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United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/4-90-008
May 1990

Air

EPA

# IMPROVE

## Progress Report

EPA-450/4-90-008

# IMPROVE
# PROGRESS REPORT

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Office Of Air And Radiation
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

May 1990

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IMPROVE Progress Report

# I. Introduction

In Section 169A of the Clean Air Act As Amended August 1977, Congress declared as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution."[1] Mandatory class I Federal areas are national parks greater in size than 6000 acres, wilderness areas greater in size than 5000 acres and international parks that were in existence on August 7, 1977.[2] This section required the Environmental Protection Agency (EPA) to promulgate regulations requiring States to develop programs in their State Implementation Plans (SIPs) providing for visibility protection in these areas. EPA promulgated these regulations on December 2, 1980.[3]

Section 51.305 of the 1980 regulations required States to develop a monitoring strategy for evaluating visibility in the mandatory class I areas and to provide a mechanism for using any available data in decisions required by the visibility protection program. On July 12, 1985, EPA promulgated federal regulations for, among other things, a visibility monitoring strategy for those states that did not submit revisions to their SIPs for visibility protection.[4] The federal effort to develop the entire Section 169A visibility program is described in more detail by Metsa[5].) The federally promulgated visibility monitoring strategy called for the establishment of a cooperative visibility monitoring effort between the EPA and several federal land management agencies: the National Park Service (NPS), the Fish and Wildlife Service (FWS) and the Bureau of Land Management (BLM) of the U. S. Department of Interior; and the Forest Service (FS) of the U. S. Department of Agriculture. Interagency Monitoring of PROtected Visual Environments, or IMPROVE, is the name given to this new federal monitoring program to address the specific data needs of the Section 169A visibility protection program.

In consideration of the requirements of the Section 169A regulatory program, the objectives of the IMPROVE program are:

1. To establish the background visibility levels necessary to assess impacts of potential new sources,

2. To determine the sources and levels of reasonably attributable visibility impairment,

3. To collect data useful for assessing progress toward the national visibility goal, and

4. To promote the development of improved visibility monitoring technology and the collection of comparable visibility data.

In order to meet these objectives two distinct monitoring activities were developed and initiated. A background visibility monitoring network was established to meet the first objective. Impairment attribution studies are conducted to meet the second objective. Long-term operation of this network would allow trends analysis required to meet the third objective. The fourth objective is addressed by the documentation of the design and operations of the monitoring network and attribution studies along with the preparation of several guidance documents.

To accomplish these activities, a technical steering committee was formed with representation from the EPA, NPS, FWS, FS and the BLM. The committee's responsibilities include designing, deploying, and operating the entire monitoring program; selecting the sites for the various background stations and special studies; developing guidance documents for States and other parties that must monitor visibility; providing some data analysis and interpretation; establishing a database that can be accessed by outside parties and writing periodic status reports to inform the public of the status of these monitoring initiatives. The committee has hired contractors, as needed, to accomplish the above tasks.

This report summarizes the progress made to date in developing and implementing the IMPROVE monitoring network. Section II addresses the background monitoring network and Section III reviews the impairment attribution monitoring efforts.

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1 42 U.S.C. 7491.

2 Section 162(a) of the Clean Air Act as amended 1977, 42 U.S.C. 7472(a). A complete list of all the mandatory class I Federal areas appears at 40 CFR 81.400-437.

3 45 FR 80084, codified at 40 CFR 51.300 <u>et seq.</u>

4 50 FR 28544, codified at 40 CFR Sections 52.21 (amended) and 52.26-52.28.

5 J. C. Metsa, "Visibility Protection Plans - EPA's Regulatory Program", Transactions of the Air Pollution Control Association Specialty Conference on Visibility Protection: Research and Policy Aspects, September 7-10, 1986, Grand Teton National Park, Wyoming.

## II. Background Visibility Monitoring Network

### Introduction

The design of the background visibility monitoring network was constrained by several factors: insufficient resources to monitor at all of the visibility protected areas, and the lack of an officially accepted approach for visibility monitoring. The response by the steering group to these constraints was to establish and use site selection criteria to determine which of the visibility protected areas to monitor, and to develop a quality monitoring approach applied uniformly at each of the selected locations. The steering committee felt that it was better to compromise on the number of monitoring locations than on the ultimate quality and utility of the information gathered.

### Site Selection

The steering committee employed site selection criteria in a review of each of the 156 visibility protected class I areas to determine which would be a part of the network. There were four criteria: anticipated changes to the area's visibility, existing visibility problems, scenic sensitivity and value, and the representativeness of the data to other visibility protected areas.

Representatives of the NPS, FS, and FWS researched each of their visibility protected areas for information pertinent to the four selection criteria. The areas were discussed individually at a steering committee meeting and were separated into four divisions by the majority vote of the IMPROVE participants (one vote per agency) using the selection criteria as a guide. Since the best estimates at the time were that the resources for the program would support about 20 monitoring sites, the first division was restricted to that number. Areas grouped into division I were reasonably assured monitoring. There were 16 areas selected for division II which would be the next to receive monitoring if cost were lower than anticipated or if additional funds became available. Divisions III and IV contained areas with even lower priority for inclusion in the network.

Of the 20 areas originally selected for background visibility monitoring (division I), 19 are a part of the network. One of the 20 selected sites, Superstition Wilderness near Phoenix, Arizona, had a chronic and determined vandalism problem that prevented siting a monitoring station there. Tonto National Monument (not a visibility protected area), a few miles north of the Superstitions Wilderness, was selected as a substitute. It is representative of regional air quality in the

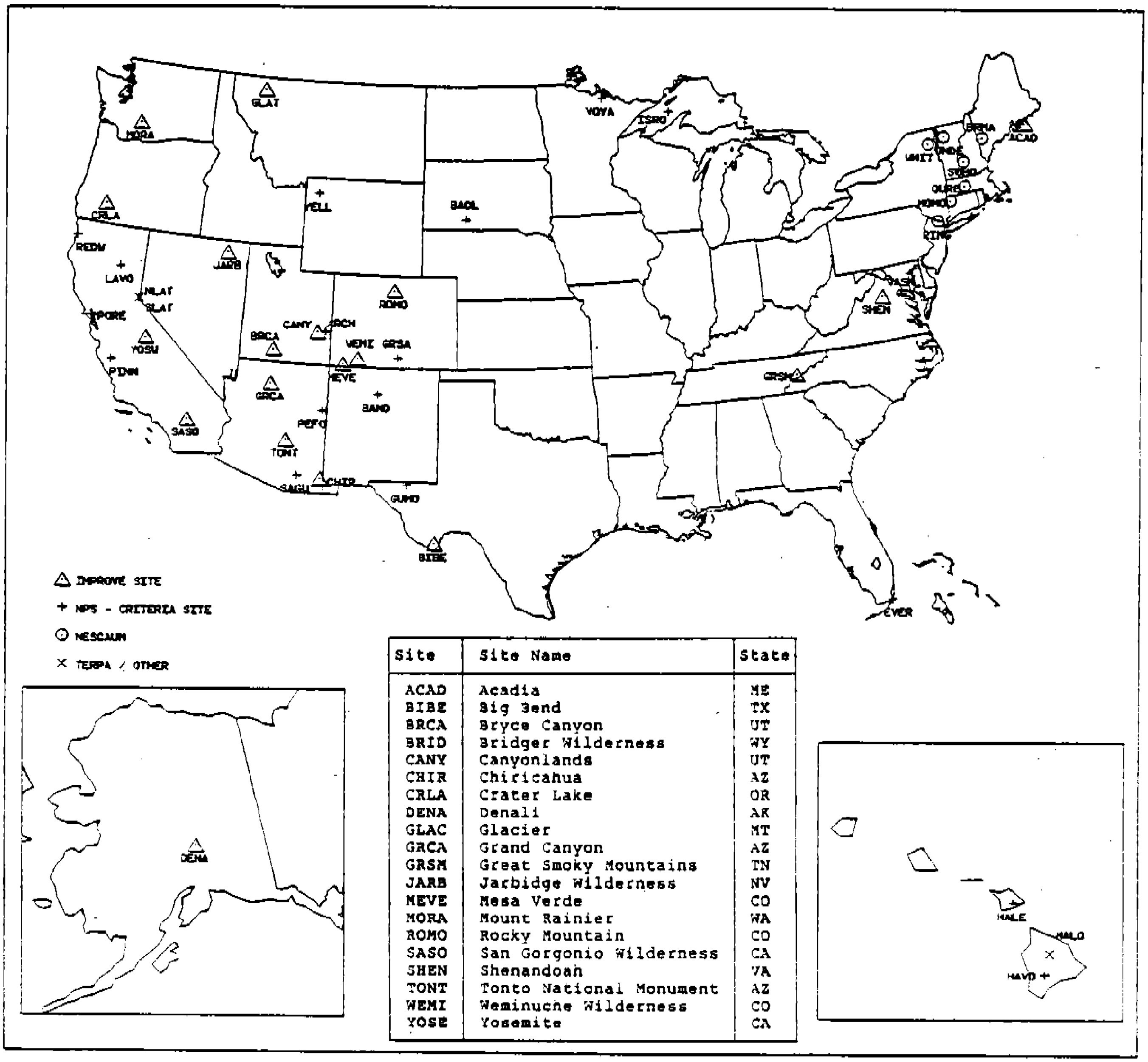
Superstitions and has adequate security for the instrumentation. IMPROVE resources have not allowed the establishment of more than the originally anticipated 20 sites. The names and locations of these are indicated on the map shown in figure 1.

