conditions.

The UV dose rates obtained from the model are then adjusted for the effects of elevation and cloud cover at specific locations. Higher elevations will increase the UV dose rate because there is less atmosphere to absorb and scatter UV rays. Greater cloud cover will tend to reduce the UV dose rate because clouds screen out some—but not all—UV rays.

The resulting value is the next day's UV Index forecast. The UV forecasts for selected locations are provided daily on a 0 to 10+ scale, where 0 indicates a minimal likely level of exposure to UV rays and 10+ means a very high level of exposure.

For more information about the UV Index, or for daily forecasts, please consult <www.epa.gov/sunwise>.

Special Considerations for Children

Although many of the sun's harmful effects do not appear until later in life, recent medical research has shown that it is very important to protect children and young adults from overexposure to UV radiation. The majority of most people's sun exposure occurs before age 18, and studies increasingly suggest a link between early exposure and skin cancer as an adult.

Helping Children Be SunWise

Take special care with children, since they tend to spend more time outdoors than adults and can burn more easily. The precautions described in this booklet can help ensure that the children around you avoid UV-related health problems, both now and later in life. Started early and followed consistently, each of these steps will become an accepted habit, as easy as fastening seatbelts every time you drive the car.

In response to the serious public-health threat posed by overexposure to UV radiation, EPA is working with schools and communities across the nation to launch the SunWise School Program. SunWise teaches children in elementary school and their caregivers how to protect themselves from overexposure to the sun. Educating children about sun safety is the key to reducing the risk of future UV-related health problems.

Participating schools will sponsor activities that raise children's awareness of the largely preventable health risks from UV radiation and teach simple steps to avoid overexposure. Such activities might include:

- Cross-curricular classroom lessons.
- Reporting the UV Index and UV ground data on the SunWise Internet Learning Site.
- Infrastructure enhancements (e.g., policy changes and shade structures).
- Community partnerships.
- Schoolwide sun safety activities.
- Train-the-trainer video.

For additional information about the SunWise School Program, please contact EPA's Stratospheric Ozone Information Hotline at 800 296-1996 or visit the program's Web site at <www.epa.gov/sunwise>.

For More Information

To learn more about the UV Index and how to protect yourself from overexposure to the sun's UV rays, call EPA's Stratospheric Ozone Information Hotline at 800 296-1996 or visit our Web site at <www.epa.gov/sunwise>. Hotline staff can supply you with the following fact sheets and other useful information:

- Health Effects of Overexposure to the Sun
- UV Radiation
- Action Steps for Sun Protection
- Ozone Depletion
- What is the Ultraviolet (UV) Index?
- Ultraviolet Index: What You Need to Know
- SunWise School Program

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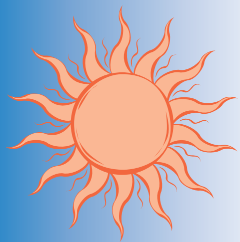
UV INDEX

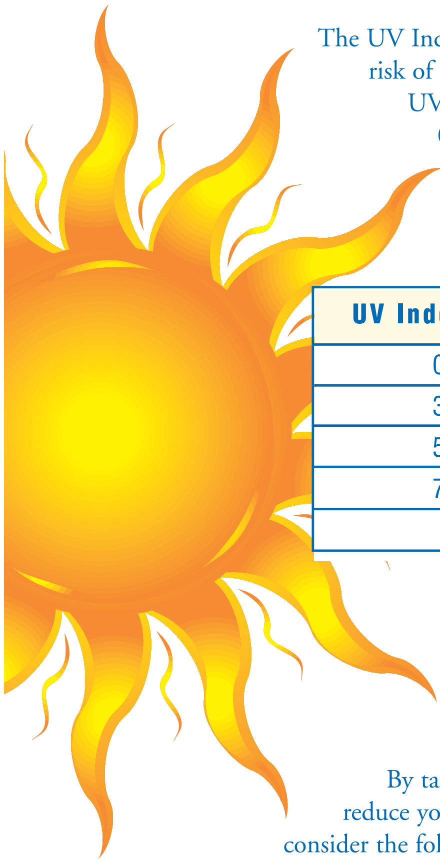
BE SUNWISE



UV INDEX

What Is the UV Index?

Some exposure to sunlight can be enjoyable; however, too much could be dangerous. Overexposure to the sun's ultraviolet (UV) radiation can cause immediate effects such as sunburn and long-term problems such as skin cancer and cataracts. Developed by the National Weather Service and the U.S. Environmental Protection Agency (EPA), the UV Index provides important information to help you plan your outdoor activities to prevent overexposure to the sun's rays.



The UV Index provides a daily forecast of the expected risk of overexposure to the sun. The Index predicts UV intensity levels on a scale of 0 to 10+, where 0 indicates a minimal risk of overexposure and 10+ means a very high risk. Calculated on a next-day basis for dozens of cities across the United States, the UV Index takes into account clouds and other local conditions that affect the amount of UV radiation reaching the ground in different parts of the country.

