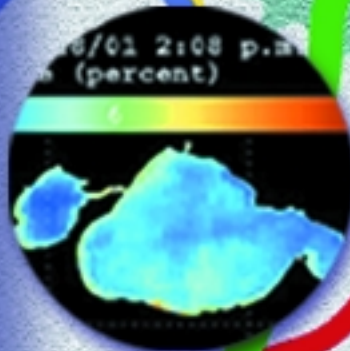
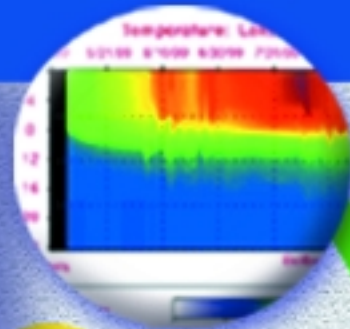






Risk Communication in Action: Environmental Case Studies

DATA
GIS
River
Ozone
Air Quality
Index



-  Excellent
-  Good
-  Fair
-  Poor

EMPACT

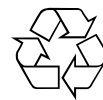
Environmental Monitoring for Public Access
& Community Tracking

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September 2002

RISK COMMUNICATION IN ACTION: ENVIRONMENTAL CASE STUDIES

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



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INTRODUCTION: TOOLS FOR COMMUNICATING ENVIRONMENTAL HEALTH RISKS TO THE PUBLIC

Communicating environmental health risks to the public has increasingly become a responsibility of local and state officials and private groups involved in environmental monitoring. People have come to expect access to more information about local air and water quality, for example, and advances in environmental monitoring and computer technology (such as the Internet) have made time—sometimes daily—communication of environmental conditions possible. The experiences of the U.S. Environmental Protection Agency (EPA), state governments, and some local governments and private organizations in providing such time-relevant environmental risk communication can help other municipalities, states, and private groups develop or expand their own local environmental risk communication programs.

This handbook reflects the experiences of a variety of projects that have been part of EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program, which was active from 1996 to 2002. A key goal of the EMPACT Program was to facilitate the process of providing the public with time-relevant environmental information, including information on any health risks associated with certain environmental conditions. Achieving this goal involved helping communities identify and use effective ways to collect, manage, and distribute timely environmental and health risk information; it also involved sharing the experiences of various municipalities that have successfully accomplished these objectives.

Local and state EMPACT projects have been involved in a variety of environmental monitoring and risk communication activities, such as air quality monitoring and beach, lake, and river monitoring. In the course of these activities, certain tools and combinations of tools have proven to be effective for environmental risk communication, particularly *data visualization* and *data interpretation* tools. Data visualization tools graphically depict, in this context, environmental health risks or environmental quality conditions. Data interpretation tools describe complex scientific concepts in relatively simple terms (as index values, for example); this can help people understand the potential health risks associated with exposure to certain environmental conditions (such as air pollution). Some projects have developed such tools on a national scale, and some of these tools are available “as is” or are easily adaptable for use by localities to report local environmental conditions. Examples include EPA's AIRNow project for air quality and the EPA SunWise project on UV radiation exposure from the sun. Other tools were developed on a more regional or local scale; some of these tools could be adopted by other communities (such as beach flags indicating local water quality, or the use of color-coded indexes or maps).

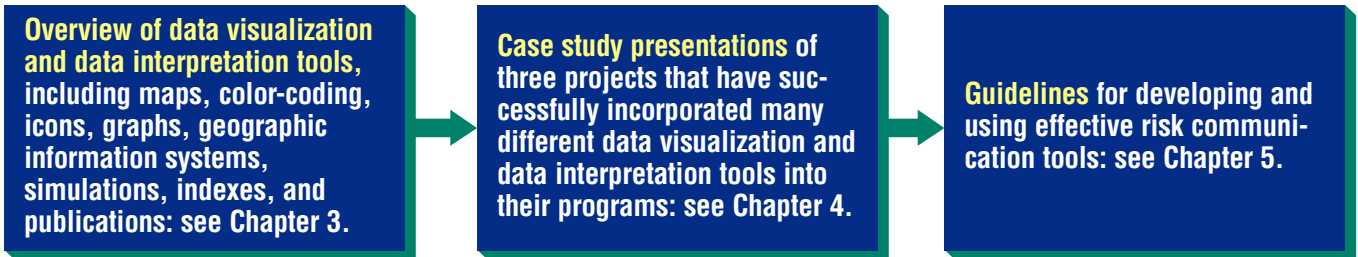
This handbook discusses a wide variety of data visualization and data interpretation tools that municipalities involved in EMPACT projects have used successfully in environmental risk communication programs. The handbook explains what the tools are and how they can be used, and also presents a number of case studies of projects using such tools. It also provides some basic guidelines for developing and using data visualization and data interpretation tools. EPA hopes that sharing this information will help other states and municipalities establish environmental risk communication programs and expand existing programs to incorporate timelier, more effective risk communication methods.

2

HOW TO USE THIS HANDBOOK

This handbook provides both general and detailed information on how to use a wide variety of data visualization and data interpretation tools for effective environmental risk communication. The handbook is intended for local and state officials, environmental groups, and others who are responsible for communicating environmental conditions and associated health risks to the public. The handbook is organized as described below.

2.1 ROAD MAP



2.2 FREQUENTLY ASKED QUESTIONS

Whether you are just beginning to consider developing an environmental risk communication program or are in the process of expanding your program, the following *frequently asked questions* may be useful.

Q: What are data visualization and data interpretation tools, and why are they important?

A: Data visualization tools present information primarily through images (such as maps, icons, and pie charts) rather than words. Data interpretation tools (such as indexes) describe complex scientific concepts in relatively simple terms. Both of these tools can be particularly powerful in communicating information about environmental quality conditions (such as water quality) and environmental health risks.

Q: What is time-relevant risk communication?

A: The term “time-relevant” refers to the goal of providing real-time (such as daily or near-daily) environmental information. Providing time-relevant information can be particularly important when one seeks to communicate environmental risks, because such risks depend on conditions (such as air or water quality) that can change each day. The Internet and other data visualization and data interpretation tools often make it possible to communicate environmental risk information fairly quickly.

Q: What are some of the most effective ways to inform the public about environmental risks?

A: According to the experience of some environmental risk communication projects, the most effective ways to disseminate environmental risk information may include establishing a Web site that displays a variety of data visualization tools (e.g., maps, color-coded charts), arranging for local news media to present your information, establishing a telephone hotline, and developing a collection of printed materials. Many other outreach methods may also be effective, such as setting up kiosks at strategic locations to distribute information (sometimes on onsite computers), giving presentations to local officials and others, and incorporating the information into school science curriculums.

Q: Why is it sometimes desirable to make special presentations to children, senior citizens, and people with certain health problems?

A: Children, senior citizens, and people with certain illnesses are often uniquely sensitive to the kinds of environmental problem that time-relevant monitoring typically addresses, such as ozone pollution and UV radiation. Therefore, it is sometimes worthwhile to tailor special materials for these audiences, since their issues and concerns may differ significantly from those of the general population.

Q: How can our program avoid jargon and complex language in the materials we develop on environmental risks?

A: One solution is to use graphic images as much as possible to convey your message in your materials. When you need to use language, first think about the literacy and education levels of your audience, and then tailor your language so that it will be comprehensible to the vast majority of that audience. With some effort and good writing skills, it is usually possible to express a complex concept clearly and in relatively simple terms. Where literacy and education vary dramatically, you may want to develop several editions of your written materials for different reading levels. Also, focus groups and interviews with members of your target audience can play an important role in identifying any jargon or overly complex language.

3

DATA VISUALIZATION AND DATA INTERPRETATION TOOLS FOR ENVIRONMENTAL RISK COMMUNICATION

3.1 INTRODUCTION

This chapter describes specific data visualization and data interpretation tools that can often improve risk communication by presenting environmental risk information in more “user-friendly” ways. Examples of each tool from actual EMPACT projects are provided. If you are considering using some of these tools for environmental risk communication, check to see whether any data visualization or data interpretation tools already exist that can meet your needs or be modified to do so. Some municipalities and organizations have successfully used tools developed by other projects.

Experience has shown that the most effective tools are simple to understand and use, provide consistent messages, and reflect a uniform system that aligns with or complements already existing systems. For example, if you use color-coding, use colors that are commonly used, understood, and associated with particular messages (e.g., green for “go,” red for “stop”). Also, your tools will be more effective if they can be adapted to fit a variety of presentation formats (e.g., Web sites, brochures, presentations) and the requirements of the media (e.g., print, television, radio).

Section 3.2 describes a variety of data visualization tools, and Section 3.3 describes some important data interpretation tools. Section 3.4 summarizes the ways that risk information can be distributed to your audiences (e.g., the Internet, newspapers, television). The ways in which projects have developed and used several of these tools, often in conjunction with one another (e.g., a color-coded index) are described throughout this chapter and in Chapter 4.

3.2 DATA VISUALIZATION TOOLS

In this handbook, data visualization tools are any graphic representation of data to communicate health risks or other aspects of environmental quality. Presenting data in a visual format can enhance your audience’s understanding of and interest in the data. Data visualization tools discussed below include maps, color-coding, icons, graphs, geographic information systems (GIS), and simulations.

3.2.1 HOW CAN MAPS BE USED FOR ENVIRONMENTAL RISK COMMUNICATION?

Maps are one of the most basic and familiar data visualization tools that can be used to communicate time-relevant environmental quality information for particular locations. A map showing environmental quality data can be based on specific geographic information (as in Figure 3-1) or it can illustrate environmental quality conditions on a broader conceptual scale, as in Figure 3-2. If kept simple (e.g., clutter-free) and accompanied by a good key that explains the symbols it uses, a map can be one of the easiest data interpretation and visualization tools to develop and/or use. Figures 3-1 and 3-2 below illustrate how one EMPACT project, the SunWise Project, has successfully used different types of maps in its risk communication efforts. SunWise staff developed the maps to be intuitive and consistent with other map-reporting systems, such as the EMPACT AIRNow map for ozone (see Chapter 4 for a discussion of the AIRNow project). Many other EMPACT projects have also developed and used maps (see Chapter 4 for examples). The AIRNow project, for example, uses animated maps that depict the formation and movement of ozone throughout the course of the day; the colors on the map change as the ozone concentrations change.

Figure 3-1. Daily UV Index map (site-specific). This map illustrates, on a daily basis, the levels of ultraviolet (UV) radiation in the atmosphere at specific geographic locations nationwide. (Overexposure to UV radiation can cause immediate effects such as sunburn and long-term problems such as skin cancer and cataracts.) Forecast UV levels are superimposed on the map so that users can obtain an idea of the UV radiation levels to which they could be exposed. Specific geographic locations for which environmental quality are available are generally easy to locate on the map, and a simple key explains the map's numbering system and color-coding. The key also translates numerical UV Index levels into different color-coded exposure categories of minimal, low, moderate, high, and very high exposure. See Section 3.3.1 for more information about the UV Index. Sources: U.S. EPA, 2002a (<http://www.epa.gov/sunwise>); U.S. EPA, 2002b (<http://www.epa.gov/oei>); National Weather Service, 2002 (<http://www.nws.noaa.gov>).

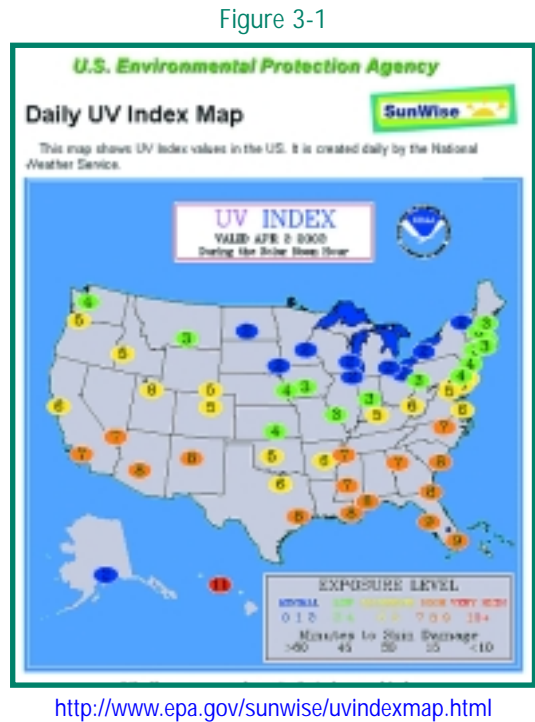
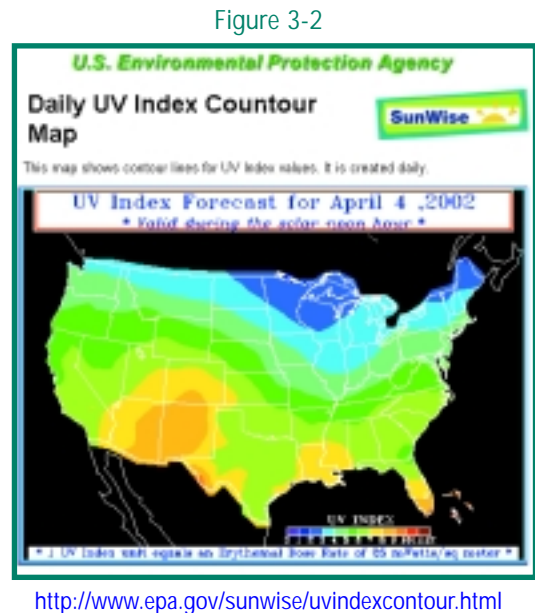


Figure 3-2. Daily UV Index contour map. This map shows another way to communicate UV exposure levels. Rather than indicating specific locations (as Figure 3-1 does), this map uses color-coded areas to identify UV levels in general regions of the country on a daily basis. Source: U.S. EPA, 2002a (<http://www.epa.gov/sunwise>).



3.2.2 HOW CAN COLOR-CODING SHOW ENVIRONMENTAL QUALITY CONDITIONS?

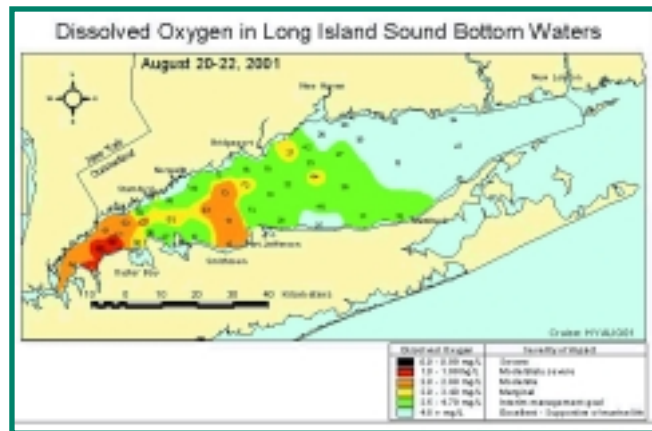
Like maps, color-coding is already familiar to many people, and thus its message can be easily understood. The use of color-coding to indicate “good” or “poor” environmental quality conditions (and ranges between those extremes) has been combined successfully with maps, graphs, indexes, icons, and other tools for risk communication. Appropriate choices of colors (and ranges of colors) can enhance a viewer’s understanding. For example, using generally universally known color-coding schemes, such as green to represent “go” (e.g., the air quality in a particular area today is good, with little or no risk) and red to represent “stop” (e.g., the air quality in this location today is unhealthy, and people may experience health effects) is recommended.

Like maps, color-coding is already familiar to many people, and thus its message can be easily understood. The use of color-coding to indicate “good” or “poor” environmental quality conditions (and ranges between those extremes) has been combined successfully with maps, graphs, indexes, icons, and other tools for risk communication. Appropriate choices of colors (and ranges of colors) can enhance a viewer’s understanding. For example, using generally universally known color-coding schemes, such as green to represent “go” (e.g., the air quality in a particular area today is good, with little or no risk) and red to represent “stop” (e.g., the air quality in this location today is unhealthy, and people may experience health effects) is recommended.

Figure 3-3 is an example of using color-coding in maps. Examples of color-coding used in conjunction with other data visualization tools can be found throughout this handbook. Chapter 4 discusses how specific projects use color-coding.

Figure 3-3. Color-coding used to indicate dissolved oxygen levels. Using a combination of mapping and color-coding, the Connecticut Department of Environmental Protection developed a system to express dissolved oxygen levels, which serve as one indicator of water quality. The colors selected range from blue for excellent dissolved oxygen levels that support marine life to black for severely impaired waters with very low dissolved oxygen levels. Additional clearly differentiated colors (green, yellow, orange, and red) indicate intermediate levels of water quality conditions. Source: University of Connecticut, 2002 (<http://www.mysound.uconn.edu/index.html>).

Figure 3-3



<http://www.dep.state.ct.us/wtr/lis/monitoring/hyaug01.jpg>

3.2.3 HOW ARE ICONS (OR IMAGES) USED IN ENVIRONMENTAL RISK COMMUNICATION?

The term “icon” is used here in a very general sense to describe any visual cue, or image, that is used to communicate information—anything from a physical placard (e.g., a beach closure symbol or sign) to a symbol on a computer screen. Although words may be added, an icon should ideally be able to convey at least its basic meaning without relying on language. For example, the Charles River/Boston Harbor project uses two icons, as shown in Figure 3-4, to indicate whether water quality conditions in certain areas of the river or harbor are suitable for boating or whether health risks exist. These symbols are used both on the program Web site and on actual flags that are posted at boat houses along the Charles River. Another beach water quality program, the Southeastern Wisconsin Beach Health Program, uses an icon of a swimmer and an icon of a crossed-out swimmer to indicate the concepts of open and closed swimming beaches (see Chapter 5 and <http://infotrek.er.usgs.gov/pls/beachhealth>). Other examples of icons used to indicate environmental quality or health risks are included in Chapter 4.

Figure 3-4. Icons used in beach flagging program. The Charles River/Boston Harbor project uses different-colored flags with an icon of a boat on its Web site (and actual flags at various sites on the river, including boat launches) to quickly and easily communicate water quality and health risks to recreational water users. Blue flags indicate that water quality conditions are suitable for boating, while red flags, with a line through the boat, indicate potential health risks from boating at a particular place and time. Source: Charles River Watershed Association, 2002 (<http://www.crwa.org/wq/daily/2002/daily.html>).

Figure 3-4



<http://www.crwa.org/wq/daily/2001/daily.html>

3.2.4 HOW ARE GRAPHS USED TO SHOW TIME-RELEVANT ENVIRONMENTAL DATA?

Graphs are another commonly used and relatively easy-to-understand data visualization tool. They are often used to convey information about how several variables are related or compare. EMPACT projects such as Lake Access (see Chapter 4) and the Boulder Area Sustainability Information Network (<http://bcn.boulder.co.us/basin>) allow users to generate graphs as needed by specifying which variables they want plotted, as shown in Figure 3-5, and also how they would like them plotted. For example, the Lake Access Web site lets users plot variables as changing bands of color rather than as lines.

Figure 3-5. Use of a graph to plot several water quality parameters. Using a “profile plotter” application, users of the Lake Access project Web site can choose from a number of different water quality variables to plot, including temperature, pH, specific conductance, dissolved oxygen, and turbidity. This particular graph shows temperature, pH, and dissolved oxygen concentrations at various depths in a particular lake at 4:00 a.m. on October 22, 2001, in the form of a lake profile line plot. Graphing these and other water quality variables can reveal how water quality changes over time and depth. *Source:* Lake Access, 2002 (www.lakeaccess.org).

Figure 3-5



3.2.5 GEOGRAPHIC INFORMATION SYSTEMS

GIS are effective data visualization tools for displaying, analyzing, and modeling spatial or geographic information. A GIS can be used to generate maps, animations, and two- and three-dimensional models once detailed data are input into the system by skilled staff. (This process can be labor-intensive and fairly expensive.) Two key advantages of GIS are that it allows users to quickly overlay and view several different data layers simultaneously, such as open-space lands, water resources, and population, and that it lets users view and compare different future scenarios (such as future land uses) and their possible impacts (e.g., on environmental resources). State environmental agencies and private organizations are increasingly developing GIS maps that include environmental and related features, such as hydrology, land uses, zoning codes, soils, topography, political boundaries, watershed boundaries, and transportation data. These maps may be readily available for display and use, including through the Internet. Often users can retrieve information, generate maps (including customized maps), and query data simply by clicking on a map feature. However, some GIS maps are relevant for only particular geographic locations. Once developed, GIS maps are relatively easy to use and understand by local officials and the public. Figure 3-6 shows a color-coded GIS map that focuses on land uses and water quality.

3.3.1 WHAT ARE ENVIRONMENTAL INDEXES?

Indexing is a data interpretation tool that involves expressing one or more quantitative measurements as part of a scale—for instance, a scale ranging from poor to excellent. An environmental index might range, for example, from 0 (representing low risk of exposure) to 100 (representing a high exposure risk). Or, instead of a health risk, one or more environmental conditions might be represented (e.g., dissolved oxygen levels as one indication of water quality). The development of an index often also involves establishing “weighting factors” (i.e., giving the more important variables more weight than less important variables) as well as an equation for combining all the relevant data values into the index scale.

When you develop or use indexes, related color-coding schemes or other data visualization and data interpretation tools, you will often need to decide where “good” (or “low risk”) ends and “poor” (or “high risk”) begins, as well as how additional intermediate ranges are to be determined. These key junctures are “cutoff” points that identify the important data ranges in the overall index scheme. In the context of environmental risk communication, basing cutoff points and ranges on scientific information is recommended whenever possible so that the index reflects actual risk levels (as is the case for many of the indexes discussed as examples in this chapter and Chapter 4).

Index values and their meanings can be calculated and reported in a number of different ways, such as reporting the highest single number based on measurements of several different pollutants (as in the Air Quality Index discussed below); mathematically combining the ratings of different parameters into a single index value (as in the River Index described in Chapter 4); or expressing the different index ranges as multiples or percentages of measurements or standards generally used.

A number of EMPACT projects use indexes as key data interpretation tools for risk communication, including the SunWise Program and the AIRNow project. These two projects’ use of indexes is described below; see also Chapter 4, which provides a detailed, step-by-step review of how the River Index was developed. Some of these indexes might be directly applicable and useable for your location, such as the UV Index used by the SunWise program and the Air Quality Index used by AIRNow. Other existing indexes might be useful if modified for your location or program objectives. The examples provided below and in Chapter 4 provide an overview of how environmental indexes are developed, what they are based on, and how they are used.

3.3.1.1 THE EPA SUNWISE PROGRAM AND THE UV INDEX

The EPA SunWise Program uses the National Weather Service’s (NWS’s) Ultraviolet Index (or UV Index), which provides a daily forecast of the expected risk of overexposure to the sun. The Index predicts the next day’s UV radiation levels on a 0 to 10+ (up to 15) scale, where 0 indicates a minimal likely level of exposure to UV rays and 10+ means a very high level of exposure. The higher the UV Index, the greater the dose rate (the amount of UV skin- and eye-damaging radiation to which a person will be exposed), and the less time it takes before skin damage occurs. (For more background information on the UV Index, visit http://www.cpc.ncep.noaa.gov/products/stratosphere/uv_index/index.html.)

The NWS develops the UV Index by using a computer model to first calculate the UV dose rate, then adjust the result for important effects likely to influence this rate. For UV radiation, such effects include elevation and cloud cover at specific locations. The resulting value is the next day’s UV Index forecast. The SunWise Program also allows users to enter their ZIP code to get a UV forecast specifically for that location. The UV Index used in the SunWise Program includes the cutoff ranges listed in Table 3-1.

TABLE 3-1. UV INDEX SCALE RANGES

Index Number		
0 to 2		
3 to 4	Low	Wear a hat with a wide brim and sunglasses to protect your eyes. Use a sunscreen with an SPF of at least 15 and wear long-sleeved shirts and long pants when outdoors.
5 to 6	Moderate	Use sunscreen if you work outdoors and remember to protect sensitive areas like the nose and the rims of the ears. Sunscreen prevents sunburn and some of the sun's damaging effects on the immune system. Use a lip balm or lip cream containing a sunscreen. Lip balms can help protect some people from getting cold sores.
7 to 9	High	Wear long-sleeved shirts and trousers made from tightly woven fabrics. UV rays can pass through the holes of loosely knit fabrics.
10+	Very High	Avoid being in the sun as much as possible. Wear sunglasses that block 99 to 100 percent of all UV rays (both UVA and UVB). Wear a hat with a wide brim.

Source: Climate Prediction Center, 2000

3.3.1.2 THE AIRNOW PROGRAM AND THE AIR QUALITY INDEX

The EMPACT AIRNow project uses the Air Quality Index (AQI) developed by EPA to communicate the level of health concern associated with different concentrations of certain air pollutants. The AQI ranges from 0 (“good” air quality) to 500 (“hazardous” air quality). The higher the Index value, the greater the health concern.

The reported Index value reflects the single pollutant with the highest value. Exposure to multiple pollutants is not reflected due to a lack of data on associated health effects. To facilitate risk communication, reporting of the AQI has shifted in recent years: instead of numbers, the colors with which the Index values are associated are reported.

The AQI is divided into six color-coded ranges, as shown in Table 3-2. These correspond to the color scheme used in AIRNow’s ozone map (see Chapter 4). The use of uniform colors that are easily understandable by the general public to support a nationally uniform index was an important goal that was successfully achieved (though debate occurred regarding which particular colors to use).

TABLE 3-2. AIR QUALITY INDEX (AQI) SCALE RANGES AND CORRESPONDING COLORS

Color		
Green		
Yellow	51 to 100	Moderate
Orange	101 to 150	Unhealthy for sensitive groups
Red	151 to 200	Unhealthy
Purple	201 to 300	Very unhealthy
Maroon	301 to 500	Hazardous

Generally, the different AQI ranges (or cutoff points) are defined by different populations known to exhibit noticeable health problems at these different ranges. (See the AIRNow case study in Chapter 4 for a more detailed discussion of the cutoff points and populations). Including Index ranges for sensitive groups provides useful information for these populations, while not alarming the general public (Stone, 2000).

EPA used focus groups, discussions with state and local agencies and the news media, and public comment to help decide cutoff ranges and corresponding colors for the AQI. Some people suggested additional or different colors, shades, or categories than were finally selected. For fine particulate matter (PM_{2.5}), EPA lowered the cutoffs in response to public comment. Because the scientific basis for setting standards for particulate matter is not very precise, there was a legitimate reason for the public to question where the lines should be drawn. Even the name of the index may be important. For example, the AQI was previously called the “Pollutant Standards Index”; this name was changed to the “Air Quality Index” because focus groups and others much preferred a name that reflected air quality rather than air pollution (Stone, 2000).

3.3.1.3 IF YOU’RE CONSIDERING DEVELOPING OR USING AN INDEX...

In choosing an index that would be a useful tool in your environmental risk communication efforts, consider what other organizations might partner with you in developing and launching the index, think about the limitations of the index you are investigating (e.g., what it cannot communicate), and decide whether that index meets the specific needs of your program. These factors are discussed below.