Subsequent to the development of the monitoring protocol used in the IMPROVE visibility background monitoring network, a number of IMPROVE "look-a-like" sites were established by individual government agencies. Though these sites are not a part of the IMPROVE program, the steering committee has encouraged their establishment by sharing information and providing advice as requested. As a result, the same monitoring systems, procedures, and instrument siting criteria are employed at most of these locations. These site locations can also be seen in figure 1. The sponsors of these sites have agreed to exchange data with the IMPROVE program, so that in an importance sense these sites can be thought of as an extension of the background visibility monitoring network. Table 1a lists the monitoring systems in use at the IMPROVE "look-a-like" sites. Site identification, location and elevation for both IMPROVE and IMPROVE "look-a-like" sites are listed in Table 1b.

Monitoring Techniques

The background visibility monitoring approach involves aerosol, optical, and view monitoring. View monitoring documents the appearance of the scene, optical monitoring measures the scene-independent optical condition of the atmosphere, and aerosol monitoring determines the nature of the air pollutants responsible for visual impairments. In the opinion of the steering committee, each of these types of monitoring are required for visibility monitoring of protected areas.

Aerosol monitoring in the IMPROVE network is accomplished by a combination of particle sampling and sample analysis. The sampler employed was designed specifically for the program. It collects four simultaneous samples: one PM-10 sample (particles less than 10 micron diameter) on a teflon filter and three PM-2.5 samples (particles less than 2.5 micron diameter) on teflon, nylon, and quartz filters. Each of the four samples is collected by a separate subsystem (or module) including everything from the inlet to the pump with only the support structure and controller/timer in common. The particle size segregation for the PM-10 module is accomplished by a wind insensitive inlet with a 10 micron cutoff, while the PM-2.5 segregation is produced by passing the sampled air through a cyclone separator. Constant sample flow (18.9 liters per minute for the PM-10 module and 21.7 liters per minute for each of the PM-2.5 modules) is maintained by a critical orifice in each module. The IMPROVE sampler is programed to automatically collect two 24-hour duration samples




| Site | Site Name | State |
|---|---|---|
| ACAD | Acadia | ME |
| BIBE | Big Bend | TX |
| BRCA | Bryce Canyon | UT |
| BRID | Bridger Wilderness | WY |
| CANY | Canyonlands | UT |
| CHIR | Chiricahua | AZ |
| CRLA | Crater Lake | OR |
| DENA | Denali | AK |
| GLAC | Glacier | MT |
| GRCA | Grand Canyon | AZ |
| GRSM | Great Smoky Mountains | TN |
| JARB | Jarbidge Wilderness | NV |
| MEVE | Mesa Verde | CO |
| MORA | Mount Rainier | WA |
| ROMO | Rocky Mountain | CO |
| SASO | San Gorgonio Wilderness | CA |
| SHEN | Shenandoah | VA |
| TONT | Tonto National Monument | AZ |
| WEMI | Weminuche Wilderness | CO |
| YOSE | Yosemite | CA |

Figure 1. IMPROVE background visibility monitoring network including IMPROVE "look-a-like" sites. IMPROVE sites are listed on this figure.

**TABLE 1a**

**Non-IMPROVE sites to be operated under IMPROVE protocol**

| Site Name | State | IMPROVE Sampler | Camera Auto 35 mm | Transmis-someter |
|---|---|---|---|---|
| **NPS CRITERIA SITES** | | | | |
| Arches | UT | SO2 | + | |
| Badlands | SD | SO2 | + | + |
| Bandelier | NM | SO2 | + | |
| Carlsbad Caverns | NM | | + | |
| Great Sand Dunes | CO | SO2 | + | |
| Guadalupe Mountains | TX | SO2 | + | |
| Haleakala | HI | SO2 | + | |
| Hawaii Volcanoes | HI | SO2 | + | |
| Isle Royale | MI | SO2 | + | |
| Lassen Volcanic | CA | SO2 | + | |
| Petrified Forest | AZ | SO2 | + | + |
| Pinnacles | CA | SO2 | + | + |
| Point Reyes | CA | SO2 | + | |
| Redwood | CA | SO2 | + | |
| Virgin Islands | VI | SO2 | | |
| Voyageurs | MN | SO2 | + | + |
| Yellowstone | WY | SO2 | + | |
| **NOAA/IMPROVE** | | | | |
| Mauna Loa | HI | (1) | | |
| **NESCAUM**[A] | | | | |
| Bridgeton | ME | (2) | | |
| Mt Sunapee | NH | (2) | | |
| Underhill | VT | (2) | | |
| Whiteface Mtn | NY | (2) | | |
| Quabbin Reservoir | MA | (2) | | |
| Mohawk Mtn | CT | (2) | | |
| Ringwood | NJ | (2) | | |
| **TERPA** | | | | |
| North Shore | CA | + | + | |
| South Shore | CA | + | + | |

Modifications to IMPROVE samplers:
SO2-Impregnated quartz filter following teflon in PM10 module.
(1)-Two fine teflon modules, one continuous, one downslope winds only.
(2)-One fine teflon module, two sites with fine quartz module additional sample on national 1 day-in-6 cycle.
A-Not operated under IMPROVE protocol.

**Table 1b**
**Monitoring Site Locations**

**IMPROVE**

| ID | Site Name | Lat | Lon | Elev(ft) |
|---|---|---|---|---|
| ACAD | Acadia | 44.22 | 68.16 | 420 |
| BIBE | Big Bend | 29.30 | 103.18 | 3500 |
| BRCA | Bryce Canyon | 37.57 | 112.18 | 8000 |
| BRID | Bridger Wilderness | 43.05 | 109.48 | 8000 |
| CANY | Canyonlands | 38.45 | 109.82 | 5925 |
| CHIR | Chiricahua | 32.00 | 109.21 | 5400 |
| CRLA | Crater Lake | 42.88 | 122.70 | 6500 |
| DENA | Denali | 63.45 | 149.30 | 2100 |
| GLAC | Glacier | 48.50 | 113.99 | 4500 |
| GRCA | Grand Canyon | 36.07 | 112.17 | 6800 |
| GRSM | Great Smoky Mountains | 35.75 | 83.50 | 2500 |
| JARB | Jarbidge Wilderness | 41.53 | 115.24 | 6200 |
| MEVE | Mesa Verde | 37.12 | 108.29 | 7210 |
| MORA | Mount Rainier | 46.47 | 121.45 | 5140 |
| ROMO | Rocky Mountain | 40.37 | 105.57 | 7900 |
| SASO | San Gorgonio Wilderness | 34.12 | 116.56 | 5618 |
| SHEN | Shenandoah | 38.48 | 78.12 | 3600 |
| TONT | Tonto National Monument | 33.63 | 111.13 | 2600 |
| WEMI | Weminuche Wilderness | 107.48 | 37.39 | 8410 |
| YOSE | Yosemite | 37.45 | 119.35 | 5300 |