UV Index Number	Exposure Level
0 to 2	Minimal
3 to 4	Low
5 to 6	Moderate
7 to 9	High
10+	Very High

By taking a few simple precautions, you can greatly reduce your risk of sun-related illnesses. To be SunWise, consider the following steps:

- Limit your time in the sun between 10 a.m. and 4 p.m.
- Whenever possible, seek shade.
- Use a broad spectrum sunscreen with an SPF of at least 15.
- Wear a wide-brimmed hat and if possible, tightly woven, full-length clothing.
- Wear UV-protective sunglasses.
- Avoid sunlamps and tanning salons.
- Watch for the UV Index daily.

While you should always take precautions against overexposure to the sun, please take special care to adopt the safeguards when the UV Index predicts levels of moderate or above. Watch for UV Index reports in your local newspapers and on television, and remember to be SunWise! For more information, call EPA's Stratospheric Ozone Information Hotline at 800 296-1996, or visit our Web site at <www.epa.gov/sunwise>.

EPA

EPA430-H-99-001 September 1999

United States Environmental Protection Agency
Air and Radiation 6205J
EPA430-F-99-024
September 1999
www.epa.gov/sunwise

UV Radiation

The sun radiates energy over a broad spectrum of wavelengths. Ultraviolet (UV) radiation, which has a shorter wavelength than either visible blue or violet light, is responsible for sunburn and other adverse health effects. Fortunately for life on Earth, our atmosphere's stratospheric ozone layer shields us from most UV radiation. What gets through the ozone layer, however, can cause the following problems, particularly for people who spend substantial time outdoors:

- Skin cancer
- Cataracts
- Suppression of the immune system
- Premature aging of the skin

Because of these serious health effects, you should limit your exposure to UV radiation and protect yourself when outdoors.

Types of UV Radiation

Scientists classify UV radiation into three types or bands—UVA, UVB, and UVC. The stratospheric ozone layer absorbs some, but not all, of these types of UV radiation:

UVA: Not absorbed by the ozone layer.

UVB: Mostly absorbed by the ozone layer, but some does reach the Earth's surface.

UVC: Completely absorbed by the ozone layer and oxygen.

UVA and UVB that reach the Earth's surface contribute to the serious health effects listed above.

UV Levels Depend on a Number of Factors

The level of UV radiation that reaches the Earth's surface can vary, depending on a variety of factors. Each of the following factors can increase your risk of UV radiation overexposure and its consequent health effects.

Stratospheric Ozone

The ozone layer absorbs most of the sun's UV rays, but the amount of absorption varies depending on the time of year and other natural phenomena. That absorption also has decreased, as the ozone layer has thinned due to the release of ozone-depleting substances that have been widely used in industry.

Time of Day

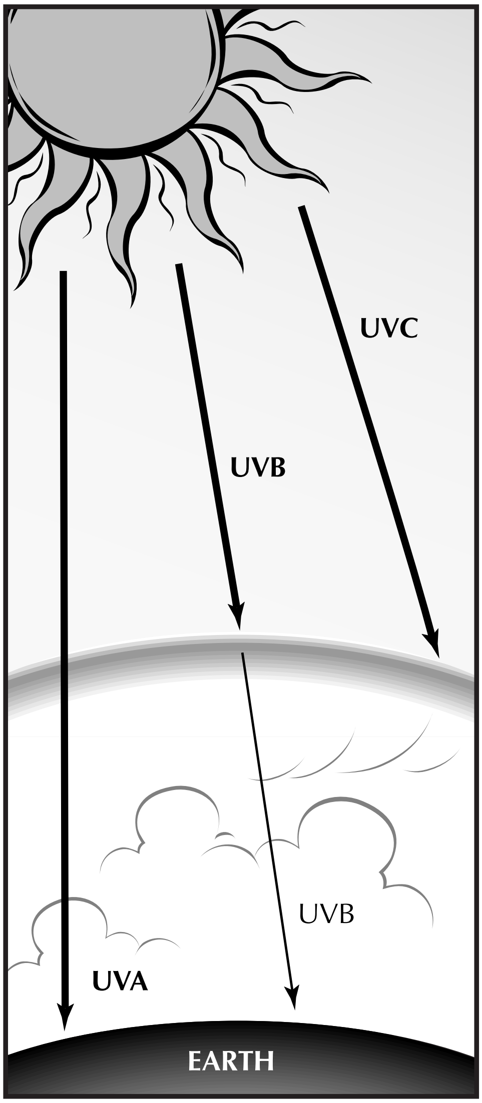
The sun is at its highest in the sky around noon. At this time, the sun's rays have the least distance to travel through the atmosphere and UVB levels are at their highest. In the early morning and late afternoon, the sun's rays pass through the atmosphere at an angle and their intensity is greatly reduced.

Time of Year

The sun's angle varies with the seasons, causing the intensity of UV rays to change. UV intensity tends to be highest during the summer months.

Latitude

The sun's rays are strongest at the equator, where the sun is most directly overhead and UV rays must travel the least distance through the atmosphere. Ozone also is naturally thinner in the tropics compared to the mid- and high-latitudes, so there is less ozone to absorb the UV radiation as it passes through the atmosphere. At higher latitudes the sun is lower in the sky, so UV rays must travel a greater distance through ozone-rich portions of the atmosphere and, in turn, expose those latitudes to less UV radiation.



