INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS

IMPROVE

2nd Quarter 2009 | The IMPROVE Newsletter | Volume 18 / Number 2

Monitoring update

Feature Article: Assessing data uncertainties, Page 4

Network operation status

The IMPROVE (**I**nteragency **M**onitoring of **Pro**tected **V**isual **E**nvironments) Program consists of 110 aerosol visibility monitoring sites selected to provide regionally representative coverage and data for 155 Class I federally protected areas. Additional instrumentation that operates according to IMPROVE protocols in support of the program includes:

- 60 aerosol samplers
- 33 nephelometers
- 4 transmissometers
- 4 digital camera systems
- 63 Webcamera systems
- 5 interpretive displays

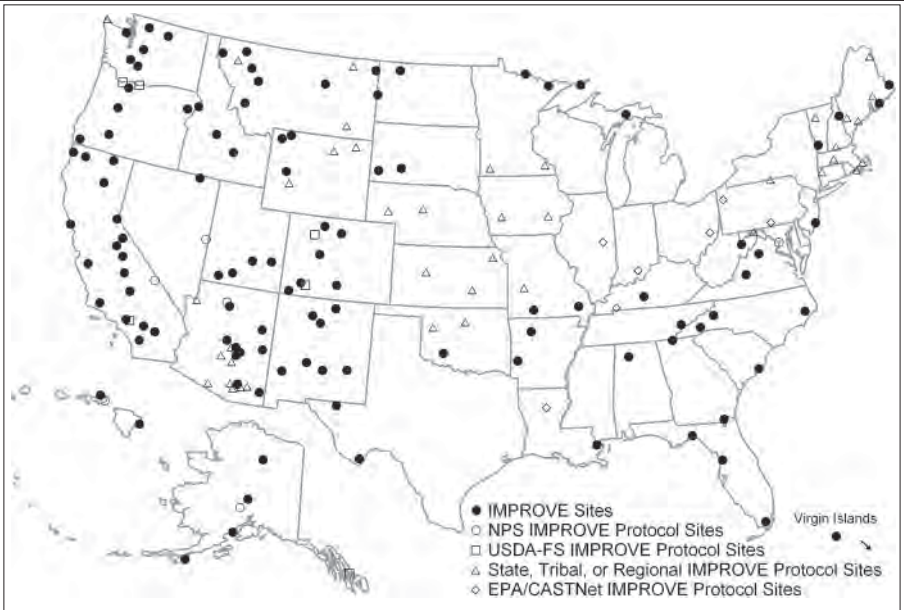
IMPROVE Program participants are listed on page 8. Federal land management agencies, states, tribes, regional air partnerships, and other agencies operate supporting instrumentation at monitoring sites as presented in the map below. Preliminary data collection statistics for the 2nd Quarter 2009 (April, May, and June) are:

- Aerosol (channel A only) 95% collection
- Aerosol (all modules) 93% completeness
- Optical (nephelometer) 96% collection
- Optical (transmissometer) 87% collection
- Scene (photographic) (does not include Webcameras) 95% collection

The Midwest Haze Camera Network received a new Webcamera in June. Two cameras now operate in Chicago -- the new camera photographs downtown Chicago, while the current camera photographs Chicago's Northside.

Data availability status

Data and photographic spectrums are available on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Data/data.htm* and on the VIEWS Web site at *http://vista.cira.colostate.edu/views*. Aerosol data are available through December 2008. Nephelometer and transmissometer data are available through March 2009 and December 2008 respectively. Real-time Webcamera displays are available on agency-supported Web sites:



IMPROVE and IMPROVE Protocol Sites
2nd Quarter 2009

- National Park Service *http://www.nature.nps.gov/air/WebCams/index.htm*
- USDA-Forest Service *http://www.fsvisimages.com*
- CAMNET (Northeast Camera Network) *http://www.hazecam.net*
- Midwest Haze Camera Network *http://www.mwhazecam.net*
- Wyoming Visibility Network *http://www.wyvisnet.com*
- Phoenix, AZ, Visibility Network *http://www.phoenixvis.net*

The EPA AIRNow Web site *http://airnow.gov* includes many of these as well as additional visibility-related Webcameras. Click on View Other Visibility Webcams.