Partners. Working with other relevant organizations can be important when you seek to develop or use an environmental index that meets your needs. For the UV Index, NWS has worked with EPA, the Centers for Disease Control and Prevention, meteorologists, health and medical professionals, and the World Meteorological Organization to ensure consistency among different UV Indexes. For the AQI, EPA staff worked with state and local air agencies and regional organizations for 2 years, attended many meetings and conferences nationwide, and held eight focus groups throughout the country.

What Index Meets Your Needs? If you are interested in using an index as an indicator of environmental quality and/or exposure risk, first do some research to find out if an index already exists that may address your needs. If an index suitable for your purposes does not exist and you decide to develop your own index or modify an existing one:

- Make sure to include people on your index development team who know the science behind the concepts involved. Also have the index validated—that is, tested to make sure that its results are indeed useable for their intended purpose.
- Try to achieve some consistency with similar or related indexes to minimize confusion regarding the meaning of colors and numbers in risk communication efforts.
- Include as many key factors as possible in your index development process that could influence the results and accuracy of the index. If any important factors are not accounted for, let the user know what they are and how they might influence the index results.

Communicate What the Index Does Not Do

It may be important to communicate certain caveats about environmental indexes to the public. For example, the UV Index's users are informed that because the Index is a forecast, it will not always be exactly correct (though it is very reliable, with an 84 percent accuracy rate to within +/- 2 percentage points). Also, users should be told if the index does not account for any potentially important factors. For the UV Index, the effects of air pollutants, haze, and surface reflection from snow, water, and sand are not included. These factors can result in higher actual UV exposure under these environmental conditions than the UV Index value indicates. In addition, the UV Index is not intended for individuals who are very sensitive to the sun, such as people with lupus erythematosus or other sun-sensitive diseases, or people taking certain medications that result in sun sensitivity.

- Determine the needed frequency of reporting of your index. For many projects, daily reporting may be needed so that the public can use the information in a timely manner, but the frequency should also reflect realistic expectations. For example, for the AQI, reporting is required daily; however, “daily” is defined as a minimum of 5 days a week, since there is concern that some state and local agencies may not be able to provide AQI reports on weekends (Stone, 2000).
- Solicit feedback from a broad audience during development of the index, including the public. Expect people to disagree about the semantics of what to call intermediate categories on the borderline between “good” and “poor.” For example, should there be one intermediate category? Two? Four? Bear in mind that you may never achieve complete consensus on index cutoffs and ranges. EPA has found that between 4 and 10 ranges are usually adequate to communicate variability in environmental quality and health effects, based on a review of different countries’ use of indexes (Stone, 2000).

3.3.2 PUBLICATIONS

Almost all EMPACT projects develop and use publications to communicate their risk information to the public or other more specific audiences. They use a variety of formats, such as pamphlets, fact sheets, handbooks, and flyers. While publications cannot provide time-relevant (e.g., daily) data, they do provide information about how to interpret the data and what associated health risks from certain environmental conditions might be. Guidance for developing publications (as well as other types of written text) appropriate for different types of readers is provided in Chapter 5.

3.4 WHAT'S THE BEST WAY TO "GET THE WORD OUT?"—DISTRIBUTION METHODS

Even the best risk communication tools will not be effective unless your audience knows about them. Thus, establishing a good distribution system is important. After clearly identifying your target audience(s), you might want to do some research on how your audience typically receives information. Some common sources of public information are:

- Television
- Newspapers
- The Internet
- Meetings
- Schools

Then, choose one or more distribution methods that are likely to reach the most people in your target audience. A Web site may be an excellent way to distribute your risk information if your audience is likely to have access to the Internet; if not, you might want to choose another distribution method in addition to, or instead of, a Web site.

4 CASE STUDIES: DEVELOPING AND USING DATA VISUALIZATION AND DATA INTERPRETATION TOOLS

4.1 INTRODUCTION

This chapter shows how three particular EMPACT projects have successfully used a variety of the data visualization and data interpretation tools discussed in Chapter 3, often integrating several tools into their programs. The AIRNow Project (Section 4.2) provides hourly air quality conditions and daily forecasts for many areas across the country using color-coded maps, an index, a telephone hotline, the media, and printed publications, among other tools. The River Index Project (Section 4.3) primarily uses an index system to report on the water quality of various river segments surrounding Dayton, Ohio, including an indication of whether river conditions are favorable for recreational activities. The River Index incorporates color-coding into its risk communication efforts to facilitate the public's understanding of the index values. The discussion of the River Index also includes a detailed explanation of how the index was developed.

The Lake Access Project (Section 4.4) uses color-coded maps, an index, charts, GIS, kiosks, and three-dimensional animation, among other tools, to provide near-real-time water quality information to different audiences, with information ranging from simple to more complex, as selected by the user. All of these projects rely in part on their Web sites, in addition to other tools, for effective risk communication. Understanding how these projects use this wide range of risk communication tools "in real life" will hopefully be useful to other projects that are considering developing or expanding their own environmental risk communication programs.

4.2 AIRNOW PROJECT

4.2.1 PROJECT HISTORY

The AIRNow project, launched in 1998, offers daily air quality forecasts as well as real-time air quality data for over 200 cities across the United States in a visual, easy-to-understand format. AIRNow, serving as a central clearinghouse for data collected from state and local agencies, reviews the data for quality assurance and transfers the information to the public via its Web site, <http://www.epa.gov/airnow>. It also provides links to more detailed state and local air quality Web sites. The AIRNow project was initially funded by EMPACT and was developed in partnership with state and local air quality agencies.

The AIRNow project collects data from existing local and state ozone monitoring networks. These networks are equipped with data loggers and modems that collect and transmit measurements to state host computers. In areas where ozone monitoring networks are not well established, special-purpose monitors are used. Each participating state agency's host computer is linked to a central EPA database called the Data Management Center (DMC). The DMC manages and quality-checks the data and sends them out for use in making ozone maps, which are posted on the AIRNow Web site.

The AIRNow project uses the AQI as one of its primary risk communication tools. Under the Clean Air Act, EPA is required to establish a nationally uniform index for reporting air quality. In 1976, EPA established the Pollutant Standard Index (PSI), which provided information on pollutant concentrations for ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. In 1998, EPA adopted several important revisions to the PSI and changed its name to "Air Quality Index." Other changes included providing uniform categories, colors, and descriptors for air quality; revising the ozone and particulate matter standards to address new scientific findings; and adding a category to characterize air quality deemed to be "unhealthy for sensitive groups." Most significantly, the new AQI was useful as a forecasting tool, whereas PSI values had only been reported as historical data for previous days.

The development of the AQI and AIRNow coincided with the rapid growth of the Internet. This fortuitous timing enabled AIRNow tools to quickly become widely adopted for air quality risk communication.

4.2.2 EFFECTIVE METHODS

The AIRNow program successfully integrates several risk communication tools, including color-coded geographic maps, an index, a recorded telephone hotline, and traditional printed materials, as shown in Table 4-1. These tools provide information that is relatively easy to understand for people with little prior knowledge about air pollution and its risks. The information alerts the public about air quality during the ozone season through a Web site with a memorable URL (<http://www.epa.gov/airnow>) and weather reporting by media outlets. The data are also used by local agencies. The following subsections describe some of the risk communication tools used by AIRNow, particularly the AQI and real-time ozone maps.

4.2.2.1 THE AIR QUALITY INDEX

The AQI serves as the foundation for AIRNow. It is a tool developed by EPA (see Chapter 3) to provide timely and easy-to-understand information on local air quality and associated health concerns.

TABLE 4-1. SUMMARY OF AIRNOW COMMUNICATION PRODUCTS

Product/Event	Targeted Audience	Distribution Mechanism
Data Interpretation and Presentation Tools		
Still-frame and animated ozone maps	<ul style="list-style-type: none"> • General public • People with sensitivity to ozone exposure 	<ul style="list-style-type: none"> • AIRNow Web site; Web sites of state and local air pollution agencies • Television, via local weather broadcasts in a handful of local markets
The Air Quality Index (AQI)	<ul style="list-style-type: none"> • General public • People with sensitivity to exposure to pollutants covered by the AQI 	<ul style="list-style-type: none"> • AIRNow Web site; Web sites of state and local air pollution agencies • Newspapers
Interactive AQI calculator	<ul style="list-style-type: none"> • General public • People with sensitivity to exposure to pollutants covered by the AQI 	<ul style="list-style-type: none"> • AIRNow Web site
Web Sites and Other Internet Applications		
AIRNow Web site	<ul style="list-style-type: none"> • General public 	<ul style="list-style-type: none"> • Internet
Publications		
Various publications: <i>Air Quality Guide for Ozone, Guideline for Developing an Ozone Forecasting Program, Guideline for Reporting of Daily Air Quality, Ozone and Your Health, and Report of Eight Focus Groups...</i> ¹	<ul style="list-style-type: none"> • General public • State and local air pollution agencies • State and local public health agencies 	<ul style="list-style-type: none"> • AIRNow Web site
Other Outreach and Education Products or Information Dissemination Techniques		
Satellite forum	<ul style="list-style-type: none"> • State and local air pollution and public health agencies 	<ul style="list-style-type: none"> • Broadcast via EPA's Air Pollution Distance Learning Network

¹ U.S. EPA, 1999a-d, 1998.

The AQI converts raw measurements of the six pollutants regulated by the Clean Air Act (ozone, fine and coarse particulate matter, carbon monoxide, nitrogen dioxide, and sulfur dioxide) into a number on a scale of 0 to 500. The scale is subdivided into categories such as “good,” “moderate,” “unhealthy,” and “hazardous.” Converting the measurements involves using standard conversion scales developed by EPA, as described below:

- The AQI value of 100, which is the upper bound of the “moderate” category, corresponds to health-based national air quality standards (the National Ambient Air Quality Standards, or NAAQS) established for each of these pollutants. These standards, and the corresponding Index value of 100, reflect scientifically peer-reviewed information on health effects.
- The Index value of 50, which is the upper bound of the “good” category, is defined in one of three ways: (a) the level of the annual standard (if an annual standard has been established for that pollutant); (b) a concentration equal to one-half the value of the short-term standard used to define an Index value of 100; or (c) the concentration at which the risk to the public becomes very small (e.g., the 8-hour ozone average), and/or the magnitude of the health effects becomes highly uncertain.
- Between the Index values of 100 and 500, a linear relationship generally exists between increasing values and increasingly severe health effects associated with pollutant levels. For example, the value for ozone of 150 (the upper bound for the “Unhealthy for Sensitive Groups” category) corresponds to an ozone concentration of 0.10 parts per million (ppm), based on a risk assessment conducted for the ozone NAAQS that indicated that this is the level at which exposures are associated with an increase in the number of individuals who could experience effects (including possible respiratory effects in the general population and a greater likelihood of respiratory symptoms and breathing difficulty in sensitive groups) (Stone, 2000).

Originally, EPA based the AQI for ozone (the focus of the EMPACT AIRNow project) on a 1-hour standard. Since 1997, the Index has been based instead on an 8-hour standard, because research has found that the original 1-hour standard was not adequately protective of human health. The 1-hour standard limited ozone levels to 0.12 ppm averaged over a 1-hour period; the new 8-hour standard requires that a community’s ozone levels be no higher than 0.08 ppm when averaged over an 8-hour period.

An ozone measurement of 0.08 ppm (which is the NAAQS for ozone) corresponds to a “moderate” AQI value of 100 for ozone; carbon dioxide levels between 4.5 and 9.4 ppm correspond to “moderate” AQI values between 51 to 100. A similar measurement-to-index value conversion process is conducted for all six NAAQS pollutants individually; the highest individual pollutant value is then reported as the AQI for that local area for a particular day. Information may also be reported for any other pollutant with an Index value above 100.

AIRNow associates each of the six AQI categories with a color (also used in ozone mapping), and the level of health concern associated with each AQI category is summarized by a descriptor. Table 3-2 (in Chapter 3) outlines these categories and descriptors; Table 4-2 explains how they relate to the 1-to-500 scale. Table 4-3 explains what types of health effect are associated with each of the six categories and what individuals can do to avoid these effects.

4.2.2.2 OZONE MAPS

The AIRNow ozone maps present the AQI in a visual, easy-to-understand format. The maps use the categories and color scheme developed for the AQI and delineate geographic concentrations of ground-level ozone so that individuals can easily determine the quality of the air in their immediate vicinity.

TABLE 4-2. AQI COLOR-CODED INDEX RANGES AND RISK COMMUNICATION OF HEALTH CONCERNS

Air Quality Index Rating and Associated Color	
<i>Good</i> (green)	When the AQI value for your community is between 0 and 50, air quality is considered satisfactory in your area.
<i>Moderate</i> (yellow)	When the AQI value for your community is between 51 and 100, air quality is acceptable in your area. (However, people who are extremely sensitive to ozone may experience respiratory symptoms.)
<i>Unhealthy for sensitive groups</i> (orange)	Some people are particularly sensitive to the harmful effects of certain air pollutants. For example, people with asthma may be sensitive to sulfur dioxide and ozone, while people with heart disease may be sensitive to carbon monoxide. Some groups of 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. Members of the general public are not likely to be affected when the AQI is in this range.
<i>Unhealthy</i> (red)	When AQI values are between 151 and 200, everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.
<i>Very unhealthy</i> (purple)	AQI values between 201 and 300 trigger a health alert for everyone.
<i>Hazardous</i> (maroon)	AQI values over 300 trigger health warnings of emergency conditions. Such values rarely occur in the United States.

Consider Focus Groups for Public Feedback

In developing the AQI and ozone maps, EPA conducted a series of eight focus groups around the country which evaluated the effectiveness of these tools for risk communication. The groups examined how effectively the map, cautionary statements, and an ozone health effects booklet (*Smog—Who Does it Hurt?*) conveyed information to the general public and targeted audiences. Four different versions of the map were tested.