**NPS CRITERIA SITES**

| ID | Site Name | Lat | Lon | Elev(ft) |
|---|---|---|---|---|
| ARCH | Arches | 38.49 | 109.37 | 5650 |
| BADL | Badlands | 43.45 | 101.56 | 2493 |
| BAND | Bandelier | 35.83 | 106.33 | 6500 |
| EVER | Everglades | 25.28 | 80.30 | 0 |
| GRSA | Great Sands | 37.45 | 105.30 | 8200 |
| GUMO | Guadalupe Mountains | 31.86 | 104.66 | 5400 |
| HALE | Haleakala | 20.50 | 156.16 | 3800 |
| HAVO | Hawaii Volcanoes | 19.26 | 155.16 | 4100 |
| ISRO | Isle Royale | 47.54 | 89.08 | 700 |
| LAVO | Lassen Volcanic | 40.32 | 121.34 | 5900 |
| PEFO | Petrified Forest | 35.00 | 109.30 | 5500 |
| PINN | Pinnacles | 36.29 | 121.09 | 1040 |
| PORE | Point Reyes | 38.07 | 122.53 | 125 |
| REDW | Redwood | 41.33 | 124.05 | 760 |
| SAGU | Saguaro | 37.10 | 110.44 | 3080 |
| VIIS | Virgin Islands | - | - | - |
| VOYA | Voyageurs | 48.35 | 93.10 | 1140 |
| WASH | Washington DC | 38.55 | 77.00 | 30 |
| YELL | Yellowstone | 44.33 | 110.24 | 7744 |

**Table 1b, cont.**
**Monitoring Site Locations**

**NESCAUM**

| ID | Site Name | Lat | Lon | Elev(ft) |
|---|---|---|---|---|
| BRMA | Bridgeton ME | 44.10 | 70.73 | 728 |
| MOMO | Mohawk Mountain CT | 41.83 | 73.30 | 1500 |
| UNDE | Underhill VT | 44.53 | 72.87 | 1300 |
| QURE | Quabbin Res. MA | 42.30 | 72.33 | 1020 |
| RING | Ringwood St. Park NJ | 41.12 | 74.23 | 605 |
| SUMO | Sunapee Mtn NH | 43.32 | 72.07 | 2700 |
| WHMO | Whiteface Mountain NY | 44.38 | 73.85 | 2100 |

**NOAA/IMPROVE**

| | | | | |
|---|---|---|---|---|
| MALO | Mauna Loa | 19.32 | 155.35 | 11150 |

per week. Appendix A-2, the "IMPROVE Sampler Manual" contains a much more detailed description of the sampler and its operation.

Mass and elemental analyses are conducted on the PM-10 samples. The PM-2.5 samples are analyzed for mass, elements, ions (including particulate nitrates sampled through a denuder), organic and elemental carbon, and optical absorption. Figure 2 indicates the lower detection limits of the various analyses for typical IMPROVE samples. Appendix A, the "Standard Operating Procedures for IMPROVE Particulate Monitoring Network," describes the analysis methodology including quality assurance procedures.

The IMPROVE network employs a long path transmissometer for optical measurements. These instruments measure the amount of light transmitted through the atmosphere over a known distance. Transmission measurements are converted to the path-averaged extinction coefficient by the digital electronics of the instrument. The light source (transmitter) and light monitoring (receiver) components of the instrument are separated by a distance of from one to fifteen kilometers depending on conditions at the monitoring location. To facilitate deployment in remote areas where commercial electric power availability is sparse, the transmitter is typically solar powered. Appendix B, "Transmissometer Standard Operating Procedures Manual," contains a more detailed description of the instrument and its use.

The transmissometers are a relatively new instrument having been employed at a few locations in field comparison and instrument evaluation studies prior to their selection for the IMPROVE network. Though they performed well under these circumstances, it was felt that experience in long term routine operations at a few sites would be advantageous in order to work out any unforseen difficulties in hardware or procedures prior to deploying at all 20 sites. In addition, manpower and funding resources were not available to deploy all of the transmissometers in a single year. For these reasons, the transmissometer deployment was distributed over a two year period as shown in table 2.

In order to gather optical data prior to the scheduled installation of its transmissometer, most sites employed automated 35mm camera systems to document contrast of distant terrain features. Color transparencies (slides) of suitable targets are analyzed by a scanning microdensitometer to determine apparent contrast. An estimate of the path-averaged extinction coefficient can be calculated from the apparent contrast in the same manner as with contrast data from teleradiometers. Extinction coefficient data determined in this way are subject to a greater uncertainty than those available from the transmissometer. However, the ability to initiate optical monitoring concurrent with the other measurements was considered worth the additional analysis and data processing effort. [As

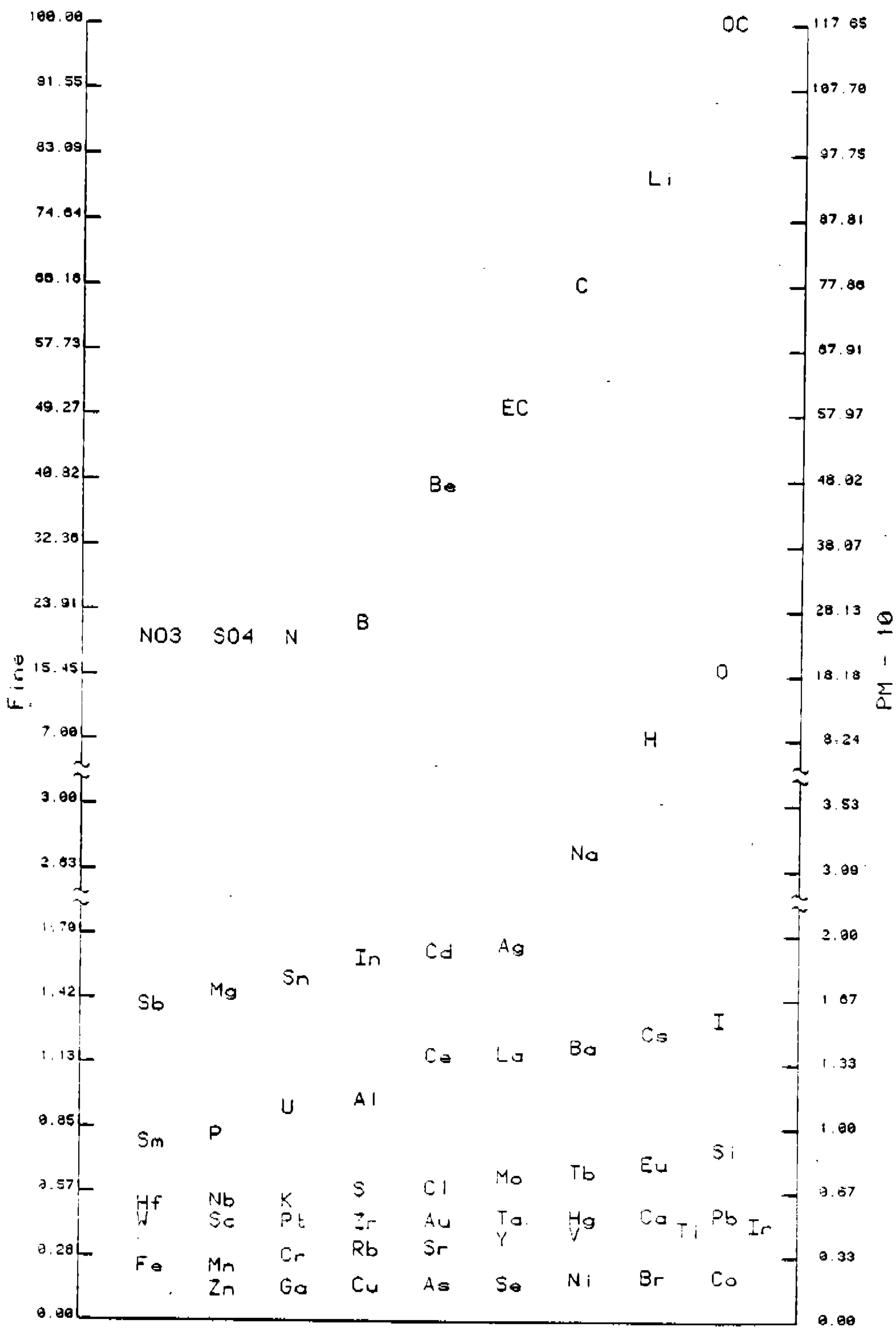



Figure 2. Lower detectable limits for IMPROVE sampler in $\mu g/m^3$.