The stratospheric ozone layer screens out much of the sun's harmful UV radiation.

Altitude

UV intensity increases with altitude because there is less atmosphere to absorb the damaging rays. Thus, when you go to higher altitudes, your risk of overexposure increases.

Weather Conditions

Cloud cover reduces UV levels, but not completely. Depending on the thickness of the cloud cover, it is possible to burn—and increase your risk of long-term skin and eye damage—on a cloudy summer day, even if it does not feel very warm.

Reflection

Some surfaces, such as snow, sand, grass, or water can reflect much of the UV radiation that reaches them. Because of this reflection, UV intensity can be deceptively high even in shaded areas.

EPA's SunWise School Program

In response to the serious public health threat posed by exposure to increased UV levels, the U.S. Environmental Protection Agency (EPA) is working with schools and communities across the nation through the SunWise School Program. SunWise aims to teach children in elementary school and their caregivers how to protect themselves from overexposure to the sun.

For More Information

To learn more about UV radiation, the SunWise School Program, and actions being taken to prevent ozone depletion, call EPA's Stratospheric Ozone Information Hotline at 800 296-1996 or visit our Web site at <www.epa.gov/sunwise>.

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Air and Radiation 6205J
EPA430-F-99-023
September 1999
www.epa.gov/sunwise

EPA

Ozone Depletion

The ozone layer forms a thin shield in the upper atmosphere, protecting life on Earth from the sun's ultraviolet (UV) rays. In the 1980s, scientists began accumulating evidence that the ozone layer was being depleted. Depletion of the ozone layer results in increased UV radiation reaching the Earth's surface, which in turn can lead to a greater chance of overexposure to UV radiation and the related health effects of skin cancer, cataracts, and immune suppression.

What Is Stratospheric Ozone?

Ozone is a naturally occurring gas that is found in two layers of the atmosphere. In the layer surrounding the Earth's surface—the troposphere—ground-level or "bad" ozone is an air pollutant that is a key ingredient of urban smog. The troposphere extends up to the stratosphere, which is where "good" ozone protects life on Earth by absorbing some of the sun's UV rays. Stratospheric ozone is most concentrated between 6 to 30 miles above the Earth's surface.

Ozone Depletion

Until recently, chlorofluorocarbons (CFCs) were used widely in industry and elsewhere as refrigerants, insulating foams, and solvents. Strong winds carry CFCs into the stratosphere in a process that can take as long as 2 to 5 years. When CFCs break down in the stratosphere, they release chlorine, which attacks ozone. Each chlorine atom acts as a catalyst, repeatedly combining with and breaking apart as many as 100,000 ozone molecules during its stratospheric life.

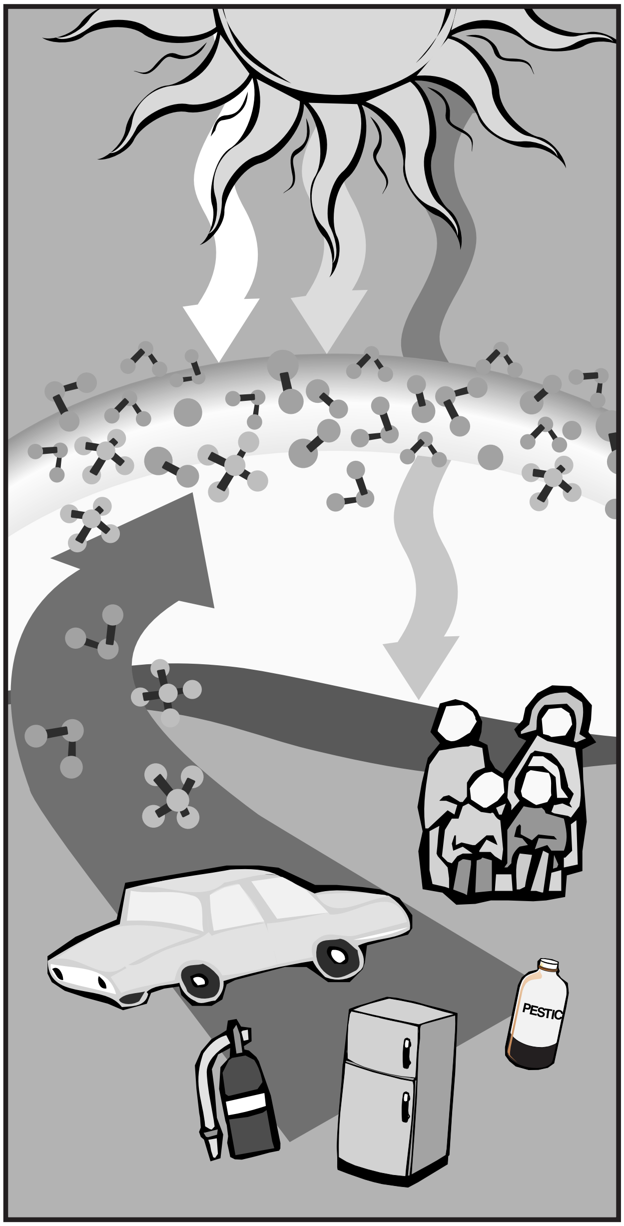
Other ozone-depleting substances include pesticides such as methyl bromide, halons used in fire extinguishers, and methyl chloroform used in industrial processes.

What Is Being Done?

Countries around the world, including the United States, have recognized the threats posed by ozone depletion and adopted a treaty called the Montreal Protocol to phase out the production and use of ozone-depleting substances.

How Ozone Depletion Affects UV Levels

Scientists predict that ozone depletion should peak between 2000 and 2010. As international control measures reduce the release of CFCs and other ozone-depleting substances, natural atmospheric processes will repair the ozone layer around the middle of the 21st century. Until that time, we can expect increased levels of UV radiation at the Earth's surface. These increased UV levels can lead to a greater risk of overexposure to UV radiation and related health effects.



The use and emission of ozone-depleting substances damages the stratospheric ozone layer, which allows more UV rays to reach the Earth's surface and cause adverse human health effects.

EPA's SunWise School Program

In response to the serious public health threat posed by exposure to increased UV levels, the U.S. Environmental Protection Agency (EPA) is working with schools and communities across the nation through the SunWise School Program. SunWise aims to teach children in elementary school and their caregivers about ozone depletion, UV radiation, and how to protect themselves from overexposure to the sun.

For More Information

To learn more about the ozone layer, the SunWise School Program, and actions being taken to prevent ozone depletion, call EPA's Stratospheric Ozone Information Hotline at 800 296-1996 or visit our Web site at <www.epa.gov/sunwise>.

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DATA SHEET: BLUE GROUP: WEATHER

Month # 1

Day 1 Date:	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 2	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 3	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 4	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 5	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									

8:00 AM
4:00 PM (16:00)

Day 6	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 7	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 8	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 9	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 10	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 11	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 12	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 13	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 14	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 15	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

Day 16	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5

Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 17	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 18	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 19	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									
Day 20	enter date here						Carbon		
	WindSpeed	Wind Direction	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)									
8:00 AM									
4:00 PM (16:00)									

							Carbon		
Month 1 Average	WindSpeed		Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
8:00 AM	#DIV/0!								

4:00 PM (16:00)

Standard Deviation	WindSpeed	Humidity	Temperature	Rainfall	Ozone	Monoxide	PM10	PM2.5
Midnight (00:00)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
8:00 AM	#DIV/0!							
4:00 PM (16:00)								

DATA SHEET: Brown Group: Visibility

Time of Day: Write time here

Day #	Date	Visibility Webcam	AQI Ozone (O3)	Carbon Monoxide	Particulates 10	Particulates 2.5	Weather General Conditions	Humidity
1 Mon								
2 Tues								
3 Wed								
4 Thur								
5 Fri								
6 Mon								
7 Tue								
8 Wed								
9 Thur								
10 Fri								
11 Mon								
12 Tue								
13 Wed								
14 Thur								
15 Fri								
16 Mon								
17 Tue								
18 Wed								
19 Thur								
20 Fri								
Month 1 Average		#DIV/0!	#DIV/0!					
Standard Deviation		#DIV/0!	#DIV/0!					

Time of Day:	Write time here	Visibility	AQI				Weather	
Day #	Date	Webcam	Ozone (O3)	Carbon Monoxide	Particulates 10	Particulates 2.5	General Conditions	Humidity
21 Mon								
22 Tue								
23 Wed								
24 Thur								
25 Fri								
26 Mon								
27 Tue								
28 Wed								
29 Thur								
30 Fri								
31 Mon								
32 Tue								
33 Wed								
34 Thur								
35 Fri								
36 Mon								
37 Tue								
38 Wed								
39 Thur								
40 Fri								
Month 2 Average		#DIV/0!	#DIV/0!					
Standard Deviation		#DIV/0!	#DIV/0!					

Time of Day:	Write time here	Visibility	AQI				Weather	
Day #	Date	Webcam	Ozone (O3)	Carbon Monoxide	Particulates 10	Particulates 2.5	General Conditions	Humidity
41 Mon								
42 Tue								
43 Wed								
44 Thur								
45 Fri								
46 Mon								
47 Tue								
48 Wed								
49 Thur								
50 Fri								
51 Mon								
52 Tue								
53 Wed								
54 Thur								
55 Fri								
56 Mon								
57 Tue								
58 Wed								
59 Thur								
60 Fri								
Month 3 Average		#DIV/0!	#DIV/0!					
Standard Deviation		#DIV/0!	#DIV/0!					

Time of Day:	Write time here	Visibility	AQI				Weather	
Day #	Date	Webcam	Ozone (O3)	Carbon Monoxide	Particulates 10	Particulates 2.5	General Conditions	Humidity
61 Mon								
62 Tue								
63 Wed								
64 Thur								
65 Fri								
66 Mon								
67 Tue								
68 Wed								
69 Thur								
70 Fri								
71 Mon								
72 Tue								
73 Wed								
74 Thur								
75 Fri								
76 Mon								
77 Tue								
78 Wed								
79 Thur								
80 Fri								
Month 4 Average		#DIV/0!	#DIV/0!					
Standard Deviation		#DIV/0!	#DIV/0!					

Time of Day:	Write time here	Visibility	AQI				Weather	
Day #	Date	Webcam	Ozone (O3)	Carbon Monoxide	Particulates 10	Particulates 2.5	General Conditions	Humidity
81 Mon								
82 Tue								
83 Wed								
84 Thur								
85 Fri								
86 Mon								
87 Tue								
88 Wed								
89 Thur								
90 Fri								
91 Mon								
92 Tue								
93 Wed								
94 Thur								
95 Fri								
96 Mon								
97 Tue								
98 Wed								
99 Thur								
100 Fri								
Month 5 Average		#DIV/0!	#DIV/0!					
Standard Deviation		#DIV/0!	#DIV/0!					

Ozone		GREEN GROUP: LOCATION Using 8 Hour AQI				
DAY	DATE	Children's Park	Craycroft & 22nd	Downtown	Saguaro	Tangerine
1 Mon						
2 Tues						
3 Wed						
4 Thur						
5 Fri						
Average		**#DIV/0!**	**#DIV/0!**			
tandard Deviation		#DIV/0!				
6 Mon						
7 Tue						
8 Wed						
9 Thur						
10 Fri						
Average		**#DIV/0!**				
tandard Deviation		#DIV/0!				
11 Mon						
12 Tue						
13 Wed						
14 Thur						
15 Fri						
Average		**#DIV/0!**				
tandard Deviation		#DIV/0!				
16 Mon						
17 Tue						
18 Wed						
19 Thur						
20 Fri						
Average		**#DIV/0!**				
Standard Deviation		#DIV/0!				
Month 1 Average		**#DIV/0!**				
Standard Deviation		**#DIV/0!**				

Month # 2

DAY	DATE	Children's Park	Craycroft & 22nd	Downtown	Saguaro	Tangerine
21 Mon						
22 Tue						
23 Wed						
24 Thur						
25 Fri						
Average						
Standard Deviation						
26 Mon						
27 Tue						
28 Wed						
29 Thur						
30 Fri						
Average						
Standard Deviation						
31 Mon						
32 Tue						
33 Wed						
34 Thur						
35 Fri						
Average						
Standard Deviation						
36 Mon						
37 Tue						
38 Wed						
39 Thur						
40 Fri						
Average						
Standard Deviation						
Month 2 Average						
Standard Deviation						

Month # 3

DAY	DATE	Children's Park	Craycroft & 22nd	Downtown	Saguaro	Tangerine
41 Mon						
42 Tue						
43 Wed						
44 Thur						
45 Fri						
Average						
tandard Deviation						
46 Mon						
47 Tue						
48 Wed						
49 Thur						
50 Fri						
Average						
tandard Deviation						
51 Mon						
52 Tue						
53 Wed						
54 Thur						
55 Fri						
Average						
tandard Deviation						
56 Mon						
57 Tue						
58 Wed						
59 Thur						
60 Fri						
Average						
Standard Deviation						
Month 3 Average						
Standard Deviation						

Month # 4

DAY	DATE	Children's Park	Craycroft & 22nd	Downtown	Saguaro	Tangerine
61 Mon						
62 Tue						
63 Wed						
64 Thur						
65 Fri						
Average						
tandard Deviation						
66 Mon						
67 Tue						
68 Wed						
69 Thur						
70 Fri						
Average						
tandard Deviation						
71 Mon						
72 Tue						
73 Wed						
74 Thur						
75 Fri						
Average						
tandard Deviation						
76 Mon						
77 Tue						
78 Wed						
79 Thur						
80 Fri						
Average						
Standard Deviation						
Month 4 Average						
Standard Deviation						

Month # 5

DAY	DATE	Children's Park	Craycroft & 22nd	Downtown	Saguaro	Tangerine
81 Mon						
82 Tue						
83 Wed						
84 Thur						
85 Fri						
Average						
Standard Deviation						
86 Mon						
87 Tue						
88 Wed						
89 Thur						
90 Fri						
Average						
Standard Deviation						
91 Mon						
92 Tue						
93 Wed						
94 Thur						
95 Fri						
Average						
Standard Deviation						
96 Mon						
97 Tue						
98 Wed						
99 Thur						
100 Fri						
Average						
Standard Deviation						
Month 5 Average						
Standard Deviation						

Practice Data Sheet

Month # 1

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
1 Mon	1/27/2001					
2 Tues						
3 Wed						
4 Thur						
5 Fri						
Average		**#DIV/0!**				
Standard Deviation		#DIV/0!				
6 Mon						
7 Tue						
8 Wed						
9 Thur						
10 Fri						
Average		**#DIV/0!**				
Standard Deviation		#DIV/0!				
11 Mon						
12 Tue						
13 Wed						
14 Thur						
15 Fri						
Average		**#DIV/0!**				
Standard Deviation		#DIV/0!				
DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
16 Mon						

17 Tue	
18 Wed	
19 Thur	
20 Fri	
Average	**#DIV/0!**
Standard Deviation	#DIV/0!
Month 1 Average	**#DIV/0!**
Standard Deviation	**#DIV/0!**

DATA SHEET: GREEN GROUP: LOCATION

Comparing Pollutants By Location Using 8 Hour AQI

Start Date:
Month # 2

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
21 Mon						
22 Tue						
23 Wed						
24 Thur						
25 Fri						
Average						
Standard Deviation						
26 Mon						
27 Tue						
28 Wed						
29 Thur						
30 Fri						
Average						
Standard Deviation						
31 Mon						
32 Tue						
33 Wed						
34 Thur						
35 Fri						

Average						
Standard Deviation						
DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
36 Mon						
37 Tue						
38 Wed						
39 Thur						
40 Fri						
Average						
Standard Deviation						
Month 2 Average						
Standard Deviation						

DATA SHEET: GREEN GROUP: LOCATION

Comparing Pollutants By Location Using 8 Hour AQI

Start Date:
Month # 3

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
41 Mon						
42 Tue						
43 Wed						
44 Thur						
45 Fri						
Average						
Standard Deviation						
46 Mon						
47 Tue						
48 Wed						
49 Thur						
50 Fri						
Average						
Standard Deviation						
51 Mon						
52 Tue						
53 Wed						
54 Thur						
55 Fri						

Average						
Standard Deviation						
DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
56 Mon						
57 Tue						
58 Wed						
59 Thur						
60 Fri						
Average						
Standard Deviation						
Month 3 Average						
Standard Deviation						

DATA SHEET: GREEN GROUP: LOCATION
Comparing Pollutants By Location Using 8 Hour AQI

Start Date:
Month # 4

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
61 Mon						
62 Tue						
63 Wed						
64 Thur						
65 Fri						
Average						
Standard Deviation						
66 Mon						
67 Tue						
68 Wed						
69 Thur						
70 Fri						
Average						
Standard Deviation						
71 Mon						
72 Tue						
73 Wed						
74 Thur						
75 Fri						

Average
Standard Deviation

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
76 Mon						
77 Tue						
78 Wed						
79 Thur						
80 Fri						
Average						
Standard Deviation						
Month 4 Average						
Standard Deviation						

DATA SHEET: GREEN GROUP: LOCATION

Comparing Pollutants By Location Using 8 Hour AQI

Start Date:
Month # 5

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
81 Mon						
82 Tue						
83 Wed						
84 Thur						
85 Fri						
Average						
Standard Deviation						
86 Mon						
87 Tue						
88 Wed						
89 Thur						
90 Fri						
Average						
Standard Deviation						
91 Mon						
92 Tue						
93 Wed						
94 Thur						
95 Fri						

Average
Standard Deviation

DAY	DATE	Alvernon & 22nd	Cherry & Glenn	Children's Park	Craycroft & 22nd	Downtown
96 Mon						
97 Tue						
98 Wed						
99 Thur						
100 Fri						
Average						
Standard Deviation						
Month 5 Average						
Standard Deviation						

DATA SHEET: RED GROUP: TIME

Month # 1

Monitoring Location:

Date:

Day:	1 M	2 T	3W	4Th	5 F	Average	Standard Deviatio	6 M	7 T	8 W	9Th	10F	Average	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!
1:00						#DIV/0!	#DIV/0!							
2:00						#DIV/0!	#DIV/0!							
3:00						#DIV/0!	#DIV/0!							
4:00														
5:00 AM														
6:00														
7:00														
8:00														
9:00														
10:00														
11:00														
Noon														
1:00 PM														
14:00														
15:00														
16:00														
17:00														
18:00														
19:00														
20:00														
21:00														
22:00														

Carbon Monoxide

Month 1 Cont'd DATA SHEET: RED GROUP: TIME

Monitoring Location:

Date:															Average	Standard
Day:	11M	12T	13W	14Th	15F	Average	Standard Deviatio	16M	17 T	18 W	19Th	20F	Average	Standard Deviatio	Month 1	Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1:00															#DIV/0!	#DIV/0!
2:00															#DIV/0!	#DIV/0!
3:00																#DIV/0!
4:00																#DIV/0!
5:00 AM																#DIV/0!
6:00																#DIV/0!
7:00																#DIV/0!
8:00																#DIV/0!
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Noon																#DIV/0!
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20:00																#DIV/0!
21:00																#DIV/0!

22:00							#DIV/0!
23:00							#DIV/0!

Page 3

DATA SHEET: RED GROUP: TIME

Month # 2
Monitoring Location:

Date:

Day :	21M	22T	23W	24Th	25F	Average	Standard Deviatio	26M	27T	28W	29Th	30F	Average	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!
1:00														
2:00														
3:00														
4:00														
5:00 AM														
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Noon														
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19:00														
20:00														

21:00						
22:00						
23:00						

Month 2 Cont'd

DATA SHEET: RED GROUP: TIME

Monitoring Location:

Date:

Day:	31M	32T	33W	34Th	35F	Average	Standard Deviatio	36M	37T	38W	39Th	40F	Average	Standard Deviatio	Average Month 1	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1:00																#DIV/0!
2:00																#DIV/0!
3:00																#DIV/0!
4:00																#DIV/0!
5:00 AM																#DIV/0!
6:00																#DIV/0!
7:00																#DIV/0!
8:00																#DIV/0!
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Noon																#DIV/0!
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17:00																#DIV/0!
18:00																#DIV/0!
19:00																#DIV/0!

20:00	#DIV/0!
21:00	#DIV/0!
22:00	#DIV/0!
23:00	#DIV/0!

DATA SHEET: RED GROUP: TIME

Month # 3

Monitoring Location:

Date:

Day:	41M	42T	43W	44Th	45F	Average	Standard Deviatio	46M	47T	48W	49Th	50F	Average	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!
1:00														
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3:00														
4:00														
5:00 AM														
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19:00								
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21:00								
22:00								
23:00								

Month 3 Cont'd DATA SHEET: RED GROUP: TIME

Monitoring Location:

Date:

Day:	51M 52T 53W 54Th 55F	Average	Standard Deviatio	56M 57T 58W 59Th 60F	Average	Standard Deviatio	Average Month 1	Standard Deviation
Midnight		#DIV/0!	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1:00								#DIV/0!
2:00								#DIV/0!
3:00								#DIV/0!
4:00								#DIV/0!
5:00 AM								#DIV/0!
6:00								#DIV/0!
7:00								#DIV/0!
8:00								#DIV/0!
9:00								#DIV/0!
10:00								#DIV/0!
11:00								#DIV/0!
Noon								#DIV/0!
1:00 PM								#DIV/0!
14:00								#DIV/0!
15:00								#DIV/0!

16:00							#DIV/0!
17:00							#DIV/0!
18:00							#DIV/0!
19:00							#DIV/0!
20:00							#DIV/0!
21:00							#DIV/0!
22:00							#DIV/0!
23:00							#DIV/0!

DATA SHEET: RED GROUP: TIME

Month # 4

Monitoring Location:

Date:

Day:	61M	62T	63W	64Th	65F	Average	Standard Deviatio	66M	67T	68W	69Th	70F	Average	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!
1:00														
2:00														
3:00														
4:00														
5:00 AM														
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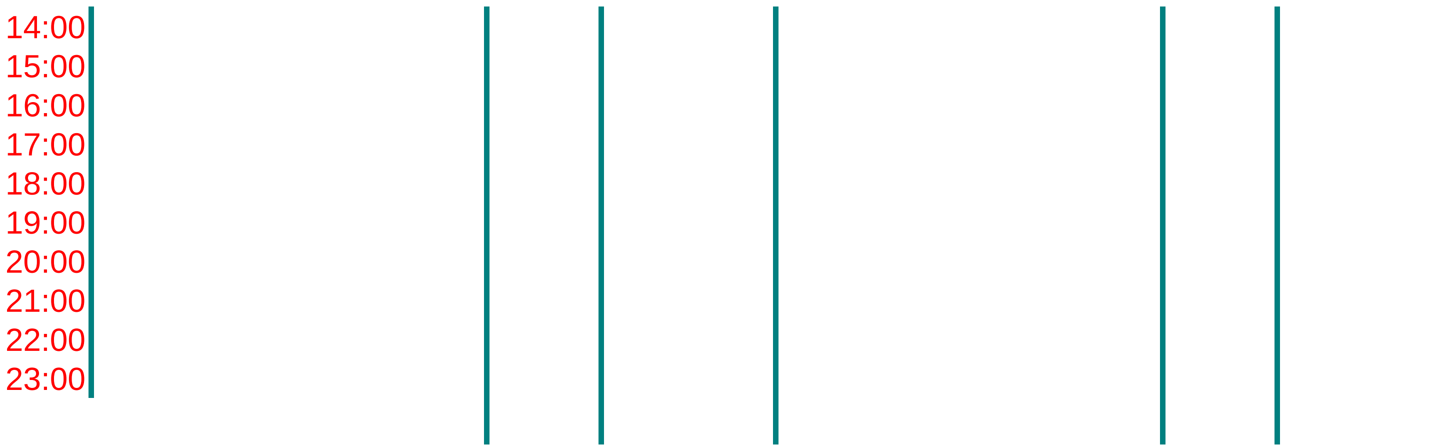
7:00														
8:00														
9:00														
10:00														
11:00														
Noon														
1:00 PM														

Carbon Monoxide



Month 4 Cont'd DATA SHEET: RED GROUP: TIME

Monitoring Location:

Date:

Day:	71M	72T	73W	74Th	75F	Average	Standard Deviatio	76M	77T	78W	79Th	80F	Average	Standard Deviatic	Average Month 1	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1:00																#DIV/0!
2:00																#DIV/0!
3:00																#DIV/0!
4:00																#DIV/0!
5:00 AM																#DIV/0!
6:00																#DIV/0!
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11:00																#DIV/0!
Noon																#DIV/0!
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18:00																#DIV/0!
19:00																#DIV/0!
20:00																#DIV/0!
21:00																#DIV/0!
22:00																#DIV/0!