***Monitoring update** continued on page 3....*

Visibility news

Solar-powered IMPROVE sampler installed at Ripple Creek, Colorado

Flat Tops Wilderness, CO, is a typical Forest Service wilderness, with oil and gas development nearby and upwind, elevations from 7500' to 12000', and surrounded by forest. The nearest line power, normally required for an IMPROVE site, is miles away. Only one other site in the network operates without line power: Tuxedni along the Cook Inlet in Alaska. It was desirable to monitor for local impacts from new development, but there were no locations with power that adequately represented the wilderness.

In 2003, Air Sciences, Inc. in Golden, CO, working for Shell Oil, developed a solar-powered IMPROVE-like sampler. It used a proprietary controller that allowed real-time access of operational information via the Web. The key to the solar conversion was the use of a low power pump which can maintain IMPROVE flow rates.

The sampler was installed close to the Wilderness boundary at 9600' on Ripple Creek Pass. The site (RICR1) was operated by Shell and Air Sciences until 2008. When Shell Oil ended funding, the White River National Forest worked closely with Air Sciences and UC-Davis to make the site an IMPROVE protocol site. The site restarted in early 2009 and though its operation is imperiled by funding issues, it remains a prototype for a fully solar-powered IMPROVE sampler.

For more information contact Scott Copeland at the USDA-Forest Service. Telephone: 307/332-9737. E-mail: copeland@cira.colostate.edu.

The Ripple Creek IMPROVE Protocol monitoring site. Colorado.

Power generation at the Tuxedni IMPROVE monitoring site

The IMPROVE site at Tuxedni, AK, is in one of the most remote and challenging areas in the network. The site is located at a remote wilderness lodge, Alaska Homestead Lodge, located south of Anchorage in Silver Salmon Creek, in the Tuxedni Bay area. There are no roads to drive to the lodge, and the only access is by bush plane. Weather is always an issue, especially in the winter with freezing temperatures and snow conditions. The volcanic eruption of Mt. Redoubt, 35 miles to the north, provided additional challenges this past winter in dealing with the ash fall.

The Tuxedni site lies off the electrical power grid, so producing sufficient power for the energy needs of the lodge and of the IMPROVE sampler requires steady attention. Power is produced with a combination of a 3000 watt Whisper Wind generator, 2000 watts of solar, a 10 KW diesel generator, and a 2 KW gas generator. If there is enough wind or sun, the diesel or gas generators are not needed, which is preferred. The wind generator supplies between 45% to 50% of the power at the site, the solar panels produce 30% to 40%, and the diesel and gas generators produce 10% to 15%.

The wind generator has been the biggest producer of power but also presents by far the greatest maintenance burden. It sits on a 110' tower and since Tuxedni Bay is a turbulent windy area, it gets lots of abuse. Two years ago, site operator and lodge owner James Isaak took the wind generator off and completely reinforced all weak areas, put in bigger bearings, and installed new blades; it has been running ever since without problems. The solar panels are very reliable as there are no moving parts on them.

The newest addition to the power generation system at Tuxedni is a new battery room to store a new bank of batteries. Four 1690 amp hour, 12 volt battery banks were purchased to meet the needs of both the IMPROVE sampler and the lodge.

***Tuxedni power** continued on page 5....*

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IMPROVE Newsletters are also available on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Publications/news_letters.htm.*

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Uninterrupted power supplies at IMPROVE monitoring sites

Experience gained in understanding equipment malfunctions has allowed IMPROVE scientists at UC-Davis to better diagnose hardware problems and, in some instances, to preemptively take actions that will save future resources.

Usually, a momentary loss of power will only affect a sample by shortening the elapsed run time. However, on rare occasions, the switching off and on of power will cause the microcontroller within the sampler's control module to lose some of its parameters and inadvertently refrain from sampling for the remainder of a given week. To prevent this from occurring, uninterrupted power supplies (UPS) have been installed at selected sites which may be more prone to power fluctuations.

One of the first candidates for a UPS was Boundary Waters Canoe Area Wilderness, MN, in early 2007. Prior to the UPS, Boundary Waters experienced equipment malfunctions at a higher frequency than most sites. Most of these malfunctions were due to controller failures ostensibly caused by occasional black/brownouts; a UPS unit was installed in March 2007 as a result. Retrospectively, the installation of the UPS seems to have helped decrease the frequency of equipment problems.

A few other sites, though not significantly affected, are potentially at risk from equipment malfunctions from power fluctuations. For example, the site at Haleakala National Park, HI, is situated in an aged part of the Maui Bird Conservation Center, which according to operators occasionally experiences black/brownouts. Another example is the White River site near Aspen, CO, which has recently had a couple of unexplained power outages. Both of these sites have received a UPS as a preemptive measure. The units are now fairly inexpensive, readily available, and worth the effort for their potential security.

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***Visibility news** continued on page 6....*

Monitoring update *continued from page 1 ....*

Operators of distinction

Nearly two years ago, the Pack Monadnock, NH, (PACK1) monitoring station joined the IMPROVE aerosol network. Operated by the state of New Hampshire, Department of Environmental Services, Air Resources Division, the site is unique in several ways. Its high elevation coupled with moist climate is not common to other sites in the network, hence the site collects periods of data unique to this environment. The air quality monitoring station also collects ozone, nitrogen dioxide, PAMS, continuous fine particulate and meteorological parameters, and is part of a state network of monitoring stations.

Scott Klose, the station's operator, has been an air pollution technician with the state for nearly 10 years. His work keeps him primarily in the field each day, maintaining several of the state's monitoring stations. He ensures the systems run properly, performs troubleshooting, and maintains station housekeeping. "Most of the stations are in very public areas," said Scott. "Miller State Park can see 200-600 visitors daily, so the stations are maintained to be aesthetically pleasing. It is important to us that the visitors see our air monitoring efforts as a good thing."

Scott is also an experienced carpenter and a jack-of-all-trades, so he is often called upon to help the air quality group, part of the state Department of Environmental Services, Air Resources Division, Technical Services Bureau. He loves his job because it keeps him outdoors. When not working, Scott can find numerous things to do outdoors including hunting, fishing, boating, snowmobiling, and playing softball. His extended family is all in the local area so he does not have to go far to visit.

Working closely with UC-Davis technicians over the telephone allows Scott to keep his station running smooth. "We recently received 14 inches of rain in 30 days," said Scott. "Water got in the aerosol modules and I worked closely with Eric Harvey (operator and field support at UC-Davis) to alleviate the water problem. Scott then put in extra effort to solve the issue by drying out the cyclones and tubing lines, then checked them frequently during the rains to make sure the problem didn't reoccur until a more permanent solution was implemented, along with many other maintenance issues. These extra efforts helped prevent further data loss.

PACK1 operator Scott Klose maintains a network of air quality stations.

***Monitoring update** continued on page 7....*

Feature article

Reassessing IMPROVE data uncertainties (by C. McDade, University of California - Davis)

Introduction

Nicole Hyslop and Warren White, research scientists at UC-Davis, are developing a revised and enhanced formulation of IMPROVE uncertainties. An uncertainty value is reported along with each determined ambient concentration, and all of these values can be found on the VIEWS Web site, the public portal for IMPROVE data. The recent work at UC-Davis will result in uncertainty values that are more representative of the measurements being conducted.

Measuring uncertainty

IMPROVE has historically used a "bottom-up" propagation-of-errors approach for estimating uncertainty, determined by combining the individual identified components of uncertainty. Measurement uncertainty arises from all aspects of the measurement process including sample preparation, collection, analysis, data acquisition, and data processing. Some components of uncertainty are independent of concentration, such as the uncertainty associated with blank correction or interferences. Other components of uncertainty are proportional to the magnitude of the concentration, such as uncertainty in sample volume. Yet other sources of uncertainty increase less than proportionately with concentration, such as the uncertainty in a spectroscopic background. The "bottom-up" approach for estimating overall measurement uncertainty involves combining these proportional and non-proportional uncertainties, based upon our best understanding.

The "top-down" approach

Collocated sampling, with two identical modules sampling at the same location, provides a "top-down" approach for estimating measurement uncertainty, supplying closure at the system level. Comparing the concentrations reported from the two modules provides an overall estimate of uncertainty from all sources. Collocated sampling is a more comprehensive way to evaluate the uncertainty of measurements because it can include effects from unidentified sources of error.

Collocated aerosol sampling was introduced in the IMPROVE network in 2003, so we now have several years of data available for analysis. One duplicate of an existing sampling module was added at each of 24 sites, comprising six sites with each of the four module types. There is also a second full 4-module sampler at the Phoenix site. Single modules were added at all but Phoenix because the IMPROVE controller can accommodate up to five modules, so additional modules beyond five would have necessitated a second controller. As an added benefit, using single modules has allowed us to distribute our collocated measurements over 24 sites, thereby sampling a variety of atmospheric conditions and site operator styles.