**TABLE 2**

**Transmissometer deployment schedule.**

| Site | Site Name | State | Deployment Date |
|---|---|---|---|
| ACAD | Acadia National Park | Maine | 11/12/87 |
| BIBE | Big Bend National Park | Texas | 12/01/88 |
| BRID | Bridger Wilderness | Wyoming | 7/19/88 |
| BRCN | Bryce Canyon National Park | Utah | * |
| CANY | Canyonlands National Park | Utah | 12/19/86 |
| CHIR | Chiricahua National Monument | Arizona | 12/17/88 |
| CRLA | Crater Lake National Park | Oregon | 9/01/88 |
| DENA | Denali National Park | Alaska | * |
| GLAT | Glacier National Park | Montana | 1/20/89 |
| GRCT | Grand Canyon National Park | Arizona | 12/18/86 |
| GRSM | Great Smokey Mountains NP | Tennessee | ** |
| JARB | Jarbidge Wilderness | Nevada | * |
| MEVE | Mesa Verde National Park | Colorado | 9/14/88 |
| MORA | Mount Rainier National Park | Washington | *** |
| ROMM | Rocky Mountain National Park | Colorado | 12/01/87 |
| SAGO | San Gorgonio Wilderness | California | n/a |
| SHEN | Shenandoah National Park | Virginia | 3/09/88 |
| TONM | Tonto National Monument | Arizona | 4/19/89 |
| WEMI | Weminuche Wilderness | Colorado | * |
| YOSW | Yosemite National Park | California | 9/01/88 |

* - These sites are scheduled for transmissometer deployment but dates have not been set.

** - Transmissometer may not be installed. A nephelometer installation is being considered.

*** - Approval has been received for the installation of a nephelometer.

indicated below, all sites have camera systems for view monitoring thus the deployment and operation of camera systems required no additional effort.]

The primary purpose of the automated 35mm camera systems is for view monitoring. Three color transparencies per day document the appearance of a selected scene at each of the IMPROVE sites. Except for their interim use to estimate the extinction coefficient (as indicated above), the slides are not routinely used for quantitative analysis. However, they are considered a valuable source of information for interpretation of concurrent measurements, to communicate perceived visual conditions, and for future qualitative and quantitative investigations. To aide in the use of the photography, a computer index is maintained which contains qualitative information on the appearance of the scene, meteorology, and air quality, as well as identification information for each color slide. Procedures for the collection, archival, and documentation of the transparencies are contained in Appendix C, Visibility Monitoring and Data Analysis Using Automatic Camera Systems; Standard Operating Procedures and Quality Assurance Document".

Temperature and relative humidity are also monitored at each location to aid in the interpretation of the optical and particle measurements. Liquid water is a labile component of the particles which is dependent on the particle composition and ambient relative humidity. The liquid water content of the particles can have a significant affect on their optical property. Existing measurement techniques are unable to directly characterize this important component of the particles. Thus to estimate the role of the water it is necessary to employ empirical methods that relate extinction coefficient to the relative humidity and particle composition. Relative humidity and temperature are also valuable for distinguishing precipitation and fog event from air quality related impacts. Installation of the temperature and relative humidity sensors is conducted on the same schedule as the transmissometers since both require automatic data logging equipment.

Data from continuous monitoring equipment (transmissometer, temperature, and relative humidity sensors) are radio-transmitted from the data logger at each of the sites to a communications satellite every three hours. The satellite in turn relays the data to a computer at a ground receiving station. Daily retrievals of the data, made possible by this approach, promote greater feedback on monitoring system performance. Hence malfunctions are more quickly discovered and remedied. The Transmissometer Systems Field Operator's Manual, Appendix D provides more information concerning the temperature, relative humidity, and satellite data systems.

## Quality Assurance

The IMPROVE Steering Committee is responsible for overall quality assurance. This includes the obligation to ensure that quality assurance and standard operating procedures are well conceived and documented, that they are updated as necessary, and that they are followed. Ideally the steering committee would exercise this responsibility by enlisting the assistance of an independent quality assurance auditor (ie. one not otherwise involved in the program). This group or individual would conduct a complete system audit annually by reviewing documents, visiting sites and analysis laboratories, challenging the system with standards and other audit materials, and reporting their observations and conclusions. However, limited IMPROVE resources have not allowed contracting for an independent system audit. Until an independent audit program is established, the function of system auditor rests with the IMPROVE Steering Committee.

Quality assurance principals are employed in each component of the monitoring program. All aspects of the monitoring are documented including site selection, instrument siting, operations, calibration, maintenance, data processing and reporting. The details of these are contained in the appropriate standard operating procedures manuals (appendices A through D)

A number of the measured or derived parameters from the monitoring program are interrelated (see table 3). This allows data intercomparisons as a method to evaluate system performance and to check for outliers. In addition, various aspects of the program are subject to third party review and cross comparisons with independent monitoring, sample analysis, or research efforts. Table 4 summarizes activities of that nature.

An important quality assurance activity is the assessment of parameter specific accuracy and precision. This is generally an ongoing process which has not been fully implemented at the time this report was prepared. The approaches employed to estimate data uncertainty include error propagation methodology applied to component uncertainties (e.g. sampler flow, sample blank, and compositional analyses uncertainties) or direct uncertainty calculations based upon differences in redundant measurements.

## Data Processing, Reporting, and Status

Measurements from the IMPROVE Background Visibility Monitoring Network are converted to calibrated engineering units prior to their availability. Table 5 indicates the types of processes applied to IMPROVE sampler data and Appendix E describes the processes applied to the transmissometer. A more complete description of the application of calibration and correction factors to the data is specified in the appropriate standard operating manuals (appendices A to E)

**TABLE 3**

**Quality Assurance Comparisons**

1. Fine sulfur[a] vs. fine sulfate[b]
2. Fine sulfur[a] vs. PM10 sulfur[a]
3. Fine hydrogen vs. fine mass
4. PM10 hydrogen vs. PM10 mass
5. Sum of fine components[c] vs. fine mass
6. Sum of PM10 components[c] vs. PM10 mass
7. Elemental carbon[d] vs. optical absorption[e]
8. Organic carbon vs. nonsulfate hydrogen[f]
9. Fine mass vs. extinction
10. PM10 mass vs. extinction
11. Fine mass components[c] vs. extinction
12. PM10 mass components[c] vs. extinction

---

[a] Sample collected on teflon filter and analyzed using PIXE.

[b] Sample collected on nylon filter and analyzed using ion chromatography.

[c] Fine components are defined as sulfate, soil, elemental carbon and organic carbon.

[d] Sample collected on quartz filter and analyzed using thermal optical techniques.

[e] Sample collected on teflon filter and analyzed using LIPM.

[f] Non-sulfate hydrogen is defined as total fine hydrogen minus sulfur/4.

**TABLE 4a**

**Intercomparison Tests of IMPROVE Instrumentation**

Optical[1]

| Comparison | Location |
|---|---|
| Two Transmissometers with different path lengths plus a Nephelometer | Grand Canyon, AZ |
| One Transmissometer, Black Box, and a Nephelometer | Meteor Crater,AZ |
| One Transmissometer, Nephelometer, particle measurements for extinction budget | Page, AZ |
| One Transmissometer, Rotating Disk, and Radiance difference with natural targets | Grand Canyon, AZ |

[1] W.C. Malm, G. Persha, R. Tree, H. Iyer, E. Law-Evans, "The Relative Accuracy of Transmissometer Derived Extinction Coefficients."

**TABLE 4b, cont.**

**Intercomparison Tests of IMPROVE Instrumentation**

**Aerosol**[1]

| Comparison | Location |
|---|---|
| Mass; Absorption; Sulfur and other elements; Carbon; Compared against SFU, VI, Hi-Vols over 30 participants | Glendora, CA (ARB CSMCS) |
| Mass; Sulfur and other elements; Carbon Species; Sulfates and Ions Compared against SCISAS | Page, AZ (WHITEX) |
| Mass; Sulfur and other elements; Carbon Species; Sulfates and Ions Compared against SCISAS | Grand Canyon NP (WHITEX) |
| Mass; Absorption; Sulfur and other elements; Carbon Species Four unit comparison plus SFU | Davis, CA |
| Mass; Sulfur and other elements Compared against SCAQS sampler | Los Angeles, CA (SCAQS) |
| Individual module field comparisons at IMPROVE sites | many locations |

[1] R.A. Eldred, T.A. Cahill, M. Pitchford and W.C. Malm, "IMPROVE-- A New Remote Area Particulate Monitoring System for Visibility Studies".