23:00							#DIV/0!

DATA SHEET: RED GROUP: TIME

Month # 5

Monitoring Location:

Date:

Day:	81M	82T	83W	84Th	85F	Average	Standard Deviatio	86M	87T	88W	89Th	90F	Average	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!
1:00														
2:00														
3:00														
4:00														
5:00 AM														
6:00														
7:00														
8:00														
9:00														
10:00														
11:00														
Noon														
1:00 PM														
14:00														
15:00														
16:00														
17:00														
18:00														
19:00														
20:00														

21:00						
22:00						
23:00						

DATA SHEET: RED GROUP: TIME

Month 5 Cont'd

Monitoring Location:

Date:

Day:	91M	92T	93W	94Th	95F	Average	Standard Deviatio	96M	97T	98W	99Th	100F	Average	Standard Deviatic	Average Month 1	Standard Deviation
Midnight						#DIV/0!	#DIV/0!						#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1:00																#DIV/0!
2:00																#DIV/0!
3:00																#DIV/0!
4:00																#DIV/0!
5:00 AM																#DIV/0!
6:00																#DIV/0!
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8:00																#DIV/0!
9:00																#DIV/0!
10:00																#DIV/0!
11:00																#DIV/0!
Noon																#DIV/0!
1:00 PM																#DIV/0!
14:00																#DIV/0!
15:00																#DIV/0!
16:00																#DIV/0!
17:00																#DIV/0!
18:00																#DIV/0!

Carbon Monoxide

19:00							#DIV/0!
20:00							#DIV/0!
21:00							#DIV/0!
22:00							#DIV/0!
23:00							#DIV/0!

Month 1 DATA SHEET: Yellow Group: Health Effects

		# Asthma Attacks				AQI		Particulates	
Day #	Date	Location 1	Location 2	Location 3	Total	Carbon Monoxide	Ozone (O3)	PM 10	PM 2.5
1 Mon					0				
2 Tue					0				
3 Wed									
4 Thur									
5 Fri									
6 Mon									
7 Tue									
8 Wed									
9 Thur									
10 Fri									
11 Mon									
12 Tue									
13 Wed									
14 Thur									
15 Fri									
16 Mon									
17 Tue									
18 Wed									
19 Thur									
20 Fri									
Month 1 Average					0	#DIV/0!			
Standard Deviation					0	#DIV/0!			

Month 2 DATA SHEET: Yellow Group: Health Effects

Day #	Date	# Asthma Attacks Location 1	Location 2	Location 3	Total	AQI Carbon Monoxic	Ozone (O3)	Particulates PM 10	PM 2.5
21 Mon									
22 Tue									
23 Wed									
24 Thur									
25 Fri									
26 Mon									
27 Tue									
28 Wed									
29 Thur									
30 Fri									
31 Mon									
32 Tue									
33 Wed									
34 Thur									
35 Fri									
36 Mon									
37 Tue									
38 Wed									
39 Thur									
40 Fri									
Month 2 Average					#DIV/0!	#DIV/0!			
Standard Deviation					#DIV/0!	#DIV/0!			

Month 3		# Asthma Attacks				AQI		Particulates	
Day #	Date	Location 1	Location 2	Location 3	Total	Carbon Monoxic	Ozone (O3)	PM 10	PM 2.5
41 Mon									
42 Tue									
43 Wed									
44 Thur									
45 Fri									
46 Mon									
47 Tue									
48 Wed									
49 Thur									
50 Fri									
51 Mon									
52 Tue									
53 Wed									
54 Thur									
55 Fri									
56 Mon									
57 Tue									
58 Wed									
59 Thur									
60 Fri									
Month 3 Average					#DIV/0!	#DIV/0!			
Standard Deviation					#DIV/0!	#DIV/0!			

Month 4		# Asthma Attacks				AQI		Particulates	
Day #	Date	Location 1	Location 2	Location 3	Total	Carbon Monoxic	Ozone (O3)	PM 10	PM 2.5
61 Mon									
62 Tue									
63 Wed									
64 Thur									
65 Fri									
66 Mon									
67 Tue									
68 Wed									
69 Thur									
70 Fri									
71 Mon									
72 Tue									
73 Wed									
74 Thur									
75 Fri									
76 Mon									
77 Tue									
78 Wed									
79 Thur									
80 Fri									
Month 4 Average									
Standard Deviation									

Month 5		# Asthma Attacks				AQI		Particulates	
Day #	Date	Location 1	Location 2	Location 3	Total	Carbon Monoxic	Ozone (O3)	PM 10	PM 2.5
81 Mon									
82 Tue									
83 Wed									
84 Thur									
85 Fri									
86 Mon									
87 Tue									
88 Wed									
89 Thur									
90 Fri									
91 Mon									
92 Tue									
93 Wed									
94 Thur									
95 Fri									
96 Mon									
97 Tue									
98 Wed									
99 Thur									
100 Fri									
Month 5 Average									
Standard Deviation									