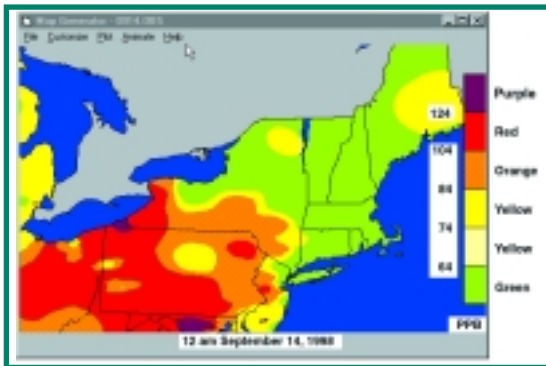
TABLE 4-3. HEALTH EFFECTS AND PROTECTION MEASURES ASSOCIATED WITH AQI CATEGORIES

Ozone Level	Health Effects and Protective Actions
Good	<p>What are the possible health effects?</p> <ul style="list-style-type: none"> No health effects are expected.
Moderate	<p>What are the possible health effects?</p> <ul style="list-style-type: none"> Unusually sensitive individuals may experience respiratory effects from prolonged exposure to ozone during outdoor exertion. <p>What can I do to protect my health?</p> <ul style="list-style-type: none"> When ozone levels are in the "moderate" range, consider limiting prolonged outdoor exertion if you are unusually sensitive to ozone.
Unhealthy for Sensitive Groups	<p>What are the possible health effects?</p> <ul style="list-style-type: none"> If you are a member of a sensitive group,¹ you may experience respiratory symptoms (such as coughing or pain when taking a deep breath) and reduced lung function, which can cause some breathing discomfort. <p>What can I do to protect my health?</p> <ul style="list-style-type: none"> If you are a member of a sensitive group,¹ limit prolonged outdoor exertion. In general, you can protect your health by reducing how long or how strenuously you exert yourself outdoors and by planning outdoor activities when ozone levels are lower (usually in the early morning or evening). You can check with your State air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at http://www.epa.gov/airnow.
Unhealthy	<p>What are the possible health effects?</p> <ul style="list-style-type: none"> If you are a member of a sensitive group,¹ you have a higher chance of experiencing respiratory symptoms (such as aggravated cough or pain when taking a deep breath), and reduced lung function, which can cause some breathing difficulty. At this level, anyone could experience respiratory effects. <p>What can I do to protect my health?</p> <ul style="list-style-type: none"> If you are a member of a sensitive group,¹ avoid prolonged outdoor exertion. Everyone else—especially children—should limit prolonged outdoor exertion. Plan outdoor activities when ozone levels are lower (usually in the early morning or evening). You can check with your State air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at http://www.epa.gov/airnow.
Very Unhealthy	<p>What are the possible health effects?</p> <ul style="list-style-type: none"> Members of sensitive groups¹ will likely experience increasingly severe respiratory symptoms and impaired breathing. Many healthy people in the general population engaged in moderate exertion will experience some kind of effect. According to EPA estimates, approximately: <ul style="list-style-type: none"> Half will experience moderately reduced lung function. One-fifth will experience severely reduced lung function. 10 to 15 percent will experience moderate to severe respiratory symptoms (such as aggravated cough and pain when taking a deep breath). People with asthma or other respiratory conditions will be more severely affected, leading some to increase medication usage and seek medical attention at an emergency room or clinic. <p>What can I do to protect my health?</p> <ul style="list-style-type: none"> If you are a member of a sensitive group,¹ avoid outdoor activity altogether. Everyone else—especially children—should limit outdoor exertion and avoid heavy exertion altogether. Check with your State air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at http://www.epa.gov/airnow.

¹Members of sensitive groups include children who are active outdoors; adults involved in moderate or strenuous outdoor activities; individuals with respiratory disease, such as asthma; and individuals with unusual susceptibility to ozone.

A Map Generator (MapGen) system produces both still-frame images of ozone concentrations, including hourly snapshots of data, and animated maps illustrating the movement of ground-level ozone over time. MapGen enables users to customize the maps based on their data and outreach needs. Users of MapGen can also customize maps to show supporting information such as geographic features, identifying text, and images. During the ozone season (May through September for most areas), the ozone maps are updated daily every hour. The software developed under this project is publicly available at no cost. Figure 4-1 shows an image composed using MapGen.

Figure 4-1



The map shows that ozone levels ranged from good to very unhealthy across the region

Figure 4-1. Ozone map generated with MapGen.

Source: U.S. EPA, 2002c (<http://www.epa.gov/airnow>).

The AIRNow project is staffed by contractors and operates on a 24/7 basis. An automated quality control procedure processes reports that come in from the local, state, and EPA offices. Program staff also conduct additional quality assurance reviews of the data. A night staff ensures 24-hour-a-day accessibility of the system. AIRNow also has contacts at the state and local levels who provide technical support to fix problems with particular ozone monitors. The continuous monitoring provided by AIRNow obviates the need for local EPA offices to constantly check their ozone measuring instruments.

Full implementation of the automated real-time ozone mapping system in the eastern United States began in 1998. The map will ultimately include all of the contiguous United States and feature additional pollutants (e.g., particulate matter).

4.2.2.3 OTHER RISK COMMUNICATION TOOLS USED BY THE AIRNOW PROGRAM

The AIRNow Web site includes an interactive AQI calculator that enables the user to convert ambient ozone concentrations (parts per billion or parts per million) to AQI values and vice versa. The AIRNow program also operates an online “WebBoard” that provides technical assistance and facilitates information sharing by program participants. The site posts question-and-answer sessions, contains a comprehensive search feature, and hosts a chat room related to ozone mapping. Off the Web, AIRNow provides conventional printed materials, such as fact sheets, booklets, and reports.

4.2.3 KEY ACCOMPLISHMENTS

Many innovative ozone outreach efforts have been implemented around the country using AIRNow communication tools. The project has placed a special focus on working with weather service providers for inclusion of the ozone maps in local television weather forecasts. The maps are also being used by local media in feature coverage of local and regional Ozone Action Day programs. AIRNow tools are also being integrated into science and health curricula, and are used for hotlines that provide recorded information about current and forecasted ozone levels.

The AIRNow Web site gets over 3 million hits a month. On national cable television, The Weather Channel and CNN include AQI forecasts on their morning and evening weather forecasts during the ozone season and are working with EPA to make this a year-round information product. The Weather Channel’s Web site, <http://www.weather.com>, includes air quality forecasts on its health page every day, year-round. (Figure 4-2 shows an example of www.weather.com’s air quality information.) Also, the national newspaper USA Today publishes AQI information during the summer and is working to make this a year-round feature.

Figure 4-2. The Weather Channel's online air quality display. Source: Image courtesy of The Weather Channel, 2002 (<http://www.weather.com>).

In addition to their widespread use in daily newspaper, television, and radio weather reporting, the AQI and other AIRNow products are the primary risk communication tools used in regional and local “Ozone Action Days” to inform the media and the public of health concerns associated with poor air quality.

4.2.4 LESSONS LEARNED

In developing and implementing AIRNow risk communication tools, EPA and participating state air quality programs have learned some valuable lessons that have contributed to their success:

- It was important to get broad public feedback in creating and refining the AQI. Although achieving consensus is always desirable, the Agency learned that complete consensus was unlikely to occur. Semantic arguments were common, especially about defining or characterizing the “gray” areas on the borderline between “good” and “bad” air quality.
- A positive (rather than negative) focus was found to be very important for effective risk communication. For example, EPA’s research showed that people overwhelmingly preferred the name “Air Quality Index” to “Pollutant Standards Index.”
- EPA also learned that it is important to offer enough categories (e.g., 4 to 10) to display variability in air quality and health effects information. State and local air agencies are not required to display categories they do not use.
- In refining the AQI, EPA learned the importance of keeping the Index as simple as possible, but consistent with the health message.
- EPA also learned to use short, media-ready statements. This is the genesis of the sensitive groups statements (for example, for ozone: “children and people with asthma are the groups most at risk”).
- It is important to use plain language (e.g., “unhealthy” rather than “unhealthful.”). (See Chapter 5.)
- Developing an appropriate and intuitive color-coding scheme is vital in public risk education. AQI has become very well understood in just 2 years because the color scheme works so well.
- In developing the AQI and AIRNow risk communication tools, it was (and continues to be) important to consider other contemporary visualization tools, such as weather maps, used by national print and broadcast media.
- A lesson learned by the Sacramento Air Quality Management Division in getting ozone maps on television was the importance of cultivating strong working relationships with local broadcast meteorologists. In addition to pushing for broadcast of the maps, Division staff provided the meteorologists with information on all types of air quality issues, made themselves available to television station staff for their weather-related news and reports, and helped the stations develop feature stories. See the box below for more information on the Sacramento ozone mapping project.

Figure 4-2



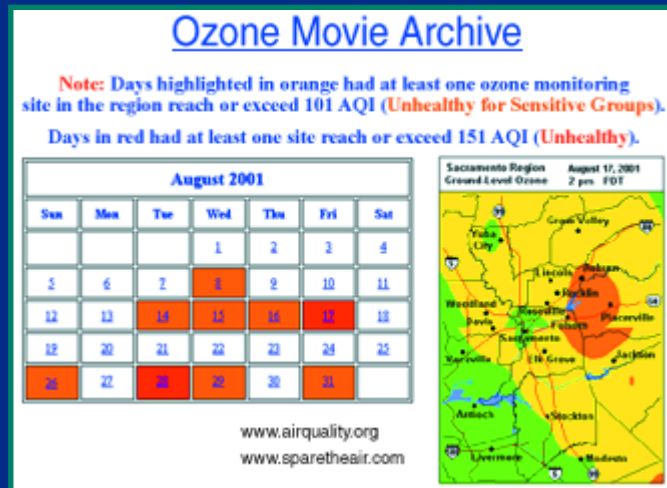
www.weather.com

- The Texas Natural Resource Conservation Commission was able to render more accurate and timely maps by using 1-hour running averages. A high modem-to-monitor ratio also proved to be important in ensuring fast data transmission. See the box below for more on the Texas ozone mapping project.
- In establishing its monitoring system, Texas learned that the density of the monitoring network is critical to producing useful and accurate ozone maps. Hence, the system uses one modem for every four monitoring stations.

Sacramento Works the Media

The Metropolitan Air Quality Management District (AQMD) in Sacramento, California, has successfully integrated AIRNow risk communication tools into local weather reports. AQMD has a long history of working with the region’s television meteorologists to familiarize them with the AQI and regional air quality issues. When ozone mapping became available in 1996, it proved to be a valuable new outreach tool.

Since 1998, two Sacramento television stations have regularly aired AQMD’s animated ozone maps and forecasts during weather segments on the stations’ combined nine daily newscasts. AQMD has consistently sought feedback from the meteorologists to ensure that the maps serve their needs. AQMD’s Web site, <http://www.sparetheair.com>, provides animated ozone maps (“Ozone Movies”) that are updated hourly during the ozone season (May 1 through October 31). The local all-news radio station also regularly broadcasts air quality forecasts within weather and traffic reports.



Source: Sacramento Metropolitan Air Quality Management District, 2002.

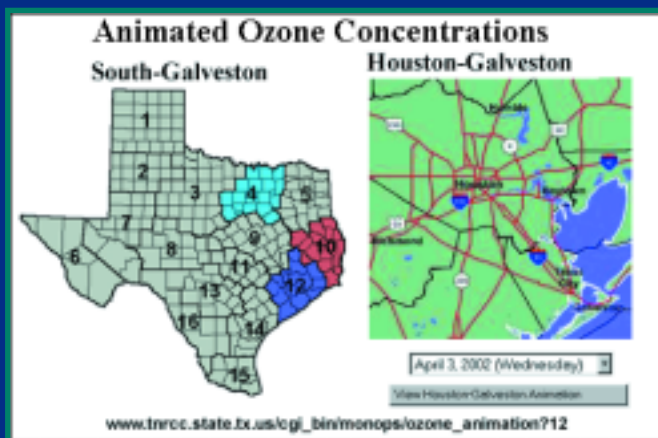
4.2.5 FUTURE PLANS

The AIRNow program is integrating new technologies into its risk communication tools. For example, EPA is working toward using a GIS map rather than standard maps for different metropolitan areas. The plan is to introduce a GIS map of the whole country that enables users to zoom in on a specific area. This will make it possible for each user to more easily localize the map and access more specific, local air quality information.

Timeliness and Accuracy in Texas

In 1994, the Texas Natural Resource Conservation Commission (TNRCC) upgraded its 20-year-old air quality monitoring technology. Of paramount concern was the need to provide accurate and immediately useful information to the public, especially during the ozone season, which is longer in Texas than in most other parts of the country. The new system purchased by Texas collects data every 5 minutes and transmits the data to regional hub computers. Every 15 minutes the hubs transmit data to the central office. In accordance with EPA rules, the central office averages 12 5-minute data reports to derive hourly averages. TNRCC is currently mapping southeastern Texas (covering the Houston, Galveston, and Brazoria region) and the Dallas/Fort Worth area, and will start mapping El Paso during the summer of 2002. TNRCC is working with the government in Ciudad Juarez, Mexico, to include monitoring on that side of the border and anticipates that the El Paso map will be bilingual.

In creating ozone maps from the data collected, TNRCC uses 1-hour running averages to improve the presentation of air quality changes over time. TNRCC is widely recognized as providing some of the fastest (and therefore most accurate) real-time air quality updates among participants in the AIRNow program.



Source: Texas Natural Resource Conservation Commission, 2002.



Photo courtesy of Miami River Index
(Dayton, Ohio)

4.3 THE RIVER INDEX PROJECT

4.3.1 PROJECT HISTORY

The Miami Valley River Index Project, one of EMPACT's MetroGrant programs, provides time-relevant water quality information on some of the rivers and creeks surrounding Dayton, Ohio. Before the project began, there was little public awareness of the Dayton area's watershed. What public awareness did exist tended to be unduly pessimistic about the environmental condition of the Miami Valley's waterways. The River Index program was founded in 1998 as a way to improve public knowledge about the condition of these

waterways and thus make them more accessible to recreational use. Some of the water-related recreational activities that the Dayton-area public now engage in include canoeing, fishing, and bicycling along the river shorelines.

Official work on the River Index Project proceeded in January 1999 as a collaboration between many different partners: the Miami Valley Regional Planning Commission, the Miami Conservancy District, the consulting firm CH2M Hill, Inc., the City of Dayton, Wright State University, the Yellow Spring Instrument Company, and the U.S. Geological Survey. The River Index Project has collected data from six Dayton-area automated monitoring sites over the last 3 years (1999, 2000, and 2001). The project's data collection season runs for the period of time in which the public is likely to make use of the rivers—roughly from the beginning of summer through early fall.

4.3.2 EFFECTIVE METHODS

4.3.2.1 OVERVIEW OF THE RIVER PROJECT INDEXES

An innovative risk communication tool of the River Index Project is its indexing system, which synthesizes a wide array of water quality data. The indexing system converts measurements into a single, easy-to-understand rating, which is disseminated to the public on the Web site <http://www.riverindex.org>.

A key concern for the River Index Project as it developed its index and other risk communication tools was that the tools meet, and be perceived as meeting, the highest professional and scientific standards. Yet generating a river quality index involved making judgement calls about where to set cutoffs between different categories of environmental quality (i.e., between “excellent” and “good” river quality). Also necessary were judgement calls about how to weight and combine an array of dissimilar measurements into a single measurement of river quality. To this end, the River Index Project recruited eight internationally recognized water quality experts to serve on a review panel that supervises the project's activities.

Drawing on their own expertise and that of a peer review panel, the staff of the River Index Project developed two indexes to convey information about local rivers:

- A **water quality** index, which synthesizes and summarizes information about the following river water measurements:
 - Dissolved oxygen
 - *E. coli*
 - pH
 - Specific conductivity
 - Temperature
- A **river** index, which includes all the parameters of the water quality index plus two additional physical parameters:
 - Flow rate
 - Turbidity

While the water quality index focuses on those issues pertaining to the health of the river ecosystem, the river index provides a broader sense of whether conditions are right for recreational use of a river. Flow rate is a particularly important parameter for determining river safety. A very high flow rate not only indicates strong, potentially dangerous currents, it warns of possible flooding. For the sake of safety, the river index is set up to automatically take the “poor” rating (regardless of how good the other parameters are) if flow rate approaches a level characteristic of flood activity. Under these circumstances, the River Index Web site also displays a special flood warning.

4.3.2.2 COMMUNICATING THE INDEX

General vs. Specific Ratings. The River Index is a mathematical procedure for “rating” a stretch of water in terms of its current suitability for recreational pursuits. The system does not specify which particular recreational activities are likely to be safe or advisable—it simply states whether or not

the river conditions are favorable for recreation in general. The developers of the River Index originally considered issuing use-based advisories (e.g., the river is or is not safe for boating, swimming, fishing, etc.) but ultimately decided against this strategy because they felt it called for overly subjective judgements and exposed the project to an undesired level of legal liability. It remains the responsibility of individual users to make their own judgments about whether or not a particular river activity is wise. The River Index Web site also provides the raw data upon which its general rating was founded, which may help the user make such decisions.

River Index Maps and Icons

On the main page of its Web site, the River Index Project displays a schematic map of the Miami River Valley, centered on the city of Dayton, Ohio. The purpose of this map is to provide an “at-a-glance” summary of water quality for all the rivers covered by the project. The most prominent features of the map are the area’s rivers and streams, colored light blue. Certain river segments are labeled on the map. The background color of each segment’s label changes to match the river’s current water quality index—a key on the map reminds the viewer of what each color means. The map also displays the boundaries of local counties.

One prominent feature of this map is the cartoon-like icon of a “happy fish.” The happy fish serves as a navigational icon and a recurrent design element throughout the Project’s Web site. On various other pages of the Web site, there are small, click-able icons of happy fish that return the user to the River Index home page. This iconography not only makes it easier to refer back to the summary map, but also gives visual and thematic cohesion to the entire Web site.



Source: River Index Project, 2002.

What the Ratings Mean. Each of the six monitoring sites may have a different river index “rating,” depending on how many points have been assigned to it in the indexing process. Table 4-4 summarizes the different ratings.

TABLE 4-4. RATING SYSTEM USED IN THE RIVER INDEX

Rating	Number of Total Points	Meaning
Excellent	32–40	"Overall measurements indicate high water quality. Conditions highly favorable for recreation."
Good	25–31	"Most measurements meet or exceed Water Quality Standards. Conditions favorable for recreation."
Fair	18–24	"Some measurements meet or exceed Water Quality Standards. Conditions marginally favorable for recreation."
Poor	11–17	"Measurements indicate some water quality problems. Conditions generally not favorable for most recreation."

Color-Coded Index Ratings. Each of the index ratings is paired with a color. Table 4-5 summarizes the color relationships used by River Index and their cultural connotations. The color scheme chosen by the River Index Project amplifies and coincides with the explanatory text for each rating. This is particularly important because some people may not bother to read and/or think about the carefully crafted text (included in Table 4-4) that explains each rating. These people may simply note the color of the rating and make their conclusions about the river based on their intuitive understanding of that color. Other people might read the explanatory language but be confused about its practical significance (e.g., about the difference between “favorable” and “highly favorable”). The cultural connotations of a color help to communicate the level of risk reflected by the different ratings.

TABLE 4-5. COLOR-CODING SYSTEM USED IN THE RIVER INDEX

Rating	Color	Cultural Significance of Color
Excellent	Green	In traffic signals, the green light says "go ahead." Similarly, this rating entices the index user to "go ahead" and use the river for recreation. Green also connotes environmental well-being. It suggests that the river is not only good for recreation, but also ecologically healthy.
Good	Blue	Unlike the other three colors, blue is not used in traffic signals. "Good" therefore lacks the directive impact that the other ratings possess. In aesthetic terms, however, it is widely accepted as the normal color of water. Even though "good" is not the best possible rating, the color blue reassures the index user that the water is still clean and safe.
Fair	Yellow	Yellow is the caution light in traffic signals. Without forbidding passage, it exhorts the viewer to exercise discretion and maintain a heightened state of awareness. Similarly, a yellow rating encourages the River Index user to think twice about his or her plans for using the river. The color encourages the user to learn more about the specific nature of the river's problems.
Poor	Red	In traffic, the color red commands the viewer to stop. In an environmental context, it also conveys an impression of danger, emergency, and authority. The color red anchors "poor" at the bottom of the ranking system and it indicates that there is, at present, a serious problem with the river. The color encourages users to avoid the river altogether until the situation improves.

Averaging Index Values. Since some of the factors that contribute to the calculation of the river index change hourly, the river index itself must be updated frequently. It is updated every 8 hours, using an average of the previous 8 hourly automated readings and the most recent manual readings. Web site visitors can “drill down” to the most recent automated readings from the monitoring stations if they wish. One reason for updating the index only every 8 hours (rather than hourly) is to prevent it from fluctuating in a seemingly random and confusing manner. It is conceivable that, depending on the value of particular water parameters, the river index might be on the borderline between two different readings—for example, “good” and “fair.” If the index were updated every hour, insignificant variation (i.e., “noise”) in a river’s water quality parameters might cause its rating to flip-flop between good and fair. This phenomenon might undermine public confidence in the index’s reliability. This pitfall is avoided by reliance on averaged data, which are more likely to reflect significant changes in water quality.

Another Data Visualization Tool: Dials

Before the widespread use of digital readouts, scientific instruments typically presented their readings by means of analog dials. In automobiles, these dials remain the principal technology for communicating real-time information (e.g., speed, RPMs, oil pressure) to the driver. Thus, for many people the idea of reading a value off of a dial is quite intuitive.

In the River Index Project, each dial has four sections, one for each of the four ratings. The needle of the dial always points to the middle of a section of the dial. All the sections of the dial are labeled (poor, fair, good, excellent) but only the one that the needle is pointing to is “lit up” with color. These dials do not represent continuous variation in index values: since the needle simply “jumps” from one state to the next, the dial would not distinguish between a “good” rating that was very close to “fair” and one that was very close to “excellent.” An interested user could make this distinction by looking at the actual numerical score for the index; but the fact that the dial does not visually distinguish between different scores within a single rating might convey the message that the distinction is unimportant.



<http://www.riverindex.org>

4.3.2.3 CALCULATING THE RIVER INDEX

Except for the special case of flood danger, the procedure for determining the River Index is described below.

Step 1: Rate individual water quality parameters. Each of the water quality parameters that contribute to the River Index can have a different value. The River Index rates these parameters as either poor (1 point), fair (2 points), good (3 points), or excellent (4 points).

Let us take the case of dissolved oxygen as an example. According to Ohio EPA regulations and the judgement of several water quality experts, dissolved oxygen levels greater than 9 milligrams per liter (mg/l) are “excellent,” levels between 5 and 9 mg/l are “good,” levels between 2 and 5 mg/l are “fair,” and any value below 2 mg/l is “poor.” Therefore, a reading of 5.6 mg/l of dissolved oxygen would translate into 3 points, as shown in Table 4-6.

TABLE 4-6. EXAMPLE OF RATING SYSTEM FOR INDIVIDUAL WATER QUALITY PARAMETERS

Dissolved Oxygen Level (mg/l)	Parameter Rating
> 9	Excellent (4 points)
5-9	Good (3 points)
2-5	Fair (2 points)
< 2	Poor (1 point)

Rating Parameters Are Based on Science

For pH, for which a central value is the best and extremes on either end are poor, the River Index splits the pH parameter into an upper and lower range. Above pH 7, a lower pH garners more points; below pH 7, a higher pH garners more points.

Range	Excellent (4 points)	Good (3 points)	Fair (2 points)	Poor (1 point)
Upper (pH>7)	7-8	8-8.4	8.5-9	> 9
Lower (pH<7)	7-8	6.5-7	6-6.4	< 6

Thus, valuation may be different for different parameters, based on scientific information. For dissolved oxygen (DO), an “excellent” rating of 4 is based on DO levels > 9, since the higher the DO level, the better the water quality. For pH, an “excellent” rating of 4 is based on pHs between 7 and 8, since a pH above or below this range is either too acidic or too basic.

Step 2: Weight and add the point values of the different parameters. On a basic level, the next step involves simply adding up all the different points from the different water quality parameters. The advantage of the point system is that it puts the parameters in a standardized form—there are only four possible values per parameter, and the larger the sum total, the better the water quality.

An element of complexity is introduced, however, when one acknowledges that not all the water quality parameters are equally important to the final quality of the river. To resolve this complexity, the River Index staff developed a system for weighting points assigned to different parameters, as shown in Table 4-7. The point value obtained in Step 1 for each parameter is multiplied by that parameter’s weighting factor to arrive at the final score for a particular parameter at a specific time and place, which will range from a minimum score of 11 to a maximum score of 40. In other words:

$$\text{Point value of each parameter} \times \text{weighting factor for each parameter} = \text{final value for each parameter}$$

TABLE 4-7. WEIGHTING FACTORS USED TO INDICATE THE RELATIVE IMPORTANCE OF PARAMETERS

Parameter	Weighting Factor
Dissolved oxygen	3
<i>E. coli</i>	1
pH	1
Specific conductivity	1
Water temperature	1
Flow	2
Turbidity	1

Thus: Total point score for river water quality = (dissolved oxygen value × 3) + (*E. coli* value × 1) + (pH value × 1) + (specific conductivity value × 1) + (water temperature value × 1) + (flow value × 2) + (turbidity value × 1)

Step 3: Assign a final rating based on the total score from the individual parameters. There remains the task of assigning a river segment a “poor,” “fair,” “good,” or “excellent” water quality rating, based on its total point value. Table 4-8 shows the cutoff ranges used in the River Index that correspond to these water quality ratings.

TABLE 4-8. OVERALL RIVER WATER QUALITY RATING AND CORRESPONDING CUTOFF RANGES

Water Quality Rating	Cutoff Ranges (Points)
Excellent	32–40
Good	25–31
Fair	18–24
Poor	11–17

One important caveat about the River Index’s rating system is that it has a limited ability to convey information about extreme deviations from the norm in any particular parameter. Say, for example, that a river somehow became extremely acidic (e.g., pH 4). Out of a possible 40 points, the river would lose 3 for the low pH. If all the other water quality parameters were in reasonable shape, the final rating for an acidic, nearly lifeless river would be “excellent.”

This of course, is a highly unlikely scenario since there is no practical reason why the pH of a river near Dayton would suddenly drop in such an extreme fashion. The scenario merely serves to demonstrate the logical limitations inherent in an empirically weighted, linear indexing system. As mentioned earlier, the River Index Project has addressed this limitation by instituting a safety override to prevent extremely high flow levels from getting “hidden” in the index’s scoring process. Any organization developing a similar data interpretation tool in another context should consider whether that tool’s parameters could range to plausible extremes beyond which the tool would cease giving reasonable output.

4.4.3 LESSONS LEARNED

The River Index Project has been successful in disseminating its daily river ratings through the media as well as its Web site. Local newspapers ran stories about the project and some listed the daily index on their weather page. Several television weather reports expressed some interest in displaying river quality information, but the nature of TV reporting made this somewhat difficult (e.g., TV weather reports would prefer to receive river index information as an immediately available, “prepackaged” video signal). Weekend TV weather reports did include the river index as a recreational advisory.

Feedback from the public was modest but almost always positive. Anglers, in particular, were a major audience for the information. The employees of a nearby vehicle manufacturing plant took a particular interest in monitoring the quality of nearby rivers. The River Index Project sponsored a pre-survey and a 2-year progress survey of their target audiences’ knowledge of river conditions. These surveys, conducted using random phone interviews, revealed that audience awareness of Dayton’s rivers has increased slightly over the time period in which the River Index Project operated. However, the survey did not reveal widespread awareness of the River Index Project or the indexes themselves. This was the case in spite of the fact that the river indexes had been announced in the area news media, advertised on buses, and incorporated into a professionally designed Web site. In hindsight, the staff of the River Index Project concluded that they should have employed a marketing expert when they first presented the river indexes to the public. They felt that the project would have benefitted from more extensive “brand-building” to increase public awareness and media interest in it. The River Index Project continues to evaluate and revise its program to make it more meaningful and cost-effective.

4.4 LAKE ACCESS PROJECT

4.4.1 PROJECT DESCRIPTION

The Lake Access water quality monitoring project was initiated in the state of Minnesota to deliver near-real-time data to a variety of audiences. The project aims to provide public officials, scientists, and the general public with information that will help them make sound decisions regarding water quality issues. The project team developed a series of data visualization tools that present scientific measurements in easy-to-understand formats such as charts or three-dimensional images. These tools allow data that were once available to and used mainly by scientists to be accessible and useful to the general public.

The Lake Access team developed interactive data presentation tools with the goal of giving users control of the data. The different audiences for Lake Access data have different specific needs and interests. For example, a public official might be interested in determining the effects that phosphorus contamination from fertilizers have on local lakes, while a fisherman might be interested in knowing the oxygen content in certain areas of a lake to help determine where fish will most likely be located. Thus, the Lake Access project made many of its tools “user-controlled” (see Chapter 5) to allow more flexibility in manipulating and presenting data.

The project team uses Remote Underwater Sampling System (RUSS) devices to collect time-relevant information from four locations in Minnesota. RUSS units collect data on five water quality variables:

- Conductivity: The amount of dissolved salts, or ions, in water.
- Turbidity: An indication of how clear the water is.

- Dissolved oxygen: A certain amount of oxygen is necessary for the survival of aquatic organisms.
- Water temperature.
- pH: In water, the pH level determines the solubility and availability of chemical constituents, including heavy metals.

These RUSS units are also used in lakes elsewhere in the country. The Lake Access project aims to work with these other monitoring programs, such as those at Lake Onondaga in Syracuse, New York; Lake Washington, Seattle; and elsewhere in Minnesota. The project team also collects other types of information from additional monitoring stations, and integrates the non-RUSS data with the RUSS data.

The Lake Access project is a cooperative effort of the Suburban Hennepin Regional Park District; the Minnehaha Creek Watershed District; the University of Minnesota Water on the Web Investigators (i.e., the Natural Resources Research Institute, the University of Minnesota-Duluth Department of Education, and Minnesota Sea Grant); and Apprise Technologies, Inc., which holds the license to RUSS technologies. Many of the key features on the Lake Access Web site, such as the data visualization tools, were developed under a grant from The National Science Foundation's Advanced Technology Education Program.

4.4.2 EFFECTIVE METHODS

The Lake Access project's data visualization and interpretation tools include color maps, charts, and three-dimensional animation to convey and manipulate water quality profiles collected by RUSS units and from manual sampling. Although these tools are designed to work with data generated by RUSS technology, they could also be set up to work with data collected from different monitoring systems in other communities. The Lake Access project team also uses the Carlson Trophic State Index to rate water quality. A summary of the data visualization and interpretation tools developed or used by Lake Access is shown in Table 4-9, and some of the tools are discussed below.

Some of the Lake Access data visualization and interpretation tools deliver numerical data (Lake Access Live) or offer users simple graphs and charts created in Microsoft Excel. Others offer more sophisticated tools, such as GIS, that allow users to manipulate data. Most of the tools use color and graphical interfaces to enable users to “see” the information.

4.4.2.1 CARLSON TROPHIC STATE INDEX

The Lake Access project uses the Carlson Trophic State Index, which measures a water body's eutrophication—the process by which lakes are enriched with nutrients, which increases the production of aquatic plants and algae, removes oxygen, and diminishes water quality. The Index, which is used by many organizations to set water quality goals, combines various measurements (e.g., transparency, phosphorus concentration) into a rating of water quality that ranges from 0 to 100 (0 indicates clear water; 50 to 60 indicates mild concentration of nutrients, decreased transparency, and “threatened” quality; and 100 indicates algal scums and summer fish kills).

TABLE 4-9. SUMMARY OF LAKE ACCESS DATA VISUALIZATION AND DATA INTERPRETATION TOOLS

Tool Group	Tools	Primary Uses
Data visualization tools (DVToolkit includes Profile Plotter, Color Mapper, and Depth Versus Time Profiler)	Lake Access Live: near-real-time display of numeric data; Profile Plotter; Color Mapper; Depth Versus Time Profiler	<ul style="list-style-type: none"> • Explore lake data as they vary with depth and over time. • Create animated water quality profiles. • Feed real-time data to Web site. • Investigate correlations between water quality variables and trends.
Geographic information systems (GIS)	Several, including ArcInfo; ArcView; GeoMedia; and MapInfo Professional	<ul style="list-style-type: none"> • Integrate and model spatial data (e.g., water quality and land use). • Develop Internet mapping applications.
Data interpretation tool	Carlson Trophic State Index	<ul style="list-style-type: none"> • Measure lake quality with a single index.
Lake Access Web Site	Color maps; charts; DVToolkit; GIS maps	<ul style="list-style-type: none"> • Interactive capabilities to develop custom maps.
Spreadsheet programs	Microsoft Excel; Lotus 1-2-3	<ul style="list-style-type: none"> • Display raw data. • Investigate correlations between water quality variables and trends. • Create summary graphs of data.

The Lake Access Web site (described below) shows the data in sample color-coded graphs. For example, blue represents clear water, while green indicates degrees of eutrophication. For water quality between 40 and 45, a light green shade is visible, and at 80, the shade is dark green. The site provides an in-depth discussion of the Index, and lets users access Index information for the four Minnesota lakes showcased in this project.

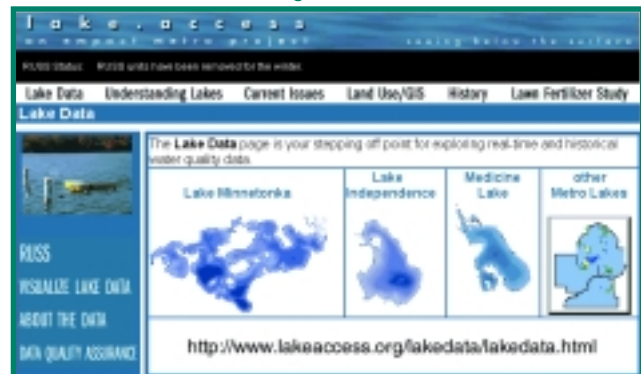
4.4.2.2 LAKE ACCESS WEB SITE

The Lake Access Web site (<http://www.lakeaccess.org>) is the project’s primary avenue of disseminating information through visually interactive tools (e.g., color maps and charts of temperature and pH levels in lakes). The site’s design features a rolling banner that presents time-relevant data from RUSS units in three lakes, as shown in Figure 4-3. The site also features a history page about one of the lakes, providing the user with background on the many influences that have affected the lake over time.

Figure 4-3. The Lake Access Web site’s front page for lake data. Visitors to the Web site can access the tools available through the Internet or they can download the DVToolkit. With the DVToolkit saved on his or her hard drive, the user can open the data tools in a Web browser without having to connect to the site. Users must download the kit again if they want to access updated information. The Lake Access team updates the DVToolkit whenever it receives new RUSS data. When using the toolkit online, the user receives near-real-time data via the Water on the Web server (<http://wow.nrri.umn.edu/wow/>).

It may take a while to load these data, but the toolkit runs quickly once they are loaded.

Figure 4-3



In addition to the interactive toolkit, the site offers users an interactive GIS mapping feature, with maps showing land use and land cover, as well as information on soils, roads, political boundaries, and other data layers that can be used in conjunction with the water quality data, such as the graph shown in Figure 4-4.

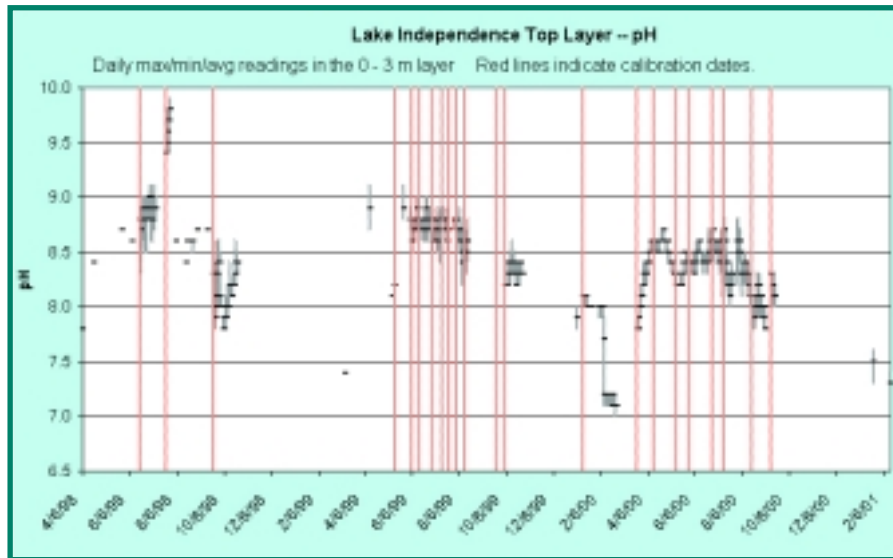


Figure 4-4. Water Quality Trends. Graphs can be very useful data visualization tools—for example, to indicate trends over time. The graph above shows average pH values in the surface layer of Lake Independence, part of the Lake Access project, over time. The vertical bars over the data points represent the range of values measured for a particular day. *Source:* Lake Access, 2002.

Communicating Information to Specific Audiences

The Lake Access Web site is organized to present data to four distinct groups: swimmers, boaters, anglers, and land owners. For different users, the site offers different information that varies from simple to complex. For example, if users click on the “Swimmers” link, the site takes them to a page that shows the water temperature for Lake Independence, explains the risks of exposure to certain types and levels of bacteria, and describes the illness “swimmer’s itch.” For fishers, the link takes users to a page depicting the oxygen concentrations in Lake Minnetonka, Halstead Bay. Data are presented in color graphs, in which green indicates ample oxygen, and black or darker colors represent areas of depleted oxygen.

The “Lake Data” section of the site provides more complex information and leads users to the DVToolkit. The section explains how RUSS data are collected, tells how the team ensures the quality of the data, and provides a link to EPA’s guidance on quality assurance measures. The “Lake Data” section also explains important terms, such as conductivity, dissolved oxygen, pH, and turbidity.

Use of Color Coding. The DVToolkit, as well as the Excel-based graphs and charts, uses color to help convey the data to the user. For example, the Color Mapper uses intuitive colors that range from blue (to indicate cold) to red (to indicate hot) when measuring lake temperature, and colors ranging from green (for “good”) to black (for “poor”) when measuring oxygen concentration.

Intuitive colors make it easier for users to understand data. For example, when using the Color Mapper, users can see changes in oxygen concentration in the background color. When oxygen concentration reaches 5 on the Color Mapper, the color fades to brown, then to blue when the

concentration reaches 3, then to black. For temperature, the color is blue until about 10 degrees Celsius, after which it turns green, then yellow at 20 degrees Celsius, and finally red at 25 degrees Celsius. These colors function the same way on the Depth Versus Time (DxT) Profiler and most other Lake Access data visualization and interpretation tools.

The only tool that deviates from these color codes is the Profile Plotter, which features the six Lake Access variables as lines plotted on a graph. Each category is assigned its own color, and these colors do not represent changes in data, only the category itself (e.g., temperature). Figure 4-5 shows examples from the Profile Plotter and Color Mapper.

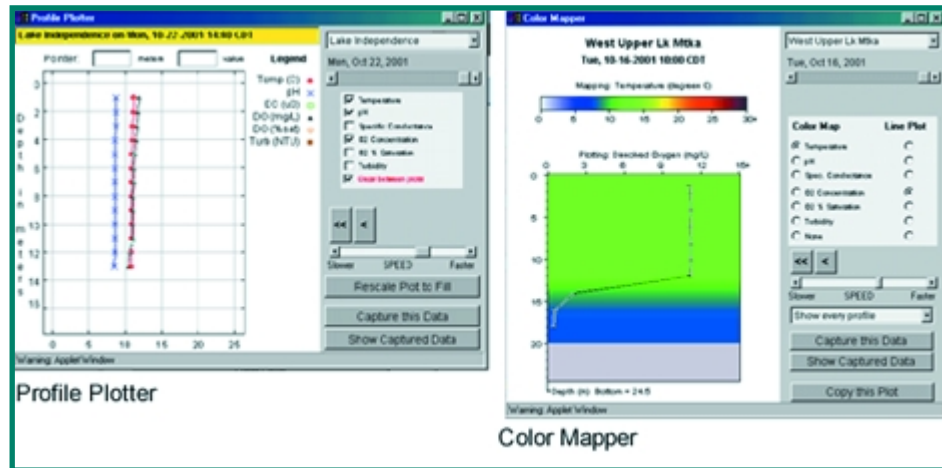


Figure 4-5. Screens from the Lake Access Profile Plotter and Color Mapper. Source: Lake Access, 2002.

4.4.2.3 ANIMATION

Lake Access also employs sophisticated animation and two- and three-dimensional graphics to convey water quality information to the public. Animation techniques are powerful visualization tools to help individuals understand technical data. The Lake Access Profile Plotter conveys water quality over time. Users can animate the profiles to see daily, monthly, and annual changes. The Color Mapper conveys the same information using a different graphical method: while the Profile Plotter uses color-coded line graphs with multiple lines designated by the user, the Color Mapper uses a single line with a color-coded background that represents another variable, allowing the user to understand the correlation between two different variables (such as pH and temperature). The Color Mapper can also be animated to show how the data change over time.

4.4.2.4 TWO- AND THREE-DIMENSIONAL VISUALIZATION

The Lake Access team wanted users to be able to display and analyze data in two or three dimensions. Accordingly, the DxT Profiler allows users to select a time period and a variable (such as oxygen concentration) and allows them to add grid lines, show the actual data points, and interpolate data by depth and time, as shown in Figure 4-6. This kind of flexibility in mapping information allows users to create sophisticated analyses of water quality data. In addition, the tool is used to create image files of the graphs for the Lake Access Web site.

The Lake Access project also uses movie files to display data. Many Web sites use movie files (e.g., MPEGs, AVIs) to showcase video clips of items such as movies and news programs, but movie files can also be used to animate data. This unique method for displaying and conveying data is extremely useful for demonstrating how lake temperature changes throughout the year. By using a combination of color, motion, and easy-to-understand charts, the animation provides users with a good idea of where and when lake temperature is affected.

The Lake Access team created an AVI animation of a chart depicting the change in lake temperature over time. The animation starts off with an image of a lake moving along the X axis of a chart, with the X axis representing time and the Y axis representing the lake's depth. The dates displayed change as the picture moves along the X axis, as does the color of the lake. The user can see how the water nearer the surface heats up during the summer months (and that the temperature at the lake bottom remains relatively unchanged), and how the entire lake reaches a uniform temperature in the winter months. A question mark appears in the lower portion of the image to indicate periods in which no data were collected. Once the image reaches the end of the axis, it becomes a three-dimensional image displaying the lake's various temperatures, as well as lake depth. It then rotates into the DxD plane, linking the animation to the output of the DxD Profiler and displaying a profile of the lake's temperature change over time.

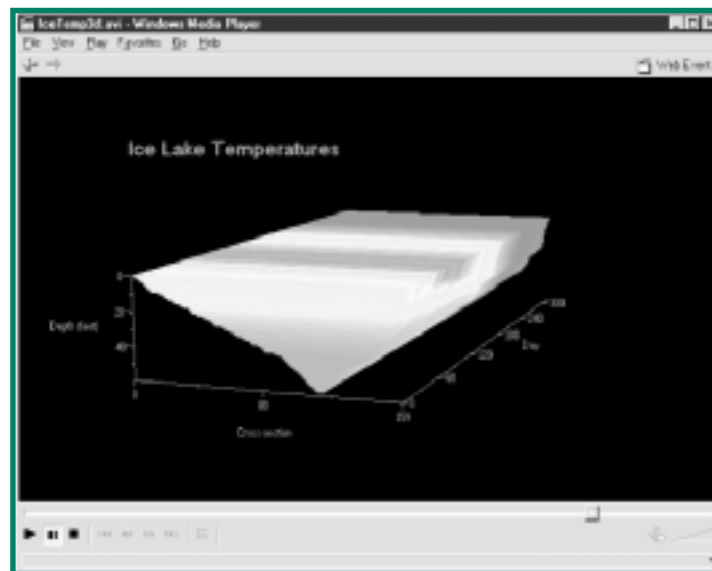


Figure 4-6. Example of Lake Access three-dimensional lake cross-section × time animation. Source: Host et al., 2000.

4.4.2.5 GEOGRAPHIC INFORMATION SYSTEMS

GIS maps provide power and flexibility in using data. At the Lake Access Web site, under “Land Use/GIS,” users can see multiple land and water features for the Minnehaha Creek Watershed and Hennepin Park District, as shown in Figure 4-7. This Web-based capability uses ArcView Internet Map Server (IMS) to distribute GIS data. Users can zoom in and out of maps and perform queries to gather information about different map elements. The IMS allows users to turn off different kinds of map layers such as roads and water bodies. The IMS screen has three sections:

- A toolbar for performing map operations
- An interactive legend that turns off different layers
- A frame that shows the map itself

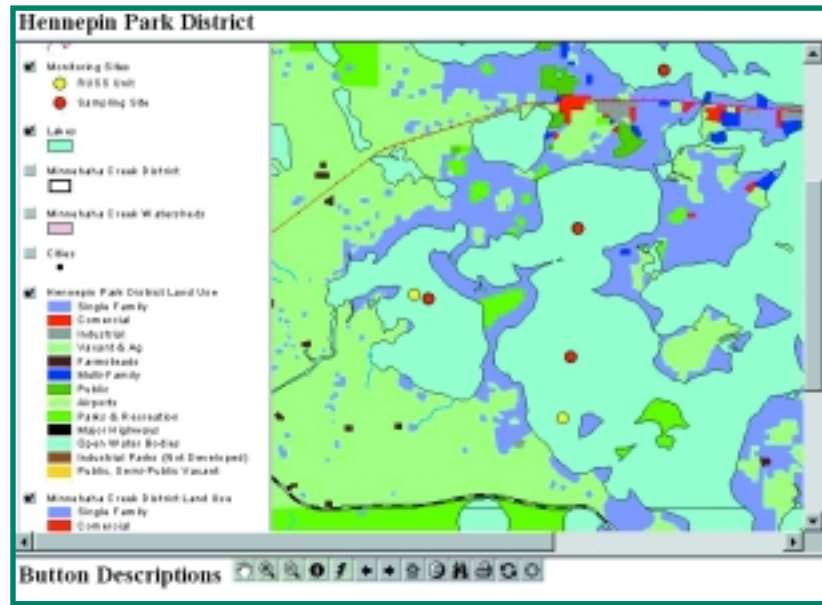


Figure 4-7. A GIS map from the Lake Access Web site. Source: Lake Access, 2002.

The DVToolkit and the GIS mapping function, all freely and easily accessible via the Lake Access Web site, are valuable data visualization tools that offer users the power to display different aspects of water quality that interest them. Using the color-coded and graphical displays created by these tools can help local officials and water users make decisions based on actual, near-real-time water quality data.

4.4.2.6 OUTREACH

To effectively market the Lake Access tools to local officials and the general public, Lake Access project coordinators worked with naturalists, teachers, museum officials, and others. After discussing target audiences, key messages, and the types of outreach materials they thought should be developed, the project team created a variety of materials, including a Web site, a printed brochure, and a survey. Kiosks were developed to reach those without Internet access.

Brochure and Survey. The Lake Access project released a “plain English” brochure describing the components of the project. The brochure, a two-page, four-color publication entitled *Seeing Below the Surface*, targets both the general public and those decision-makers interested in water quality data, explains how the data are collected through RUSS units, and provides easy-to-follow information on the data visualization tools available through the project’s Web site.

The Lake Access project also conducted a survey to ascertain the public’s general knowledge of lakes and water quality and land-use issues in the Hennepin County area in Minnesota. Administered to 450 randomly selected addresses, the survey included a cover page explaining the Lake Access project, a postcard that residents could return if they wanted to participate in a focus group, and a questionnaire covering lake use, level of concern about lake water quality, and preferred ways of receiving Lake Access project information. Forty percent of the residents responded to the survey, and the results revealed that residents were generally somewhat concerned about or interested in the lake and water quality.

Kiosks. The Lake Minnetonka Regional Parks Visitor’s Center, the Eastman Nature Center, the Science Museum of Minnesota, and the Great Lakes Aquarium in Duluth set up kiosks for users without Internet access. The kiosks feature the same information as that found on the Lake Access

Web site. Using a touch-screen computer at the kiosks, users can access the same time-relevant data from the RUSS units.

Presentations. The Lake Access team also gives presentations to local officials. After using simple visual tools, such as pie charts, to explain water quality data, the team encourages officials and other interested parties to visit the Web site to explore its DVToolkit and GIS mapping features.

4.4.3 KEY ACCOMPLISHMENTS

Local officials typically rely on scientists and engineers for water quality advice because of the technical nature of the subject. By making highly technical data accessible and comprehensible to a lay audience, Lake Access more directly involved the public in decision-making about water quality issues.

4.3.3.1 LAKE MINNETONKA

The Lake Access project has not only helped educate people about local water quality issues, but also saved tax dollars. For example, a consulting group had recommended an \$8 million project to eliminate “external loading” (phosphates that enter a water body) of phosphates into Lake Minnetonka. After data were analyzed, however, it was apparent that external loading was not as critical as “internal loading” (existing phosphates that have settled to the bottom of the lake and dissolve in the water). The \$8 million project would not have addressed this problem. The Lake Access team used the project’s data visualization tools to persuade local decision-makers to consider these facts, and the \$8 million project did not proceed.

4.3.3.2 PHOSPHORUS RUNOFF

The Lake Access team also demonstrated the negative impacts on water quality from the use of phosphorus-containing lawn fertilizers. High phosphorus concentrations in a lake promote rapid growth of algae and other plant life, adversely affecting water quality. Public education through the Lake Access data visualization and interpretation tools has prompted legislative activity to restrict the use of phosphorus fertilizers.

4.4.4 LESSONS LEARNED

- The Lake Access team learned that traditional graphing techniques, such as simple pie charts and bar graphs, are quite effective in communicating environmental information to the public. Lake Access uses a variety of more innovative data visualization tools in its outreach to environmental managers and elected officials, but it sometimes relies on the more traditional tools for its public outreach efforts.
- The Lake Access team’s partnership with a local university (the University of Minnesota) greatly facilitated the design and maintenance of the Lake Access Web site. Major research universities often have large, highly trained information technology departments; by partnering with the University, the Lake Access project gained access to knowledgeable Web designers at a reasonable cost.
- The Lake Access project planners found that the continual development of new data presentation and interpretation features is a major part of the labor involved in maintaining the Lake Access Web site. The Web site staff spend about 50 percent of their time maintaining existing data presentation components and about 50 percent developing and bringing new data presentation tools online.

Lake Access is starting a new project to analyze phosphorus runoff. The tool will use a GIS mapping function for evaluating a Minnesota watershed that drains into Lake Medicine. This new model will be based on a pre-existing one called the Source Loading and Management Model. The new model will be available on the Lake Access Web site once it is complete.

5 GUIDELINES FOR DEVELOPING AND USING DATA VISUALIZATION AND INTERPRETATION TOOLS FOR RISK COMMUNICATION

The following guidelines may help the staff of new or expanded environmental risk communication programs to effectively develop and use the risk communication tools described in this handbook and other outreach materials. Many of these guidelines are “common sense” but may be overlooked as communications materials are developed.

Use data visualization as much as possible, and minimize the use of lengthy text. When using text, use language that is appropriate for your audience.



It is often possible to use data visualization tools such as icons, maps, graphs, or other visual tools in place of language to convey risk information. These visual tools are useful because they tend to transcend cultural boundaries and differing educational levels more easily than language does. Thus, your message may be understood by more people through data visualization than through text. For example, the icon on the left may be universally understood without words.

Some information, however, may be too complex to present without any language. When developing written communications, be sure to use a level of language that accurately represents your particular audience. For example, you may want a brochure written at an elementary school reading level, with simple explanations of technical information, when addressing the general public or a more targeted audience that may have little or no knowledge about the subject matter. For a more specialized audience with some knowledge and education about a particular subject, you may want to develop text written at a junior high school or higher reading level, with more detailed technical information. If a brochure is for both the general public and a more educated audience, the more advanced text might be placed in a separate section or in a sidebar.

universal colors and images whenever possible.



Some colors schemes and images are almost universally recognized, such as red for “stop,” green for “go,” and yellow for “caution.” Also, the icon of a circle with a line through it is now well known to mean “don’t do this”; superimposing this symbol on a picture of a swimmer is a quick and easy way to communicate “don’t swim here” to a wide audience with varying degrees of education whose members may speak different languages.

Using tools such as standardized icons and color-coding can increase the usefulness of your risk communication materials.

When communicating risk information, include actions that people can take to minimize their health risks.

Communicating environmental risks usually involves informing people about the potential health effects that might be associated with exposure to certain environmental conditions, such as skin cancer and cataracts from overexposure to UV radiation from the sun; gastrointestinal illness from ingesting beach water contaminated with high levels of certain types of bacteria; or lower IQ in children who have ingested backyard soil contaminated with significant levels of lead.

It is equally important to let people know what actions they can take to avoid such risks, such as avoiding time in the sun on certain days, refraining from swimming in a particular beach area for a day or two, or obtaining state advice about whether they should get their backyard soil cleaned up. These risk avoidance actions should ideally be communicated simultaneously with the risk exposure information.

the best communication style: “Telling” or “User-Controlled”

Often one of the first steps in a risk communication/outreach program is determining who your audience is (deciding on your “target audience”), analyzing their information needs, and choosing the best communication style to fit those needs. For example, will your risk communication strategy involve primarily “telling” a large segment of the general public some relatively simple information, or will it involve giving a more specialized, knowledgeable audience some control in selecting the different types of information they are seeking? The latter might involve setting up a relatively more complicated environmental database that allows some “user control.” Some projects use a combination of these two styles, first providing general information in a “telling” style, then presenting more detailed information (or, on a Web site, links to such information).