**TABLE 5**

**Data Processing Steps for IMPROVE Particle Sampler**

| | |
|---|---|
| Flow Rate Calculation[1] | |
| Average Flow | $Q = \frac{1}{2}(Q_1+Q_2)\ (T/280)^{\frac{1}{2}}$ |
| Volume Calculation | |
| Volume | $V = Q * D * 60/1000$ |
| Concentration Calculation | |
| Mass | $MC = (PST-PRE-C)/V$ |
| Optical Absorption | $b_{abs} = A * \log(PRE/PST)/V$ |
| PIXE | _[2] |
| PESA | _[3] |
| Carbon and Ion analysis | _[4] |

where:

| | | |
|---|---|---|
| $Q$ | = | Average Flow (l/min) |
| $Q_1$ | = | Flow before collection (l/min) |
| $Q_2$ | = | Average flow after collection (l/min) |
| $T$ | = | Temperature (°K) |
| $V$ | = | Volume ($m^3$) |
| $D$ | = | Duration (hours) |
| $MC$ | = | Mass concentration ($\mu g/m^3$) |
| $PRE$ | = | Filter mass before collection ($\mu g$) |
| $PST$ | = | Filter mass after collection ($\mu g$) |
| $C$ | = | Control mass ($\mu g$) |
| $b_{abs}$ | = | absorption coefficient ($Mm^{-1}$) |

---

[1] Flow rate measurement and flow rate calculations are discussed in detail in appendix A, pages 24, 25 and 26.

[2] Insignificant elemental contamination in teflon filters. Typical blank used to estimate spectral background due to x-rays produced by filter. Subtraction handled internally by spectral analysis program, producing elemental areal density (pt) in $ng/cm^2$. Use collection area in $cm^2$.

**TABLE 5, cont.**
**Data Processing Steps**
**for IMPROVE Particle Sampler**

[3] Small hydrogen contamination in teflon filter estimated from series of analysis of clean filters at beginning of analytical sessions. Method determines areal density (pt) in $ng/cm^2$.

**hydrogen concentration = area x (pt-blank)/V**

[4] Subtracted from contamination in filter (based on field and laboratory blanks) and from artifact plus contamination (based on backup filters in tandem arrangement). Blank values determined by UC Davis in consultation with cooperating contractors. Carbon analyses assume collection area of 3.8 $cm^2$ on quartz filters.

**concentration = (measured-blank)/Volume**

Computer compatible tapes or floppy disks will be used to transmit large data records on an annual basis to participants and others who submit written request to the program steering committee. Figures 3 (a,b,c and d) are examples of site specific seasonal data summaries (also see appendix F). These are prepared and distributed to participants to provide more rapid feedback concerning the results of the monitoring.

The status of the data archives are indicated in tables 6, 7, and 8 (also see appendix G) which contain the start dates and rate of data recovered for the particle sampling, optical monitoring, and photography, respectively.

| | cases found | arithmetic mean concentrations Sep | Oct | Nov | season | distribution of concentrations minimum | median | maximum |
|---|---|---|---|---|---|---|---|---|
| H | 25 | 110 | 141 | 41 | 115 | 21 | 97 | 247 |
| Na | ... | | | | | | | |
| Mg | ... | | | | | | | |
| Al | ... | | | | | | | |
| Si | ... | | | | | | | |
| S | ... | | | | | | | |
| Cl | ... | | | | | | | |
| K | ... | | | | | | | |
| Ca | ... | | | | | | | |
| Ti | ... | | | | | | | |
| Fe | ... | | | | | | | |
| Ni | ... | | | | | | | |
| Cu | ... | | | | | | | |
| Zn | ... | | | | | | | |
| As | ... | | | | | | | |
| Se | ... | | | | | | | |
| Br | ... | | | | | | | |
| Pb | ... | | | | | | | |
| OC | ... | | | | | | | |
| LAC | ... | | | | | | | |
| SO4 | ... | | | | | | | |
| NO3 | ... | | | | | | | |
| mass | 25 | 2200 | 2400 | 1400 | 2000 | 500 | 1800 | 4200 |
| soil | ... | | | | | | | |
| recon | ... | | | | | | | |
| PM10 | ... | | | | | | | |

Figure 3a. Sample distribution on concentrations in nanograms/cubic meter for particles smaller than 2.5 μm except for PM10 mass.

| DATE | mass | H | Na | Mg | Al | Si | S | Cl | K | Ca | Ti | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/03 | 2942 | 119.1 | 121.5 | 14.2 | 182.0 | 269.4 | 298.5 | 2.4* | 43.2 | 59.6 | 4.3 | 47.9 |
| 9/07 | ... | | | | | | | | | | | |
| 9/10 | ... | | | | | | | | | | | |
| 9/14 | ... | | | | | | | | | | | |
| 9/17 | ... | | | | | | | | | | | |
| 9/21 | ... | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| 11/30 | ... | | | | | | | | | | | |

| DATE | Ni | Cu | Zn | As | Se | Br | Pb | OC | LAC | SO4 | NO3 | PM10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9/03 | 0.6* | 1.5 | 4.2 | 1.1 | 2.4 | 3.1 | 10.4 | 894 | 124 | 894 | 126 | 5510 |
| 9/07 | ... | | | | | | | | | | | |
| 9/10 | ... | | | | | | | | | | | |
| 9/14 | ... | | | | | | | | | | | |
| 9/17 | ... | | | | | | | | | | | |
| 9/21 | ... | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| ... | | | | | | | | | | | | |
| 11/30 | ... | | | | | | | | | | | |

* analytical minimum detectable limit; actual concentration is less than this amount

Figure 3b. Sample 24 hour average concentrations in nanograms/cubic meter for particles smaller than 2.5 μm except for PM10 mass.

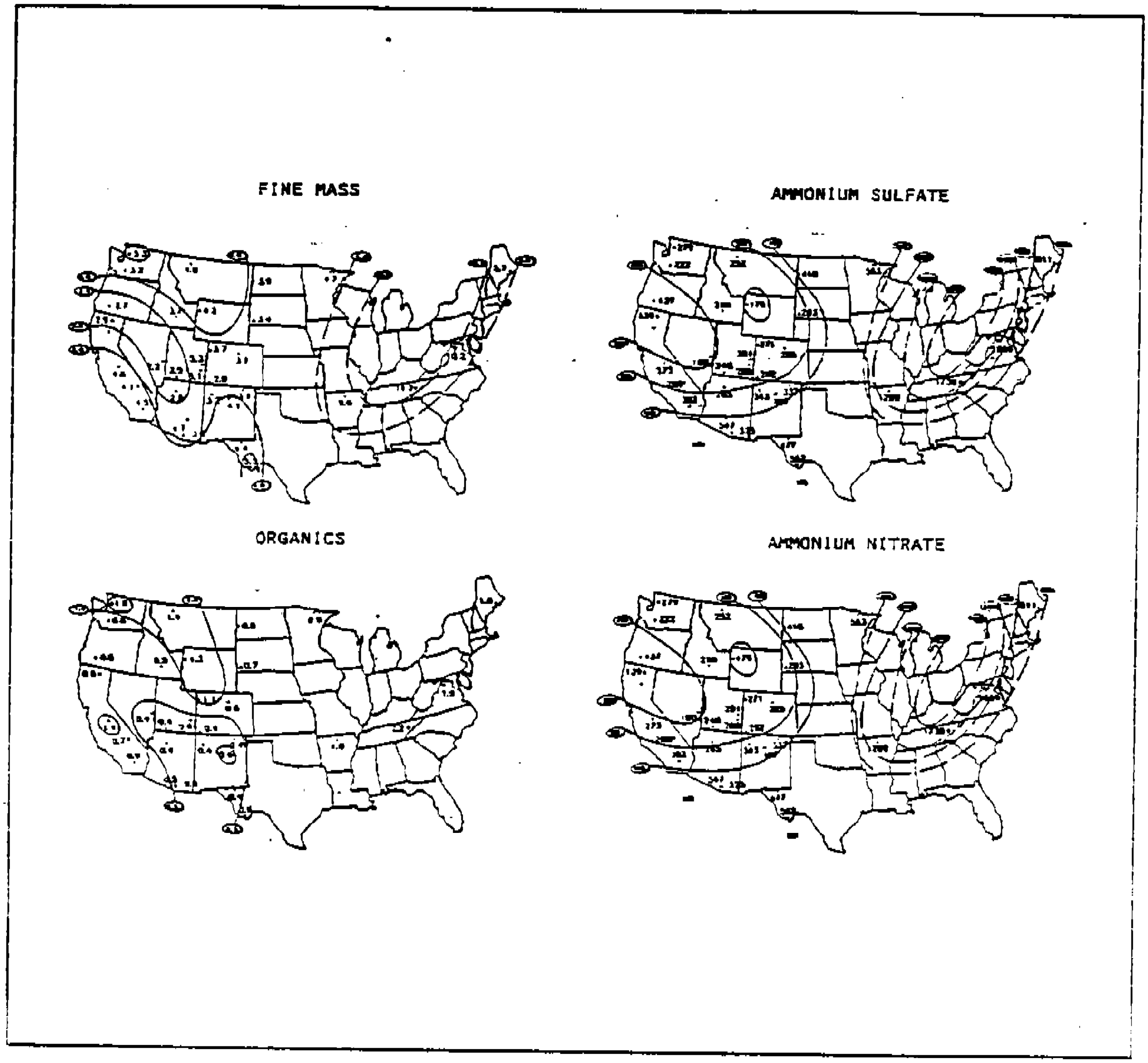
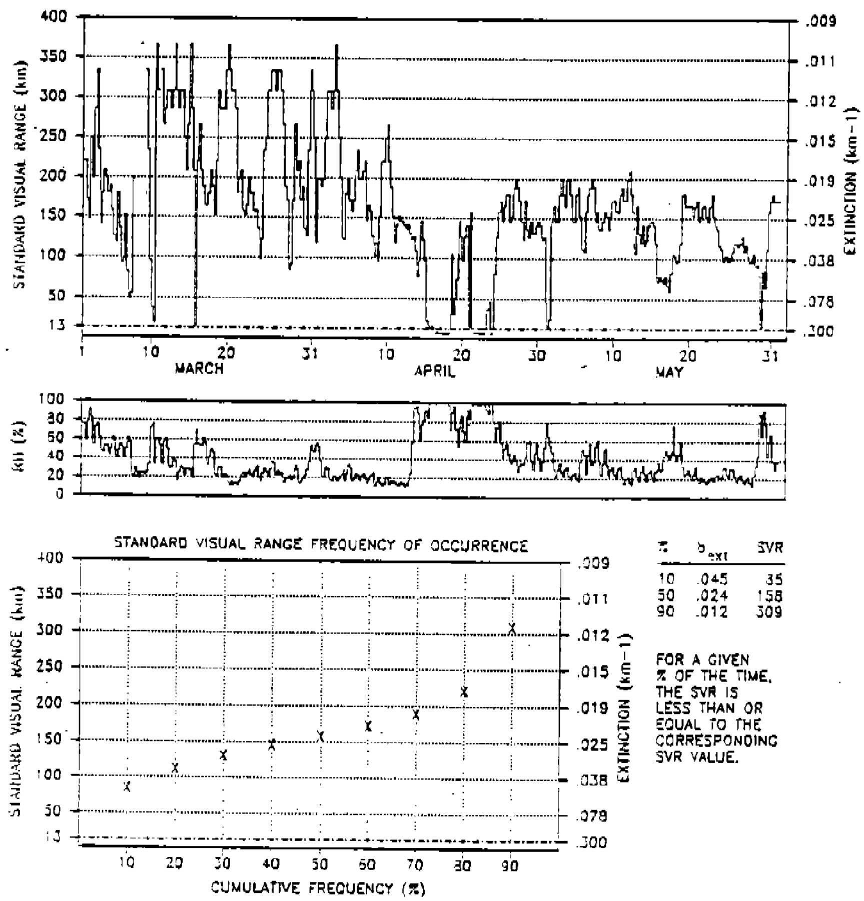



Figure 3c. Sample data summary of seasonal particulate spatial patterns.

## GRAND CANYON NATIONAL PARK

Transmissometer Data Summary -- 6 Hour Averages

March 1, 1988 - May 31, 1988




TRANSMISSOMETER DATA RECOVERY STATISTICS

| CATEGORY | NUM | % |
|---|---|---|
| TOTAL POSSIBLE 6-HOUR AVERAGES IN THE TIME PERIOD | 368 | 100 |
| USABLE 6-HOUR AVERAGES IN THE TIME PERIOD | 345 | 93 |

Figure 3d. Sample optical data quarterly summary. Site specific example for hypothetical monitoring location.

**TABLE 6**

**Particle Data Status**

Sample Inventory for IMPROVE Network
2 March 1988 to 7 May 1988

| site | samples possible | samples valid | invalid samples | |
|---|---|---|---|---|
| | | | sampler | Methods |
| Acadia | 80 | 72 ( 90%) | 8 | 0 |
| Big Bend | 80 | 80 (100%) | 0 | 0 |
| Bryce Canyon | 80 | 78 ( 98%) | 2 | 0 |
| Bridger | 80 | 51 ( 64%) | 0 | 29 |
| Canyonlands | 80 | 80 (100%) | 0 | 0 |
| Chiricahua | 80 | 80 (100%) | 0 | 0 |
| Crater Lake | 80 | 80 (100%) | 0 | 0 |
| Denali | 80 | 80 (100%) | 0 | 0 |
| Glacier | 80 | 80 (100%) | 0 | 0 |
| Grand Canyon | 80 | 80 (100%) | 0 | 0 |
| Great Smokey | 80 | 80 (100%) | 0 | 0 |
| Jarbidge | 80 | 80 (100%) | 0 | 0 |
| Mesa Verde | 80 | 80 (100%) | 0 | 0 |
| Mount Rainier | 80 | 70 ( 88%) | 0 | 10 |
| Rocky Mountain | 80 | 80 (100%) | 0 | 0 |
| San Gorgonio | 80 | 80 (100%) | 0 | 0 |
| Shenandoah | 80 | 64 ( 80%) | 0 | 16 |
| Weminuche | 80 | 80 (100%) | 0 | 0 |
| Yosemite | 80 | 80 (100%) | 0 | 0 |
| average | 80 | 76 ( 95%) | 0.5 (1%) | 3.3 (4%) |

# TABLE 7

## Optical Data Status

Preliminary
Transmissometer Data Collection Statistics
For Pre-Operational Test Period
IMPROVE and NPS IMPROVE Protocol Sites

| Site | Network | Date Installed | Year | Winter No. Possible | Winter No. Usable | Winter Percent Usable | Spring No. Possible | Spring No. Usable | Spring Percent Usable | Summer No. Possible | Summer No. Usable | Summer Percent Usable | Fall No. Possible | Fall No. Usable | Fall Percent Usable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Acadia NP | I | 11/12/87 | 1987 | | | | | | | | | | 74 | 6 | 8 |
| | | | 1988 | 364 | 49 | 13 | 368 | 85 | 23 | 368 | 98 | 26 | 364 | 139 | 38 |
| | | | 1989 | 360 | 253 | 70 | | | | | | | | | |
| 2. Badlands NP | P | 01/14/88 | 1988 | 187 | 182 | 48 | 368 | 100 | 27 | 368 | 0 | 0 | 364 | 183 | 50 |
| | | | 1989 | 360 | 244 | 67 | | | | | | | | | |
| 3. Bandelier NM | P | 10/05/88 | 1988 | | | | | | | | | | 226 | 160 | 70 |
| | | | 1989 | 360 | 320 | 88 | | | | | | | | | |
| 4. Big Bend NP | I | 12/01/88 | 1989 | 360 | 322 | 89 | | | | | | | | | |
| 5. Bridger W | I | 07/19/88 | 1988 | | | | | | | 174 | 80 | 45 | 364 | 180 | 49 |
| | | | 1989 | 360 | 196 | 54 | | | | | | | | | |
| 6. Canyonlands NP | I | 12/19/86 | 1987 | 287 | 259 | 90 | 368 | 342 | 92 | 368 | 358 | 97 | 364 | 320 | 87 |
| | | | 1988 | 364 | 266 | 73 | 368 | 357 | 97 | 368 | 193 | 52 | 364 | 361 | 99 |
| | | | 1989 | 360 | 4 | 1 | | | | | | | | | |
| 7. Chiricahua NM | I | 02/17/89 | 1989 | | | | | | | | | | | | |
| 8. Crater Lake NP | I | 03/01/88 | 1988 | | | | | | | | | | --- | --- | --- |
| | | | 1989 | --- | --- | --- | | | | | | | | | |
| 9. Glacier NP | I | 01/20/89 | 1989 | 156 | 105 | 67 | | | | | | | | | |
| 10. Grand Canyon NP | I | 12/18/86 | 1987 | 291 | 185 | 63 | 368 | 5 | 1 | 368 | 142 | 38 | 364 | 320 | 87 |
| | | | 1988 | 364 | 196 | 53 | 368 | 345 | 93 | 368 | 220 | 59 | 364 | 358 | 98 |
| | | | 1989 | 360 | 317 | 88 | | | | | | | | | |
| 11. Guadalupe NP | P | 12/01/88 | 1988 | | | | | | | | | | --- | --- | --- |
| | | | 1989 | 360 | 144 | 40 | | | | | | | | | |
| 12. Hawaii Volcanoes NP | P | * | | | | | | | | | | | | | |
| 13. Mesa Verde NP | I | 09/14/88 | 1988 | | | | | | | | | | 110 | 277 | 99 |
| | | | 1989 | 360 | 311 | 86 | | | | | | | | | |
| 14. Petrified Forest NP | P | 04/17/87 | 1987 | | | | 179 | 160 | 89 | 368 | 270 | 73 | 364 | 302 | 82 |
| | | | 1988 | 364 | 319 | 87 | 368 | 365 | 99 | 368 | 356 | 96 | 364 | 356 | 97 |
| | | | 1989 | 360 | 353 | 98 | | | | | | | | | |
| 15. Pinnacles NM | P | 03/23/88 | 1988 | | | | 278 | 272 | 97 | 368 | 340 | 92 | 364 | 123 | 33 |
| | | | 1989 | 360 | 193 | 53 | | | | | | | | | |
| 16. Rocky Mountain NP | I | 12/01/87 | 1988 | 364 | 297 | 81 | 368 | 291 | 79 | 368 | 69 | 18 | 364 | 181 | 49 |
| | | | 1989 | 360 | 226 | 65 | | | | | | | | | |
| 17. San Gorgonio W | I | 04/29/87 | | | | | | SYSTEM | | REMOVED | | | | | |
| 18. Shenandoah NP | I | 03/09/88 | 1988 | | | | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | 1989 | 360 | 118 | 32 | | | | | | | | | |
| 19. Tonto NM | I | 04/19/89 | 1989 | | | | | | | | | | | | |
| 20. Voyageurs NP | P | 06/18/88 | 1988 | | | | | | | --- | --- | --- | --- | --- | --- |
| | | | 1989 | --- | --- | --- | | | | | | | | | |
| 21. Yellowstone NP | P | * | | | | | | | | | | | | | |
| 22. Yosemite NP | I | 09/01/88 | 1988 | | | | | | | --- | --- | --- | --- | --- | --- |
| | | | 1989 | 360 | 110 | 30 | | | | | | | | | |

KEY
--- System not operating
* Transmissometer not yet installed
I = IMPROVE
P = IMPROVE Protocol

**TABLE 8**

**Photography Archive Status**

| Site | Camera Instal. Date | Winter 87 c | Winter 87 u | Spring 87 c | Spring 87 u | Summer 87 c | Summer 87 u | Fall 87 c | Fall 87 u | Winter 88 c | Winter 88 u |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ACAD | 04/20/85 | 75 | 54 | 90 | 56 | 93 | 61 | 74 | 45 | 41 | * |
| BIBE | 06/13/86 | 70 | 58 | 66 | 62 | 46 | 44 | 91 | 87 | 95 | 85 |
| BRID | 09/22/86 | 71 | 46 | 34 | 23 | 75 | 68 | 94 | 56 | 79 | 52 |
| BRCN | 04/10/84 | 80 | 5 | 42 | 25 | 94 | 79 | 92 | 60 | 99 | 45 |
| CANY | 01/21/87 | 26 | 11 | 90 | * | 91 | * | 93 | * | 85 | * |
| CHIR | 06/17/86 | 88 | 53 | 80 | 68 | 96 | 88 | 97 | 91 | 99 | 79 |
| CRLA | 07/01/86 | 51 | 33 | 65 | 49 | 99 | 91 | 95 | 76 | 85 | 38 |
| DENA | --------[1] | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| GLAT | 06/14/85 | 53 | 14 | 26 | 9 | 89 | 76 | 90 | 60 | 75 | *[2] |
| GRCT | 11/23/83 | 78 | 51 | 98 | * | 99 | * | 100 | * | 98 | * |
| GRSM | 01/04/84 | 69 | 31 | 68 | 51 | 38 | 21 | 96 | 67 | 100 | 59 |
| JARB | 09/08/86 | 33 | --[3] | 51 | 7 | 98 | 92 | 79 | 60 | 98 | 19 |
| MEVE | 07/15/86 | 34 | 18 | 97 | 59 | 80 | 75 | 52 | 41 | 95 | 67 |
| MORA | 06/21/85 | 79 | 28 | 44 | 17 | 78 | 42 | 63 | 37 | 79 | 23 |
| ROMM | 10/25/85 | 37 | 25 | 79 | 63 | 73 | 66 | 84 | 73 | 88 | * |
| SAGO | 08/13/86 | 41 | 23 | 53 | 27 | 99 | 85 | 95 | 53 | 36 | 25 |
| SHEN | 10/29/86 | 73 | 50 | 48 | 30 | 70 | 55 | 98 | 75 | 86 | 64 |
| TONM | 05/09/86 | 69 | 61 | 37 | 36 | 86 | 86 | 58 | 58 | --[4] | -- |
| WEMI | 08/12/86 | 47 | 10 | 73 | 43 | 85 | 78 | 94 | 66 | 96 | 57 |
| YOSW | 09/07/84 | 80 | 57 | 75 | 67 | 78 | 76 | 96 | 66 | 58 | 33 |

c - % of total photographs possible for scene monitoring.
u - % of photographs appropriate for path-averaged extinction coefficient calculation.
* - No SVR calculations obtained from photographic data following transmissometer installations.

---

[1] Denali National Park has not yet installed visibility monitoring equipment mailed Summer of 1986.

[2] Teakettle vista was primary target for analysis until transmissometer installed. Winter 88 collection statistics are not for the Scenic Garden Wall vista.

[3] Insufficient data to calculate any Standard Visual Range.

[4] The Superstitions camera system was stolen 11/12/87. No reinstallation followed.

## III. Process to Identify and Document Suspected Visibility Impairment

In 1985 and 1986, the Department of the Interior responded to the Environmental Protection Agency's (EPA) request for information on existing visibility impairment in those mandatory class I areas managed by the National Park Service (NPS) and Fish and Wildlife Service (FWS).[1]

The Department of the Interior indicated that there were five NPS class I areas with existing visibility impairment that was suspected of being reasonably attributable to a source or small group of sources. These areas are: Grand Canyon National Park, Petrified Forest National Park and Saguaro Wilderness in Arizona; Voyageurs National Park in Minnesota; and Canyonlands National Park in Utah. The Department also certified that there were four FWS class I areas with suspected reasonably attributable impairment: Tuxedni Wilderness in Alaska; Moosehorn Wilderness in Maine; Brigantine Wilderness in New Jersey; and Cape Romain Wilderness in South Carolina. The State of Alaska has an approved visibility State Implementation Plan and is responsible for addressing the visibility impairment in the Tuxedni Wilderness. EPA subsequently decided that only the Moosehorn Wilderness of the remaining three areas had visibility impairment that was probably caused by a single source or small group of sources.

The Roosevelt Campobello International Park Commission also certified to the EPA that visibility was impaired within the integral vistas associated with the Roosevelt Campobello International Park located in Maine and New Brunswick, Canada.