Each collocated module is semi-independent of the routine module. The collocated and routine modules have independent sample streams, including separate inlets, cyclones, pumps, and solenoid valves. Conversely, the collocated and routine modules are controlled and monitored by the same electronics (except at Phoenix), including a common timer, software, and data acquisition system. In addition, a single temperature measurement is used to adjust the measured mass flow rate to volumetric flow rate for both the collocated and routine modules. Therefore, this arrangement does not capture any uncertainty associated with the temperature measurement and may not capture all the variations resulting from electronics.

Analytical calibration and data processing uncertainties are not thoroughly addressed by this type of evaluation. The routine and collocated samples are often analyzed on the same instrument within hours or at most days of each other, particularly XRF measurements. The analyzers are typically stable over this short time period. Uncertainty resulting from the range of acceptable calibration criteria could only be evaluated if the samples were analyzed at significantly different times (such that the instrument has drifted from its calibration or was using a different calibration) or if the routine and collocated samples were always analyzed using different instruments. The routine and collocated data are collected, processed, and validated using the same systems, so uncertainties resulting from calculations, such as rounding numbers, are not reflected in the collocated data assessment.

UC-Davis research scientists Warren White and Nicole Hyslop.

The "bottom-up" approach

The "bottom-up" predicted uncertainty is comparable in magnitude to the "top-down" collocated uncertainty for some measured species, including $PM_{2.5}$ and PM_{10} mass, bromine, nitrate, and sulfate. However, the collocated IMPROVE data demonstrate that currently reported "bottom-up" uncertainty values are too low for most species, often by a factor of two or more. In general, the collocated-to-predicted uncertainty ratios are better for species that are predominantly in the fine particle size mode and are measured at concentrations well above their detection limits. In terms of analytical technique, the collocated uncertainties tend to be better for techniques that are performed on the entire filter (gravimetry for mass and ion chromatography for ions) instead of just a portion of the filter (X-ray fluorescence for elements and thermal optical reflectance for carbon).

The soil-related elements have poor uncertainties even though they are measured at concentrations well above their detection limits and their analytical uncertainties are within expectations. This observation suggests that sampling-related uncertainties such as filter deposit non-uniformity or cyclone collection efficiency variations are affecting the samples. The current element uncertainty estimates do not include any sampling-related uncertainties other than flow rate uncertainty. Research on sampler performance at UC-Davis is focused on better understanding sampling-related uncertainties and, where feasible, on implementing sampler improvements to lessen these uncertainties.

A new "hybrid" approach

The collocated data have demonstrated that the reported "bottom-up" uncertainties underestimate the actual uncertainties for many species. Consequently, the UC- Davis research team embarked on a quest to identify a more accurate, yet reasonably simple, approach for estimating and reporting uncertainty. They searched for a metric that could be applied throughout the entire network and at the same time would enhance IMPROVE's reporting of measurement uncertainty.

The result of their effort is a hybrid approach that combines new knowledge of concentration-dependent uncertainty with additional uncertainty information gained from the network's field blanks and quartz backup filters. Concentration-dependent uncertainty will now be estimated from collocated field sampling results as well as from replicate analysis of selected samples in the laboratory. The constant components of uncertainty, often due to low-level contamination, will be estimated from the 95th percentile blanks and backups (those with concentrations near the highest observed), which supply useful additional bounds on the uncertainty near each species' detection limit. This hybrid approach will provide a new, more realistic indication of overall measurement uncertainty.

Work is ongoing to put the finishing touches on this new approach and, once completed, IMPROVE will switch to the new calculations for its reported uncertainty. At that time, information will be provided on the VIEWS Web site to inform data users of the details of the calculation methods and the initial date of implementation.

Further work is continuing by Hyslop and White to better characterize measurement uncertainty and to identify the components of uncertainty that would be good candidates to be improved by advancements in measurement technology. Those readers interested in learning more details about their work should turn to the following recent references:

Nicole P. Hyslop and Warren H. White, "An Evaluation of Interagency Monitoring of Protected Visual Environments (IMPROVE) Collocated Precision and Uncertainty Estimates," Atmospheric Environment 42 (2008), pages 2691-2705.

Nicole P. