INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

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PURPOSE

This is the Premier Issue of the IMPROVE Newsletter. The purpose of this Newsletter is to provide up-to-date information on all aspects of the IMPROVE program to Steering Committee members, sponsoring agencies, program participants, and all other interested parties. This Newsletter will also be a forum for feature articles related to visibility monitoring, data analysis, and policy issues.

This Premier Issue presents an overview of the IMPROVE program. Future quarterly issues will discuss program activities that occurred during the previous monitoring season, include a feature article, and list upcoming schedules and milestones.

IMPROVE PROGRAM GOALS AND OBJECTIVES

Section 169A of the 1977 amendments to the Clean Air Act (CAA) established as a national goal the protection of visibility in federal class I areas (156 national parks and wilderness areas). In 1980, the EPA established a phased regulatory approach to visibility protection. The emphasis of the first phase was to remedy existing and future impairment caused by sources that are "reasonably attributable." EPA has not yet proposed follow-up phases. The 1990 amendments to the CAA reaffirm the importance of visibility protection.

In 1985, the EPA established Federal Implementation Plans (FIPs) for states without approved visibility provisions in their State Implementation Plans (SIPs). A monitoring program was established as part of the FIPs. Federal land management agencies (FLMs) responsible for class I areas and the land surrounding them joined the EPA in a collaborative monitoring program known as the Interagency Monitoring of Protected Visual Environments (IMPROVE). These agencies include the National Park Service (**NPS**), Forest Service (**USFS**), Fish and Wildlife Service (**FWS**), and Bureau of Land Management (**BLM**).

In 1991, the following organizations were formally added to IMPROVE:

- **STAPPA** - State and Territorial Air Pollution Program Association
- **WESTAR** - Western States Air Resources Council
- **NESCAUM** - Northeast States for Coordinated Air Use Management

Representatives from all participating agencies and organizations serve on the IMPROVE Steering Committee.

IMPROVE has been collecting data since 1987 in 20 class I areas nationwide. In 1991, ten sites in the Eastern U.S. were added to the IMPROVE network. Visibility monitoring in class I areas has also been conducted by FLMs as part of their responsibility to protect the air quality-related values of those areas. In addition, some state and local government organizations have conducted visibility monitoring in or near class I areas.

The three primary IMPROVE monitoring objectives that support the visibility protection regulations for federal class I areas are:

- establish present visibility levels;
- identify sources of existing man-made impairment; and
- document long-term trends to track progress towards meeting the long-term goal of no man-made impairment of protected areas.

IMPROVE has also been a key participant in visibility-related research, including the advancement of monitoring instrumentation, analysis techniques, visibility modeling, policy formulation and source attribution field studies.

VISIBILITY TERMINOLOGY

The following terms are commonly used by IMPROVE and other visibility monitoring programs.

A simple definition of visibility is "the appearance of scenic features when viewed from a distance." The most popular term to characterize visibility is ***observer visual range*** which is the greatest distance at which a large black object can just be seen against the horizon sky. Most in the technical community prefer to use the term ***extinction coefficient***, which is the loss of image-forming light per unit distance due to scattering and absorption by particles and gases in the atmosphere. The extinction coefficient is the sum of the ***scattering coefficient*** and ***absorption coefficient***, which are similarly defined as the loss of light per unit distance by scattering and absorption mechanisms respectively. The ability of ambient atmospheric particles and gasses to scatter and absorb light depends on their size, shape, composition, concentration and distribution.

A simple model allows the observer visual range to be estimated by dividing a constant by the extinction coefficient. The magnitude of the constant depends on the units used and assumptions concerning the minimum contrast detectable by the observer. ***Visual range*** is the common name given to the resulting estimate. To compare visibility data from different sites, visual range estimates can be normalized to a Rayleigh coefficient of 0.01 km^{-1} (Particle-free atmospheric conditions at an altitude of 1.524 km or 5000 feet). This normalized estimate is called the ***Standard Visual Range.***

Visibility-related characteristics and measurements can be partitioned into three groups:

- **Aerosol** The physical properties of the ambient atmospheric particles (chemical composition, size, shape, concentration, temporal and spatial distribution and other physical properties) through which a scene is viewed.
- **Optical** The ability of the atmosphere to scatter or absorb light passing through it. The physical properties of the atmosphere are described by extinction, scattering and absorption coefficients plus an angular dependence of the scattering known as the normalized phase function. Optical characteristics integrate the effects of atmospheric aerosols and gases.
- **Scene** The appearance of a scene viewed through the atmosphere. Scene characteristics are more nearly in line with the simple definition of visibility than aerosol or optical characteristics. Scene characteristics include observer visual range, scene contrast, color, texture, clarity, and other descriptive terms. Scene characteristics change with illumination and atmospheric composition.

IMPROVE STEERING COMMITTEE

IMPROVE Steering Committee members represent their respective agencies and meet periodically to establish and evaluate program goals and actions. IMPROVE related questions within agencies should be directed to the agency's steering committee representative. Steering Committee representatives are:

U.S. EPA
Marc Pitchford
Env. Monitoring Systems
Lab P.O. Box 93478
Vegas, Nevada 89193-3478
702/798-2363 (Phone)
702/736-7729 (Fax)

NPS
William Malm
NPS-AIR
Colorado State University
CIRA - Foothills Campus
Ft. Collins, Colorado 80523
303/491-8292 (Phone)
303/491-8598 (Fax)

USFS
Rich Fisher
Air Specialist, Wash. Office
Rocky Mtn. Experiment Sta.
240 W. Prospect
Ft. Collins, Colorado 80526
303/498-1232 (Phone)
303/323-1010 (Fax)

FWS
Sandra Silva
Fish and Wildlife Service
P.O. Box 25287
Denver, Colorado 80225
303/969-2822 (Phone)
303/969-2814 (Fax)

BLM
Scott Archer
Colorado State Office
2850 Youngfield
Lakewood,Colorado 80215
303/239-3726 (Phone)
303/239-3933 (Fax)

NESCAUM
Rich Poirot
Vt. Agency of Nat. Res.
103 South Main Street
Building 3 South
Waterbury, Vermont 05676
802/244-8731 (Phone)
802/244-5141 (Fax)

STAPPA
Dan Ely
Colorado Dept. of Health
Air Pollution Control Div.
4210 East 11th Avenue
Denver, Colorado 80220
303/331-8529 (Phone)
303/320-4079 (Fax)

WESTAR
John Core
Executive Director
Suite 1000
S1001 S.W. 5th Avelity
Portland, Oregon 97204
503/220-1660 (Phone)
503/220-1651 (Fax)

Aerosol and optical characteristics depend only on the properties of the atmosphere through which light passes. Scene characteristics, however, are also dependent on the scene and lighting conditions.

Visual air quality describes the air pollution aspects of visibility. Visual air quality is what must be monitored and preserved in class I areas, not the overall visibility which is influenced by nonpollution factors (i.e., clouds, snow cover, sun angle, etc.).

The distribution and extent of pollutants in the atmosphere relative to the observer's sight path has a large effect on the appearance of visibility impairment. If the pollutants are uniformly distributed from the ground to a height well above the highest terrain, it is known as a ***uniform haze***. If the top edge of the pollution layer is visible, as is often the case when pollution is trapped below an inversion, then it is called a ***surface layer***. A pollution distribution that is not in contact with the ground is an ***elevated layer***. ***Plumes*** can be thought of as a special case of an elevated layer, though from many vantage points it may not be possible to distinguish a plume from an elevated layer. It is possible to have combinations of pollutant distributions such as multiple elevated layers superimposed upon a uniform haze.

Uniform haze and surface layered haze can be monitored from the ground by a variety of methods. Elevated layers must be either remotely monitored from the ground or from instruments carried aloft.

ANALYTICAL AND REPORTING PROCEDURES

Contracted IMPROVE monitoring and data analysis services are currently administered by the NPS. The primary aerosol monitoring contractor is the University of California at Davis (U.C. Davis). The primary optical and scene monitoring contractor is Air Resource Specialists, Inc. (ARS). All monitoring data are summarized and reported by IMPROVE contractors for monitoring seasons defined as:

- Winter: DEC JAN FEB
- Spring: MAR APR MAY
- Summer: JUN JUL AUG
- Fall: SEP OCT NOV

The availability of data reports is generally:

- **Aerosol** Six (6) months after the end of each monitoring season - U.C. Davis
- **Optical** Ninety (90) days after the end of each monitoring season - ARS
- **Scene** All film is numbered and archived by site, and is available for review within one (1) month of receipt of unexposed film from site operators - ARS.

Seasonal and annual data reports, special study data reports, technical publications, and other data and analysis reports are prepared. Digital data bases of all quantitative data are maintained by the contractors and distributed to sponsoring agencies. The titles and availability of reports and digital data will be noted in future IMPROVE Newsletters.

A standardized method to service all data requests is currently being formulated by the IMPROVE Steering Committee. Future newsletters will include this information.

1992 IMPROVE Newsletter publication schedule:

March 1, 1992

Premier Issue

April 15, 1992

Winter 1991-92

(Dec. 1991, Jan. ,Feb. 1992)

July 15, 1992

Spring 1992

(Mar., Apr., May 1992)

October 15, 1992

Summer 1992

(June, July, Aug. 1992)

January 15, 1993

Fall 1992

(Sept., Oct., Nov. 1992)

MONITORING NETWORK DESIGN

The IMPROVE Monitoring Network currently includes thirty (30) designated monitoring sites. Table 1 details the monitoring configuration at each site and Figure 1 (page 5) is a map of the site locations. IMPROVE monitoring protocol defines that, where possible, aerosol, optical, and scene monitoring shall be conducted at each site. The phased deployment of instrumentation and initiation of operational monitoring depends on the availability of funds. Site logistics do restrict the operation of certain instruments at some sites.

Table 1
IMPROVE Monitoring Site Configuration
(as of December 31, 1991)

Site Name	Aerosol Sampler Module A-D	Transmis-someter	Nephe-lometer	Auto Cameras 35 mm	Auto Cameras 8 mm
ORIGINAL IMPROVE MONITORING SITES					
Acadia NP	1	1		1	
Big Bend NP	1	1		1	
Bridger W	1	1		1	
Bryce Canyon NP	1			3	
Canyonlands NP	1	1		1	
Chiricahua NM	1	1		1	
Crater Lake NP	1	1*		1	
Denali NP	1			1	
Glacier NP	1	1		1	
Grand Canyon NP	1	2		1	
Grt. Smoky Mtns. NP	1		1	1	
Jarbidge W	1			1	
Mesa Verde NP	1	1		1	
Mount Rainier NP	1		1	1	
Rocky Mountain NP	1	1		1	
San Gorgonio W	1	1		1	
Shenandoah NP	1	1		1	1
Tonto NM	1	1		1	
Weminuche W	1			1	
Yosemite NP	1	1		1	
EASTERN IMPROVE NETWORK					
Brigantine W	1			1	
Boundary Waters W	1			1	
Cape Romain NWR					
Dolly Sods W	1			1	
Linville Gorge W				1	
Lyebrook W	1			1	
Mammoth Cave NP	1				
Okefenokee NWR	1				
Sipsey W					
Upper Buffalo W	1			1	
TOTAL	27	15	2	28	1

* Summer only monitoring site

The instrumentation used to fulfill IMPROVE protocols include:

- **Aerosol** IMPROVE Modular Aerosol Sampler
- **Optical** Transmissometer or Nephelometer (collocated with an air temperature/relative humidity sensor)
- **Scene** Automatic Camera Systems

Other agencies also monitor visibility according to IMPROVE monitoring protocols. A map of existing IMPROVE Protocol sites in the United States is provided as Figure 2. A number of international sites also exist that employ IMPROVE aerosol monitoring protocols.

FUTURE IMPROVE NEWSLETTERS

Future newsletters will describe the seasonal progress of the IMPROVE program and feature a component of the program. The major headings for the IMPROVE Newsletter will be:

INTRODUCTION

FEATURE ARTICLE

IMPROVE SEASONAL PROGRESS REPORT

SPECIAL STUDIES UPDATE

SUMMARY OF DATA REQUESTS,

REPORTS, AND PUBLICATIONS

PROJECT ADMINISTRATION

PREVIEW OF UPCOMING ISSUE

The Newsletter will not replace either the contractor monthly progress reports or seasonal data reports, but will provide up-to-date information on the IMPROVE program. Your input is always welcome. If you have suggestions for feature articles or have comments on the IMPROVE Newsletter, contact:

Marc Pitchford (702/798-2363)

or

Air Resource Specialists, Inc. (303/484-7941)

Figure 1. IMPROVE Monitoring Network Sites.

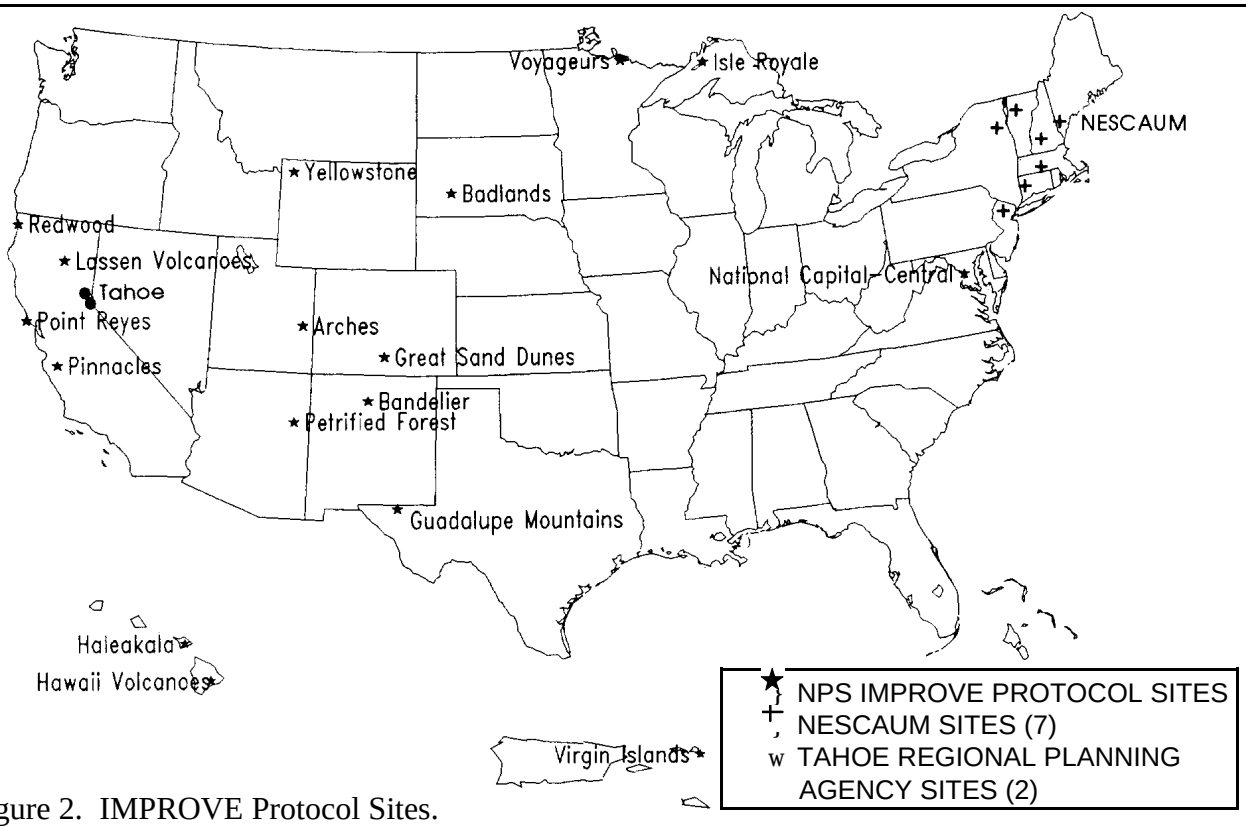

Figure 2. IMPROVE Protocol Sites.

INSTRUMENTATION AND SAMPLING PROTOCOLS

Table 2 summarizes the standard IMPROVE monitoring instrumentation and sampling protocols. Each instrument and the analytical procedures used to collect, reduce, and report the data will be featured in future issues of the IMPROVE Newsletter.

Table 2
IMPROVE Instrumentation and Sampling Protocols

Component	Instrumentation	Sample Frequency	Parameter
AEROSOL	IMPROVE Modular Aerosol Sampler	24-hour samples (midnight to midnight) taken twice/week on Wednesday and Saturday	Collects 3 samples of fine particles (smaller than 2.5um) and one of respirable particles (smaller than 10um):

MoDUL	FILTE	PARAMETER
A	25mm teflon	mass, sulfur, soil elements, orgainic mass, absorption, and trace elements (Na-Pb)
B	47mm	nitrate and chloride ions
C	25mm quartz	tandem filters for organic and elemental carbon
D	25mm teflon	PM-10 mass (may also be followed by an impregnated filter to measure SO_2 gas concentrations)

Component	Instrumentation	Sample Frequency	Parameter
OPTICAL	1) Transmissometer system (run either on line power or solar power)	Average of ten (10) one-minute samples taken each hour between 3 and 13 minutes after the hour	Hourly values of total extinction
	2) Remote, ambient nephelometer. (Systems are currently under development)	Hourly averages (specific sampling strategy under development)	Hourly values of the scattering component of total extinction
SCENE	35mm remote camera system, including 35mm camera, 135mm lens, data back, timer, environmental enclosure, mounting post, and batteries. (8mm time-lapse cameras can also be applied to document the dynamics of specific events)	3 photographs per day at 0900, 1200, and 1500 of a scenic vista	Qualitative documentation of visual appearance of a scene on 35mm slides, 3 times a day
Meteorology	Air temperature and relative humidity (collocated optical instrumentation)	Instantaneous value taken at 30 minutes past the hour (DCP scan time)	Hourly value of air temperature and relative humidity

SPECIAL STUDIES

As provided for under the 1980 visibility regulation, an attribution analysis may be required for a class I area where one or more pollution emission sources are thought to contribute substantially to visibility impairment. Often, routine monitoring data will not be sufficient for attribution analysis. In such circumstances, special studies may be required to supplement the routine monitoring information. Monitoring and other sources of information (e.g., emissions characterization, model outputs, etc.) must allow the identification of substantial visibility impairment source(s), and the assessment of the frequency, duration, and intensity of impairment from the identified source(s).

Special studies, unlike routine monitoring, do not lend themselves to standard design recommendations. The design is tailored to:

- the nature of the impairment (e.g., ground-based or elevated, short-term intermittent or long-term frequent, etc.);
- the characteristics of the source(s) (e.g., continuous or intermittent, point or area, primary particle or gas, or precursor gas for secondary particle, etc.) and;
- the information deficiencies.

Special studies range from simple to sophisticated. In the case of a plume or layer from a large nearby point source of primary particles, deployment of additional cameras to document the impairment may suffice (time-lapse photography may be particularly appropriate). To document the contribution of a more distant source of gaseous precursors for secondary particles, a substantial effort may be required, which could include a supplemental monitoring network, instrumented aircraft, and stack release and ambient monitoring of unique tracer materials.

To increase the likelihood of the success of a special study, it should be designed in conjunction with those who are responsible for conducting the attribution analysis. In some circumstances, a special study would be better accomplished in several phases, where data from the earlier phase(s) are used to help design the later phases.

In addition to source attribution, special studies have been performed to enhance the science of visibility monitoring and data analyses. Studies have focused on evaluating instrumentation, understanding the basic properties of aerosols, investigating specific aerosol/optical relationships, and other scientific principles and practical applications.

IMPROVE has been and continues to be involved in special visibility studies, including:

Project MOHAVE

Intensive study of visibility impacts of emissions from the Mojave Generating Station. The Winter 1992 intensive monitoring period was just completed. Monitoring continues and a Summer intensive period is scheduled for July through September 1992.

Shenandoah

Study of eastern aerosols and their effect on visibility under high relative humidity conditions. Data analysis of the Summer 1991 intensive is underway.

PREVENT

Intensive study of visibility causes and effects in Washington state, west of the Cascades. Analyses of the Summer 1990 data are underway.

WHITEX

Intensive study of visibility impacts of emissions from the Navajo Generating Station. Monitoring data from 1987 - 1990 supported an EPA ruling to require the Navajo Generating Station to install sulfur dioxide controls.

Moosehorn

Photographic monitoring of plume impacts from a nearby pulp and paper mill on the Moosehorn National Wildlife Refuge. Photographs documented plume impacts in theRefuge and were responsible for modification of development plans.

PREVIEW OF UPCOMING ISSUE .....

The next IMPROVE Newsletter will be available on April 15, 1992, and will include:

- Network Status for the Winter 1992 Season
- Highlights of the March IMPROVE Steering Committee Meeting
- ***FEATURE ARTICLE:*** IMPROVE data sources and availability

PUBLISHED BY:

Air Resource Specialists, Inc.

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

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For more information, address corrections, or to receive the IMPROVE Newsletter, contact:

Air Resource Specialists, Inc.
303/484-7941 Ph.
303/484-3423 FAX

Marc Pitchford
702/798-2363 Ph.
702/736-7729

Air Resource Specialists, Inc.
1901 Sharp Point Drive, Suite E
Fort Collins, Colorado 80525

TO: