
AIRNow: Arming the Public with Air Quality Data

November 2003, revised March 2004

The amazing thing about this project is that state participation is voluntary and yet all of the states with an ozone problem have embraced it. I haven't heard of many government programs that are voluntary and successful. The success of the program is a testament to Chet Wayland's quiet but effective leadership.

– Phil Dickerson, EPA Environmental Engineer

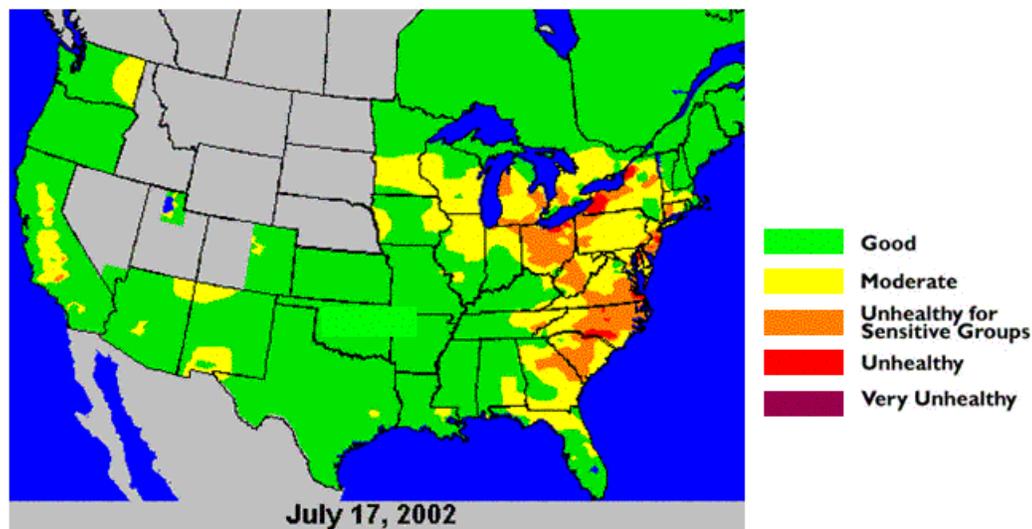
In June 2003, Chet Wayland, manager of the EPA Office of Air Quality Planning and Standards AIRNow Program, reflected on the progress AIRNow had made. Since picking up the gauntlet in 1998, Wayland's AIRNow project had grown to provide the public in 45 states and 276 metropolitan areas with up-to-the-minute ozone air quality data and one- to three-day forecasts. Although participation in the program was voluntary, air quality engineers across US state and county governments, national parks, and parts of Canada and Mexico pooled their data every hour to produce color-coded maps (see Exhibit 1). People with asthma or heart problems, young children, or those with regular exercise regimens could tell at a glance when to shift their activities indoors. Unlike the EPA's official air quality statistics, AIRNow maps and forecasts were readily available on the web, The Weather Channel, and in USA Today.

Since 1976, the EPA had required states to report ozone levels quarterly. This data was carefully collected, stored in the EPA data center, and used mainly to evaluate whether states were in compliance with federally mandated air quality standards. Phil Dickerson, EPA Environmental engineer, noted that since the data was processed and stored in a mainframe environment, "It was difficult for the public to get ahold of the data – they had to do a Freedom of Information Act (FOIA) request. And the data that we sent to them was hard to interpret." As a result, most citizens remained uninformed about ozone in their cities and neighborhoods, even when it reached potentially hazardous levels.

The AIRNow program completely changed the public's ozone awareness. It brought air quality information out of the glass house and put it in citizens'

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Exhibit 1: 8-hour Ozone Concentration Levels



Source: www.epa.gov/airnow/

living rooms. , According to Lewis Weinstock, an air quality forecaster for Forsyth County, North Carolina, the AIRNow initiative significantly changed his role. He noted, “I manage an air quality monitoring group for a local agency in Winston-Salem. We are an analysis and monitoring section. We measure pollutants for the Clean Air Act. To put our group into context, the EPA sets expectations for maintaining ozone standards, but most air quality monitoring work is delegated out to state and local agencies.” Weinstock continued,

We have a county of over 300,000 people, and North Carolina has a lot of air quality problems. Prior to AIRNow, we didn’t interact much with the public; we saw our role as taking numbers and reporting them to the state and federal government. As the Internet grew and people’s interest in air quality grew, everyone recognized there was much more immediacy to the data and value to the public. We used to tell them six months later what they shouldn’t have been doing on a particular day because of air quality conditions. Now we tell them three days ahead of time.