THE “TELLING” STYLE OF RISK COMMUNICATION

When your strategy involves providing (“telling”) relatively simple risk information to people with little prior knowledge about a subject, some of the guidelines described above for risk communication are particularly important, such as using visual tools and relatively simple language. For example, the designers of the Southeastern Wisconsin Beach Health Web site, which provides information about beach water quality conditions and closures, established a system for presenting relatively simple data about beach water quality. All visitors to this Web site initially receive essentially the same type of information (e.g., beach quality on specific days at particular beaches) presented in essentially the same way. (For users with a more detailed interest in water quality trends or specific test results, the Web site also provides a “user-controlled” section; after specifying particular data sets and time periods, more advanced users can obtain detailed laboratory results presented in tabular form.) Even when using the “telling” mode of communication, it may be useful to provide an option to display the Web site in a language other than English.

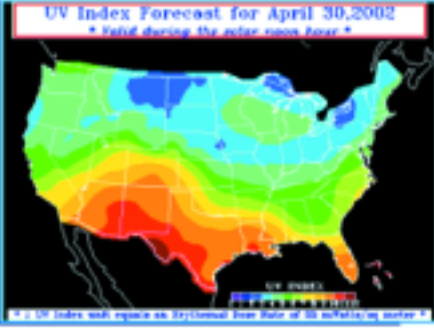
Risk communicators (including Web site designers) seeking to “tell” information to the public should avoid overestimating the amount of effort that their audience is willing to expend in pursuit of this information. Ideally, for a Web site, the user should not be required to do more than type in a single, memorable URL and then make one or two obvious clicks of the mouse in order to view the risk information.


Examples of EMPACT projects that follow the “telling” style of risk communication include: SunWise, AIRNow, Miami Valley River Index, and Southeastern Wisconsin Beach Health, some of which are discussed below.

SunWise. The SunWise program provides a wide range of educational resources designed to interest children in the issue of UV exposure and help them gauge current UV levels in their home areas. The SunWise program uses some traditional outreach methods, such as classroom exercises and colorful brochures, but it also uses some innovative materials, such as hand-held UV monitoring devices and UV-sensitive frisbees that change color depending on how long they are exposed to the sun. These educational materials prime students for the “telling” component of the SunWise program, which involves providing NWS predictions of local UV intensity. Students can obtain these predictions directly from the SunWise Web site or through other media, such as television or newspaper weather reports.

U.S. Environmental Protection Agency
Daily UV Index Contour Map
This map shows contour lines for UV Index values.
It is created daily.

UV Index Forecast for April 30, 2002
* Valid during the solar noon hour *



For More Information 

For more information about the UV Index, explore the rest of the [UV Index](#) or contact EPA's Stratospheric Protection Hotline at 800 296-1996.

<http://www.epa.gov/sunwise/uvindexcontour.html>

Today's UV Index

The UV Index is [calculated](#) daily.

• Zipcode-searchable:

- [Text Bulletin](#) [EXIT disclaimer](#) (provides a 2 column text listing of the original 58 UV Index cities and their corresponding daily forecast value)
- [Graphical Map](#) (provides a map of the US with daily UV Index values placed accordingly for the original 58 cities)
- [Contoured Map](#) (provides a map of the US that is contoured with appropriate intensity colors for daily UV Index values across the entire US)

<http://www.epa.gov/sunwise/uvindex.html>

Southeastern Wisconsin Beach Health. This program's Web site initially provides the answer to a basic question of interest to a large number of people in the Milwaukee/Racine, Wisconsin, area each summer: Which beaches are open for swimming? As soon as a user opens the Web site, he or she is presented with a list of local beaches. A color-coded icon (either a blue swimmer or a red crossed-out swimmer) provides an immediate visual indication of whether a particular beach is open for swimming. (This Web site also provides more "user-controlled" information elsewhere on the Web site.)

Find out about today's water quality at the beaches

Beachhealth

Coordinated by Milwaukee and Racine Health Departments

Sun Safety Information

August 22, 2002

Welcome to the Southeastern Wisconsin Beach Health website

Obtain the daily water quality conditions at beaches in Milwaukee, South Milwaukee, Racine, Fox Point, Shorewood, Whitefish Bay, Kenosha, Manitowoc, and Port Washington Wisconsin throughout the swimming season

Beach water quality HOTLINE (414) 290-2450 x732

In SPANISH (414) 290-2450 x739

ANNOUNCEMENTS

Milwaukee Beaches (414) 286-8744

GOOD	Bradford Beach Last Posted: 30-Aug-02 900 No Lifeguard
GOOD	McKinley Beach Last Posted: 30-Aug-02 900 No Lifeguard
FCOR	South Shore Beach Last Posted: 30-Aug-02 900 No Lifeguard

South Milwaukee beaches (414) 264-8060

FCOR	Grand Park Beach Last Posted: 29-Aug-02 1400 No Lifeguard
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<http://infotrek.er.usgs.gov/pls/beachhealth>

THE "USER-CONTROLLED" STYLE OF RISK COMMUNICATION

Some projects serve a smaller audience (e.g., a subset of the public, local health officials, etc.) that is likely to have specific and detailed interests in particular aspects of a project's environmental data. The risk communication/outreach strategies for these projects may be most useful if they give users more control over what information they obtain and how their data are presented. For example, the Lake Access project presents information about how water quality in certain lakes varies with depth and over time. Someone with an interest in such specialized data may have a fair amount of education on the topic and be willing to expend some energy in pursuing the information. It is also reasonable to assume that the precise nature of such an informed user's interest would be difficult for a risk communicator to anticipate. Therefore, it would make sense to provide greater complexity and flexibility in using data visualization and interpretation tools than in the "telling" risk communication style described above.

Examples of EMPACT projects that follow the "user-controlled" style of presentation include: Lake Access, Boulder Area Sustainability Network (BASIN), Des Moines Waterworks, and the Monitoring Your Sound (MYSound) project for Long Island Sound, as discussed below.

Boulder Area Sustainability Network. The BASIN Web site provides public access to a wide range of data sets collected from the watershed of Boulder, Colorado. These data sets provide time-relevant information about snowpack levels, stream flow, water quality, and toxic releases in the Boulder area. Users of the BASIN Web site can generate graphs of different water quality parameters by specifying the date and parameters that they are interested in viewing. They can compare the behavior of different parameters by choosing to view those parameters on a single Web page.

City of Boulder/USGS Water Quality Monitoring

**Boulder Creek Watershed
COB Water Quality
Monitoring Sites**

Water quality data is collected monthly by the City of Boulder at 18 locations along Boulder Creek.

[View data as a profile along the North Boulder Creek/Boulder Creek system](#)
[View data as annual time series at a particular location](#)
[View data as graphs of water quality parameters on a map](#)
[View the NSF Water Quality Index computed for each month and station in watershed](#)

Boulder Creek/North Boulder Creek Water Quality Profiles

To see graphs of water quality in Boulder Creek from upstream to downstream, use this form. Select the parameter(s) of interest, month, year, and indicate if you also want to see a data table.

Water Temperature Stream Flow pH (Acidity)
 Specific Conductance Alkalinity Hardness
 Turbidity Total Dissolved Solids Total Suspended Solids
 Nitrate and Nitrite Nitrite Ammonia
 Total Phosphate Ortho-phosphate Fecal Coliform Bacteria
 Dissolved Oxygen Total Organic Carbon All Parameters

2001 Select Month for Profile Include Data Table
 Plot Stream Profiles Reset Form Selections

<http://bcn.boulder.co.us/basin/data/STREAMWQ/index.html>

Des Moines Water Works. The Des Moines Water Works has established a Web site to provide information about the water quality of its drinking water sources. It provides users with custom water quality reports (including some graphs) in response to input queries. The user's input query provides information about the particular water source, laboratory test, and time period of interest to the user.

Lab Data

Select a source water location: All Source Water

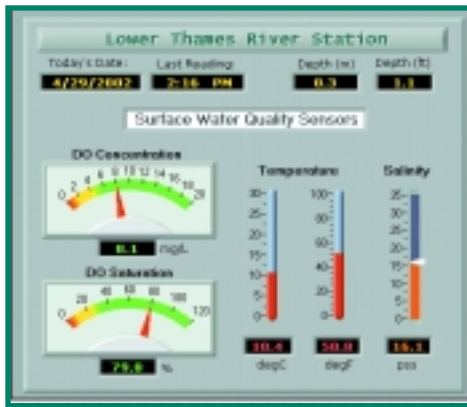
Select a source water quality test: Ammonia-N (had only)

Enter the number of days of data you want to view: from 03/03/2002 to 04/03/2002

mm/dd/yyyy mm/dd/yyyy

Show Me

<http://www.dmwv.com/eng/home.asp>



<http://www.mysound.uconn.edu>

Monitoring Your Sound. The MYSound Web page provides information about dissolved oxygen and other water quality variables at various sampling locations along Long Island Sound. Much of the information is provided in the format of an instrument display panel. Users of the MYSound Web page view current information by selecting which sampling buoy they wish to receive data from and then selecting what kinds of data they are interested in from that buoy (as well as whether they would prefer to view the data in graphical or text format).

CONCLUSION

The projects discussed in this handbook illustrate the wide range of data visualization and data interpretation tools and techniques available for environmental risk communication, including time-relevant environmental information. We hope that you have found these tools interesting and useful for adaptation to your own risk communication efforts. We also hope that this handbook stimulates further research and encourages development of additional tools to communicate environmental risk.

Table 5-1 lists the addresses of the project Web sites discussed in this handbook; visit these sites if you wish to explore the projects' risk communication messages further. The Reference list includes additional resources. Also, an overview of environmental risk communication can be found in EPA's publication *Considerations in Risk Communication: A Digest of Critical Information* (order no. EPA/625/R-02/004). Ordering information for other titles in this series can be found in the order booklet EPA/625/N-02/001 or at the EPA Web site: <http://www.epa.gov/ttbnrmrl>.

TABLE 5-1. WEBSITES OF PROJECTS HIGHLIGHTED IN THIS HANDBOOK

Web Site Name	URL
EPA AIRNow	http://www.epa.gov/airnow
Boulder Area Sustainability Information Network	http://bcn.boulder.co.us/basin
Charles River Basin Flagging Program 2002	http://www.crwa.org/wq/daily/2002/daily.html
Des Moines Water Works EMPACT Project	http://www.dmww.com/empact.asp
Smog City	http://www.e-tulsa.net
Lake Access	http://www.lakeaccess.org
Miami Valley River Index	http://www.riverindex.org
MYSound	http://www.mysound.uconn.edu
Southeastern Wisconsin Beach Health	http://infotrek.er.usgs.gov/pls/beachhealth
Spare the Air	http://www.sparetheair.com
EPA SunWise School Program	http://www.epa.gov/sunwise
Texas Natural Resource Conservation Commission: Air Monitoring	http://www.tnrcc.state.tx.us/air/monops/index.html

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- Climate Prediction Center. 2000. UV Index: how to use it! National Oceanographic and Atmospheric Administration, National Weather Service. <http://www.cpc.ncep.noaa.gov/products/stratosphere/uv_index/uv_info.html>
- Host, G.E., N.R. Will, R.P. Axler, C.J. Owen, and B.H. Munson. 2000. Interactive technologies for collecting and visualizing water quality data. *URISA Journal* 12(3):39–45.
- Lake Access. 2002. <<http://www.lakeaccess.org>>
- National Weather Service. 2002. National Oceanic and Atmospheric Administration. <<http://www.nws.noaa.gov>>
- River Index Project. 2002. Miami Valley River Index. <<http://www.riverindex.org>>
- Sacramento Metropolitan Air Quality Management District. 2002. Ozone movie archive. <<http://www.sparetheairnow.com/moviearchive.html>>
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- Texas Natural Resource Conservation Commission. 2002. Animated ozone concentrations. <http://www.tnrcc.state.tx.us/cgi-bin/monops/ozone_animation>
- Tulsa Air and Water Quality Information System. 2002. <<http://www.e-tulsa.net/smogcity/smog1.html>>
- University of Connecticut. 2002. MYSound. <<http://www.mysound.uconn.edu/index.html>>
- U.S. EPA. 1998. Report of eight focus groups on the Ozone Map, the Pollutant Standards Sub-Index for Ozone, and the Ozone Health Effects Booklet. Report prepared by Eastern Research Group, Inc. Washington, DC.
- U.S. EPA. 1999a. *Air quality guide for ozone*. EPA/456/F-99/002. Washington, DC.
- U.S. EPA. 1999b. *Guideline for developing an ozone forecasting program*. EPA/454/R-99/009. Research Triangle Park, NC.
- U.S. EPA. 1999c. *Guideline for reporting of daily air quality—Air Quality Index (AQI)*. EPA/454/R-99/010. Research Triangle Park, NC.
- U.S. EPA. 1999d. *Ozone and your health*. EPA/452/F-99/003. Washington, DC.
- U.S. EPA. 2000. *Delivering timely water quality information to your community: the Lake Access—Minneapolis project*. EPA/625/R-00/013. Washington, DC.
- U.S. EPA. 2002a. SunWise school program. <<http://www.epa.gov/sunwise>>
- U.S. EPA. 2002b. Office of Environmental Information. <<http://www.epa.gov/oei>>
- U.S. EPA. 2002c. AIRNow. <<http://www.epa.gov/airnow>>
- Weather Channel. 2002. Air quality forecast. <<http://www.weather.com/activities/health/airquality/>>

REFERENCES



United States
Environmental Protection
Agency

Office of Research and
Development
National Risk Management
Research Laboratory
Cincinnati, OH 45268

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September, 2002

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