Various monitoring efforts were initiated, beginning in 1986, to attempt to document the existing impairment and the responsible air pollution sources (see Appendix H). These studies were funded by the NPS, FWS, and the EPA through the interagency IMPROVE monitoring program. A summary of the initial findings of these monitoring efforts at each of the above listed class I areas is presented below:

---

[1] November 14, 1985, letter from Susan Recce, Department of the Interior Acting Assistant Secretary for Fish and Wildlife and Parks to Charles Elkins, EPA Acting Assistant Administrator for Air and Radiation; and March 24, 1986, letter from Richard Briceland, NPS Associate Director for Natural Resources to EPA Central Docket Section, Docket Number A-85-26.

### Voyageurs National Park

The IMPROVE program funded Air Resource Specialists, Inc. (ARS), the NPS's visibility monitoring contractor, to set up 35mm still and 8mm time-lapse movie cameras at Voyageurs National Park to assess impacts on the park's visual air quality caused by nearby sources. The cameras were in operation between October 1986 and April 1988. The resulting color slides and time-lapse films were reviewed by ARS, NPS staff, and the IMPROVE steering committee. No distinct, easily identifiable plumes were visible in the slides or the movies. ARS documented this finding in a May 5, 1988, report to the EPA chairman of the IMPROVE steering committee entitled "Monitoring For Reasonably Attributable Impact of Local Sources At Voyageurs National Park, Petrified Forest National Park and Moosehorn Wilderness." The NPS and the Department of the Interior believe that the photographic evidence available at this time does not support the development of a revision to the federal implementation plan for Minnesota to include Best Available Retrofit Technology (BART) requirements and other control measures.

### Petrified Forest National Park

The NPS and IMPROVE steering committee directed ARS to install 35mm and 8mm cameras in Petrified Forest National Park during March 1987. The photographic systems operated until March 1988. An examination of the photographic data by ARS, NPS, and IMPROVE indicated no visible plumes within the park. There was an occasional discoloration visible on the horizon, but it was not readily attributable to any specific source. ARS documented this finding in the above referenced report. The NPS and the Department of the Interior acknowledge that the evidence does not support development of BART requirements or other control measures for remedying visibility impairment at Petrified Forest National Park. If future monitoring programs provide documentation of visibility impairment caused by a specific source, the Department of the Interior will certify that to the EPA and request the commencement of a BART review.

### Saguaro Wilderness

The NPS through its contractor ARS, is now deploying one of the two time-lapse movie cameras used at Petrified Forest and Voyageurs National Park at Saguaro National Monument. The NPS will operate this 8mm camera for approximately one year. Part way through this monitoring period, the San Manuel smelter near Tucson, Arizona will comply with new more stringent sulfur dioxide emission limitations that are required by the terms of the consent decree. IMPROVE will investigate if the time-lapse movies will reflect an improvement in visual air quality because of this reduction in the region's sulfur dioxide emissions. Because the monitoring at Saguaro has only recently begun, there is no specific photographic evidence of reasonably attributable impairment at this time. If this new monitoring initiative provides documentation of visibility impairment caused by a specific source, the Department of the Interior will certify that to the EPA and request the commencement of a BART review.

Canyonlands National Park

The NPS, the Salt River Project, the Electric Power Research Institute, and others conducted the Winter Haze Intensive Tracer Experiment (WHITEX) during a six week period in the winter of 1987. The objective of this study was to quantify the air pollution impact of a specific source (Navajo Power Plant) on specific receptors (such as Canyonlands and Grand Canyon National Parks). During the short duration of the study, it appears that a Navajo Power Plant contribution was not measured at Canyonlands National Park. The six week monitoring period may have been characterized by unusually good meterological dispersion conditions and fewer haze episodes, which is somewhat atypical of the usual winter time conditions of the Colorado Plateau region. The park still continues to experience episodes of haze, and a second intensive monitoring effort may be undertaken in the next year or two to monitor the haze and attribute it to specific sources. As with the above mentioned cases, if new Canyonlands monitoring initiatives provide documentation of visibility impairment caused by a specific source, the Department of the Interior will certify that to the EPA and request the commencement of a BART review at that time.

Grand Canyon National Park

One of the objectives of the above referenced WHITEX study was to sample the haze at Grand Canyon National Park and attribute it to specific sources, such as the Navajo Power Plant. The analysis of all the data collected during this intensive monitoring effort is not complete. The NPS and the Department of the Interior requested the EPA to defer, by twelve months, its proposed decision on the necessity of BART and other control measures for the Arizona federal implementation plan pending the completion of the data analysis and interpretation of the Grand Canyon data.

Moosehorn Wilderness Area

The FWS identified the Georgia-Pacific pulp and paper mill as the probable source of existing visibility impairment in Moosehorn Wilderness Area. FWS and IMPROVE directed ARS to install an 8mm time-lapse camera at Moosehorn. The camera was installed in October 1987. The camera has recorded a visible plume from the mill nearly every day. Under certain conditions, the plume appears to cross the boundary and enter the wilderness area.

Georgia-Pacific has applied for a Prevention of Significant Deterioration (PSD) permit modification from the State of Maine for a new recovery boiler at the existing mill. The existing visibility impairment may be reduced if additional air pollution controls are required by this permit. Consequently, the FWS and the Department requested that the EPA defer its decision concerning the necessity of BART controls for Georgia-Pacific pending the completion of the PSD permit process. The time-lapse movie camera system will continue to operate throughout the permit review.

Roosevelt Campobello International Park

Because of the proximity of the above mentioned Georgia-Pacific mill to the International Park, the Commission requested the NPS to study potential impacts of the proposed mill modification on the International Park. The NPS study concluded that the reductions in emissions associated with the proposed modification would result in no impairment of visibility in the International Park or its integral vistas. No IMPROVE monitoring effort was undertaken at this park.

Following this initial Federal Land Manager certification of existing visibility impairment in class I areas, the IMPROVE steering committee and the NPS retained the contractor Desert Research Institute (DRI) to prepare a report. The objectives of this report are to identify, describe, and evaluate measurements and data interpretation methods to:

1. Document the intensity, duration, frequency, and spatial extent of existing visibility impairment in class I areas,

2. Attribute visibility impairment to natural and manmade, local and distant emissions sources, and

3. Relate emissions reductions to visibility improvement.

DRI has completed a draft of this report, entitled "Guidance on Methods to Investigate Existing Visibility Impairment and Attribute it to Sources", and is being reviewed by the IMPROVE committee. This draft addresses the documentation of existing visibility impairment; and summarizes visibility and aerosol measurement methods, existing data bases, and receptor modeling methods of visibility source apportionment. The final report will be made available to the public and interested groups by the end of 1989.

## TECHNICAL REPORT DATA

*(Please read Instructions on the reverse before completing)*

| | | |
|---|---|---|
| 1. REPORT NO. EPA-450/4-90-008 | 2. | 3. RECIPIENT'S ACCESSION NO. |
| 4. TITLE AND SUBTITLE IMPROVE Progress Report | | 5. REPORT DATE May 1990 |
| | | 6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S) Marc Pitchford, David Joseph | | 8. PERFORMING ORGANIZATION REPORT NO. |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Monitoring Systems Laboratory, U. S. Environmental Protection Agency, Las Vegas, Nevada 93478 | | 10. PROGRAM ELEMENT NO. |
| | | 11. CONTRACT/GRANT NO. |
| 12. SPONSORING AGENCY NAME AND ADDRESS Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711 | | 13. TYPE OF REPORT AND PERIOD COVERED |
| | | 14. SPONSORING AGENCY CODE |

15. SUPPLEMENTARY NOTES

16. ABSTRACT

In Section 169A of the Clean Air Act as amended August 1977, Congress declared as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution."[1] Mandatory class I Federal areas are national parks greater in size than 6000 acres, wilderness areas greater in size than 5000 acres and international parks that were in existence on August 7, 1977.[2] This section required the Environmental Protection Agency (EPA) to promulgate regulations requiring States to develop programs in their State Implementation Plans (SIPs) providing for visibility protection in these areas. EPA promulgated these regulations on December 2, 1980.[3]

This report summarizes the progress made to date in developing and implementing the interagency monitoring network which supports the effort, Interagency Monitoring of Protected Visual Environments (IMPROVE).

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| Visibility monitoring<br>State Implementation Plans (SIP)<br>Class I Federal Areas | | |

| | | |
|---|---|---|
| 18. DISTRIBUTION STATEMENT | 19. SECURITY CLASS *(This Report)* | 21. NO. OF PAGES |
| | 20. SECURITY CLASS *(This page)* | 22. PRICE |