We now see our role as being proactive, warning citizens and working with the media to make sure information is distributed accurately and quickly. AIRNow has convinced most of the air quality people to

come out from behind their computers and be ready to be in front of a camera.

Overview of Ozone and US Federal Regulations¹

Ozone occurs naturally in the Earth's upper atmosphere – 10 to 30 miles above the surface – where it forms a protective barrier that shields people from the sun's harmful ultraviolet rays. The barrier is sometimes called the "ozone layer."

Because of pollution, ozone can also be found in the Earth's lower atmosphere, at ground level. Ground-level ozone is a major ingredient of smog, and when inhaled – even at very low levels – it can damage people's lungs and cause a number of respiratory health effects. Ground-level ozone can also damage crops and many common man-made materials, such as rubber, plastic, and paint.

Ground-level ozone forms when various pollutants, such as volatile organic compounds and nitrogen oxides, mix in the air and react chemically in the presence of heat and sunlight. These pollutants are known as ozone precursors. Common sources of volatile organic compounds (often referred to as VOCs) include motor vehicles, gas stations, chemical plants and other industrial facilities. Solvents such as dry-cleaning fluid and chemicals used to clean industrial equipment are also sources of VOCs. Common sources of nitrogen oxides include motor vehicles, power plants and even wood-burning stoves.

Because ground-level ozone forms more readily in the hot, sunny conditions of summer, it tends to be a seasonal problem, approaching hazardous levels in the US between May and September. It also travels easily. A summer ozone plume generated from Boston automobile and industrial exhaust could be in Maine's Acadia National Park in a matter of days.

Ground-level ozone is regulated under the Clean Air Act, the comprehensive federal law amended in 1990, that regulates air emissions in the United States. Among other things, the Clean Air Act requires the US EPA to set standards for "criteria pollutants" – six commonly occurring air pollutants, one of which is ground-level ozone. These standards, known as the National Ambient Air Quality Standards (NAAQS), are national targets for acceptable concentrations of each of the criteria pollutants (see Exhibit 2). For each pollutant, the EPA has developed two NAAQS standards:

- The "primary standard," which is intended to protect public health.

¹ Information in this section was excerpted from Ozone Monitoring, Mapping and Public Outreach, EPA/625/R-99/007 September 1999.

- The “secondary standard,” which is intended to prevent damage to the environment and property.

Exhibit 2: National Ambient Air Quality Standards

POLLUTANT	STANDARD VALUE *		STANDARD TYPE
Carbon Monoxide (CO)			
8-hour Average	9 ppm	(10 mg/m ³)	Primary
1-hour Average	35 ppm	(40 mg/m ³)	Primary
Nitrogen Dioxide (NO₂)			
Annual Arithmetic Mean	0.053 ppm	(100 µg/m ³)	Primary & Secondary
Ozone (O₃)			
1-hour Average	0.12 ppm	(235 µg/m ³)	Primary & Secondary
8-hour Average	0.08 ppm	(157 µg/m ³)	Primary & Secondary
Lead (Pb)			
Quarterly Average	1.5 µg/m ³		Primary & Secondary
Particulate (PM 10) <i>Particles with diameters of 10 micrometers or less</i>			
Annual Arithmetic Mean	50 µg/m ³		Primary & Secondary
24-hour Average	150 µg/m ³		Primary & Secondary
Particulate (PM 2.5) <i>Particles with diameters of 2.5 micrometers or less</i>			
Annual Arithmetic Mean	15 µg/m ³		Primary & Secondary
24-hour Average	65 µg/m ³		Primary & Secondary
Sulfur Dioxide (SO₂)			
Annual Arithmetic Mean	0.030 ppm	(80 µg/m ³)	Primary
24-hour Average	0.14 ppm	(365 µg/m ³)	Primary
3-hour Average	0.50 ppm	(1300 µg/m ³)	Secondary

* Parenthetical value is an approximately equivalent concentration.

Source: www.epa.gov

A geographic area that meets the primary health-based NAAQS is called an attainment area. Areas that do not meet the primary standard are called non-attainment areas.

The Clean Air Act requires each state to develop a “state implementation plan” (SIP), which describes the programs it will use to maintain good air quality in attainment areas and meet the NAAQS in non-attainment areas. For example, if

a city or region is a non-attainment area for ozone, the SIP describes the programs that will be used to meet the primary NAAQS for ozone. For example, to address ozone non-attainment, a state could install vapor recovery nozzles at gasoline station pumps to reduce refueling emissions, adopt strict NO_x emission limits for power plants and industrial sources, limit solvent usage in factories, or tighten vehicle inspection programs.

One of the elements of a State's SIP is a network of monitors that measure concentration of the six critical pollutants, including ozone. An ozone monitoring network is an air quality surveillance system consisting of monitoring stations that measure ambient concentrations of ozone hourly. The Clean Air Act places the responsibility on states to establish and operate these ozone monitoring networks and to report the data to the EPA. This schedule gives state monitoring organizations the opportunity to review their data for accuracy before reporting it. The EPA uses data from the air quality system (AQS) to determine whether an area is complying with the standards, and if not, what enforcement actions are required.

AIRNow Takes Shape

In 1994, progressive EPA environmental engineers in Maryland began a pilot program to map their state ozone information. Hindered by poor computer capabilities and access to only one state's information, their early maps were limited and received little exposure. The pilot fizzled, but the idea survived.

Encouraged by growing interest in the Internet, the EPA's Region 1, Boston office picked up the baton in 1996. Managers there reasoned they could pull data from multiple states and make it available to the public on a website. Dave Conroy, a manager in the Boston EPA air quality planning group, recalled, "At the time, some states had toll-free numbers and sent some information to newspapers, but we felt we were not really getting the message about pollution levels out to the public. We pooled our money with Maryland through an association called NESCAUM [New England States for Coordinated Air Use Management]. NESCAUM let a contract to have the hourly ozone data from 13 New England and mid Atlantic states plus Washington, DC compiled into an animated map and posted on our website." Lee Alter, the project manager for NESCAUM who had been involved from the project's early days, continued, "We had collected the data for 20 years, but no one ever looked at it. There was no easy way to share; New York had to fax New Jersey to get its data. The regional EPA leadership backed the mapping project in order to build awareness about ozone, help people understand, for example, why vehicle inspections are important, and improve public health." By May 1997, the software was up and running. Conroy summarized, "We achieved our objectives: we made the information available so that interested people could seek it out."

That first summer, EPA Region 1 posted ozone maps and forecasts three times a day on the web from information that the states contributed voluntarily. By the end of the 1997 ozone season, however, it was struggling to overcome the contentious organizational politics and technology hurdles it faced in its bid to extend its reach to additional states. Despite its initial success, one participant reckoned that the team did not have the resources to continue to support the process through the next year.

EMPACT

Helping hands reached out from an unexpected source. As yet unaware of the Boston project, Chet Wayland and Phil Dickerson in the EPA’s central planning organization were looking for a way to accomplish the same goal, but at a national level. They learned of a new Clinton administration initiative called EMPACT (Envrionmental Monitoring for Public Access and Community Tracking). According to Dickerson, EMPACT began as a campaign promise. He noted, “When Clinton stopped in Kalamazoo in his re-election campaign, he promised people easier access to environmental data. Early in his second administration, he created the EMPACT initiative.” EMPACT funded project proposals to bring people up-to-date, understandable information about local environmental conditions (see Exhibit 3).

Exhibit 3: Key Events in U.S. Ozone Mapping

1994	U.S. State of Maryland began Ozone mapping
1997	U.S. EPA Region 1 took responsibility for ozone mapping and expanded it to 13 New England and mid Atlantic states and Washington D.C.
1997	President Clinton announced the EMPACT program
1998	EPA headquarters took over the ozone mapping program and named its initiative AIRNow
2000	EPA firewall improvements made it difficult for states to upload their ozone data to EPA data center computers
2001	Sonoma Technology was awarded the contract to run the AIRNow data collection and reporting systems

Dickerson continued,

Chet and I wanted to bring data to the public in a format that they could understand and without having to do a mainframe printout. EMPACT came along and provided resources via grants. We wrote a grant request, and it was approved. Then we knew we had to produce something. We had to figure out how we would pull it off.

In the fall of 1997, Wayland and Dickerson looked around the country and discovered that EPA Region 1 in Boston had technology that allowed them to produce ozone maps. They went to meet with representatives of Region 1. Wayland recalled, “We thought, if we can get the money to build the infrastructure we can carry this concept to a national level.” They called their project AIRNow. Dickerson continued,

Everything clicked. It was just Chet and me. Chet was the marketing management person, and I was the tech guy. I saw technology that I knew we could use, and Chet saw a process we could bring down here and expand. Region 1 was starting to groan under the weight of what they were doing and were running out of resources. We said we’ll take the project, bring it to headquarters and try to expand it. Between that October and the following May, during the ozone ‘off-season,’ we moved everything and tried to get it running with EPA headquarters in charge of it. And we tried to bring in some of the other regions. We expanded it down to South Carolina and into the Midwest.

To satisfy the EMPACT objectives, the EPA needed hourly ozone data from the states. While states already had monitors in place to comply with AQS reporting requirements, these systems were not designed for consistent, high quality, hourly data transmission. For example, some needed additional monitors or data loggers, others required faster modems. Dickerson continued,

The AIRNow data comes directly from the monitors at least once per hour. The data which is submitted to AQS quarterly has been subject to extensive quality assurance. Technically, the AIRNow and AQS data shouldn’t be that different, but if a monitor is malfunctioning, AQS allows for correction.

“In the early days of the program,” noted Ron Stockett, air quality monitor for the Missouri Department of Natural Resources, “some were concerned about sending in unchecked data.” He continued,

But when it came to ozone, we had become very confident of our instruments. We insisted that they allow us to use two instruments at each site, just for quality control. If both instruments have the same data, then the numbers should be right. If one says 20 and the other says 80, you know something is wrong. That’s our major method of quality control. We have people checking the data four times per day, and if the monitors at a location are not in agreement, we won’t use the data from that location.

States’ concerns were also eased by the fact that both ozone levels and forecasts would be shown on maps as color bars rather than precise numbers. Wayland insisted from the beginning that states agree on a standard ozone color key so that, for example, a “red alert” ozone day would have the same meaning across the country (see Exhibit 4).

Exhibit 4: Standard Ozone Air Quality Color Indicators

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	>300	Health warnings of emergency conditions. The entire population is more likely to be affected.

Source: www.epa.gov/airnow/

Wayland and Dickerson used their EMPACT grant to offer seed money to states that wanted to join the initiative. This enabled states to purchase the new hardware and software they needed to upgrade their data collection infrastructure. In addition, Wayland got his own chain of command to certify that AIRNow data would never be used to evaluate a state’s compliance with ozone regulations. According to Stockett, “The EPA

funding was critical to the success of this project. States were willing to provide horsepower, but didn't have the budget to provide hardware and software."

Picking up Steam

At the close of the 1998 ozone season, Wayland and Dickerson decided to move AIRNow's central data collection activity to the EPA's national data center in Research Triangle Park, North Carolina. They asked the EPA's IT outsourcing provider to supply post-processing, infrastructure, and an Internet web site. They worked through the government's meticulous procedures for implementing a new application and went live in April 1999. Dickerson recalls, "This was groundbreaking for the people in the computer center. They had never supported a public-access web application or had the requirement to collect and process data hourly. It was all brand new to them. And in the middle of the transition, key technology people in Boston were moving on. We had to scramble."

With central processing under control, the AIRNow program directors were able to increase the frequency of ozone maps to seven times a day. They also brought additional states on board. People like Mike Koerber, executive director of the Lake Michigan Air Directors' Consortium, were invited to meetings Wayland convened to discuss how to expand the program. Koerber remembered:

Each state had its own computer systems and databases, and we never had any luck trying to transfer mapping technology from one state to another. But all of our states were thinking about ozone action programs and how to make the data available. With AIRNow, the EPA was offering to provide a consistent system and make it as easy as possible to tie in. It was obvious to everyone that this was a good thing.

Forsyth County, North Carolina's Weinstock continued, "Being a small agency, we like innovation. When Chet called and asked us to participate in the forecasting program, he didn't have to twist my arm. North Carolina is one of the top ten states for air quality problems, so everyone realized this was a smart thing to do."

In an effort to expand the program, Wayland launched an annual AIRNow conference for all the initiative's participants and prospects. One environmental engineer recalled, "Chet would start by saying it was our program. He would have speakers talk about what they had accomplished, and then he would get up and ask us what we needed to take our programs to the next step."

Under Wayland's supportive leadership, more states and cities volunteered to participate. Sacramento, Los Angeles, San Diego, San Francisco and the central California valley had been working with Sonoma Technology, a local contractor, for several years to map their own region. Wayland signed Sonoma up as the west coast mapping center. Subsequently, Washington State, Arizona and Texas joined the initiative. By early 2000, 35 states and 100 cities were transmitting hourly ozone levels to the EPA.

As the AIRNow program expanded, it hit some technology bumps. For example, an early 2000 GAO audit of the EPA's security found serious issues. It threatened to shut down the EPA's connection to the Internet unless the agency implemented a strict firewall. On February 17, 2000, the firewall went up, and AIRNow went down. Dickerson recalls, "We came back from a conference and found that we were no longer connected to the Internet. There was no warning or lead time. It was a complete blow."

Over the next eight weeks, the AIRNow team reconfigured the data collection process so that states could drop off their ozone information to mirrored servers outside the firewall. The files would be picked up, encrypted and brought inside the firewall. The team was less than thrilled with the 15-minute processing delay this introduced into their hourly cycle, but they were back in operation before the 2000 ozone season opened.

AIRNow Airs

As luck would have it, *USA Today* was redesigning its weather page in the spring of 2000. Lynne Perri, deputy managing editor, went looking for something that would make her paper distinctive. She explained, "We needed something that our readers couldn't get from either TV or from a big city newspaper. We started talking to people, and the folks at the American Lung Association led us to Chet. There were some issues to iron out, but in the end, we decided to see if we could pull off daily air quality forecasting." AIRNow's data did not match Perri's needs exactly. She wanted daily information for 36 key cities in the US. AIRNow carried information on more than 100 cities, but some on Perri's list like Nashville and New Orleans were missing. For those cities, Perri's paper ran "N/A" while the AIRNow team tried to pull their environmental monitoring organizations into the community. Wayland also opened up conversations with CNN and The Weather Channel.

To address lingering technology glitches, Wayland hired a new program manager, John White. When White arrived, he found FORTRAN programs, flat text files and no data archives. Because of the increased media exposure and need for overall data management, the team decided to upgrade AIRNow to an Oracle database system to increase reliability and to improve the team's ability to

produce new products with the data. Despite EPA's bias toward keeping systems work in-house, the team decided to work with an outside contractor. White enumerated the reasons:

First, the contractors who run the in-house systems understand computers, but not weather or air quality. We wanted more scientific people who could help us actually understand the data and propose new ways to present the information. Second, an outside contractor turned out to be cheaper. Third, we could speed up our data turnaround process if we got outside the EPA firewall.

Sonoma Technology won the contract to develop the new MapCon software in early 2001 and when it delivered at the end of the year, earned a three-year contract to run the system. Tim Dye, vice president of meteorological programs and public outreach for Sonoma, summarized:

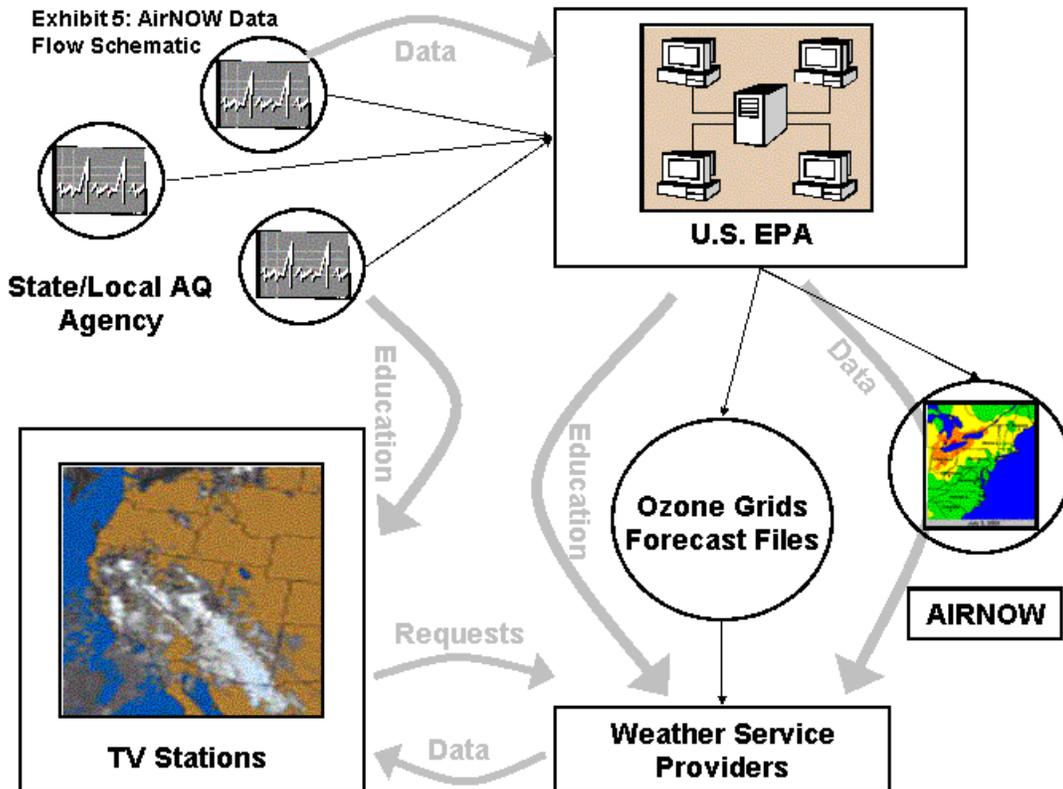
We bring two critical things to AIRNow. We are meteorologists, not computer technicians. So we know right away when the data do not look right. Secondly, we recognize the importance of reliability when we're feeding data to media outlets like The Weather Channel. We have an Oracle database running on redundant servers and hard drives. We have automated as much of the processing as possible to provide speedier, reliable service.

Dye asserted that strong communication and good coordination was at the crux of the program. He continued:

AIRNow doesn't exist without the stakeholders. They are key to its survival. The program needs to figure out how best to serve the stakeholders so they are overwhelmingly compelled to participate. How do we do it? We monitor things closely, and we have a few folks who are really good at communicating. For example, last week one of our meteorologists saw a strange reading from one of the monitors and sent out an email. The stakeholder with the problem wasn't talking to a technician; he was talking to a colleague. We speak their language.

Once processing moved to Sonoma, new products and features were added regularly. For example, the program went to hourly updates of maps from a schedule of seven times a day (Exhibit 5 shows a technical schematic). The media were receiving their data feeds like clock work. By this time, a total of 45 states and more than 100 agencies were contributing their data. This included Georgia, a late-comer among southeastern states, which had gotten tired of explaining why it was grayed out on all the air quality maps. Sonoma's Dye noted,

"AIRNow has so much momentum that people now participate because their data and information really go places and are being used by the public. AIRNow is providing ozone maps and air quality forecasts that go to The Weather Channel, *USA Today*, and local TV. This year they're updated at 30 minutes past the hour rather than at 45 minutes past the hour as was done last year. So we're closer to real-time."



By 2003, EPA had developed a feature entitled "Where I Live" on www.epa.gov to provide tailored information to individuals. They also implemented AIRNow Tech, a private website for the stakeholders. This portal, gave environmental agencies complete access to the ozone database and the ability to conduct their own analyses.

Making a Difference

It was hard to pinpoint health or environmental benefits that could be attributed directly and exclusively to AIRNow, although all would agree that it had made an impact. According to Boston's Conroy, "We started a service in the region called Smog Alert Service, where people sign up on a list to receive notice by email or fax when states are forecasting unhealthy air. There are about 2000

organizations on our list -- nurses, day camps, nursery schools. While we cannot quantify how this data helps the public, sometimes we get replies like "Thanks for the service. It helps with an asthmatic child." Another air quality forecaster noted that a football coach in California routinely cancelled practices when bad ozone days were forecast. Wayland added:

We get tons of email from the public. Someone who runs a daycare center can send the kids outside in the morning if air quality is forecast to be bad in the afternoon. Some proactive cities like Washington DC make the busses free on ozone action days. We have cases in Baltimore where companies voluntarily shut down certain manufacturing processes on a bad day. UCLA did a study that showed hospital admissions for children with respiratory problems declined four to seven percent on days when air quality forecasts were for unhealthy levels. People with asthma and heart problems know to stay indoors and rest so they won't end up in the emergency room.

Susannah Fuchs, senior program and air quality director of the American Lung Association of Eastern Missouri, noted that companies often take steps to reduce pollution during ozone season, especially if a bad air day is forecast. She pointed out, "A company's transportation coordinator might coordinate carpools or even provide bus passes." Some firms voluntarily changed their work hours to avoid adding to rush hour ozone levels. Others delayed using gasoline powered lawn mowers until air quality improved. Supporters hoped that these voluntary measures would add up to enough air quality improvement that the state would ultimately avoid EPA sanctions. One state official remarked, "We'd rather not have the EPA enforcers watching over our shoulders."

Forsyth County's Weinstock added, "I can't document that I have saved anyone's life, but people appreciate the product and tell us so. And the alerts in North Carolina have gotten state legislators to pay more attention to power plants and cars. Legislators who never would have voted for increased air quality regulation will do it now because of the code orange and red alerts." He continued, "Chet's group deserves the credit for demonstrating why this is important. They don't like to take credit for themselves, but they shield people from red tape and encourage collaboration. People love to work with them, and that's not typical of the local-state-EPA relationship. Chet has often asked us to present at his conferences, and he helped us win an EPA national award. We don't have to do this, but it's fun and innovative and our boss loves it."

Dye went further, "This program has something for everyone. Getting meaningful air quality information out there helps people to take action to improve their own health. In addition, this program enhances the capabilities of

the air quality agencies that participate. They're providing a clear public service, and when they see their work on TV, it makes that agency stand out. For myself, I'm a scientist. I used to be content to sit at my computer and do my research. With AIRNow, for the first time, I'm doing something that really makes a difference for people. It changed my life."

Facing the Future

According to LADCO's Koerber, AIRNow's success created high expectations for air quality efforts in general. He remarked, "Public awareness is high. Policy makers, the media and the public want to know, if we can do ozone, why we can't we do particles and other pollutants? These are very challenging."

Wayland and the AIRNow team pushed ahead. By October 1, 2003 they began to report and forecast air quality year round. However, monitoring and forecasting particulate matter (PM_{2.5}), the winter pollutant, involved a great deal more effort. It required a different monitor – a filter-based system which collected a sample that was sent to a laboratory for analysis. While 1300 ozone monitors were operating in the US, only 280 PM_{2.5} monitors were in place. In addition, many agencies were not staffed for year-round forecasting. Their professionals used the ozone off-season to take care of other responsibilities. Finally, EMPACT funding had run out in 2001, so the team had to rely on states and cities to fund their own operations.

USA Today's Perri encouraged, "Our readers love the ozone air quality data that we publish. Baby boomers grew up with enhanced weather coverage and want more and more sophisticated information. We will be covering the Olympics in Greece in 2004 and are already talking about how air quality in Greece can affect athletes and tourists."

Dickerson was undaunted by the challenges ahead. He explained, "People tell you to plan things in advance. But with AIRNow, if we had planned up front, I'm not sure we would have done as well. We would have come up with a different answer. As it was, we just had a spark that turned into a bigger and bigger fire." Wayland continued, "Five years ago, colleagues within the EPA felt that the AIRNow program would never work and believed it would be difficult to find the requisite state resources to fund the program. Today, given the public's demand for information about air quality, it would be difficult, maybe impossible, to stop the program."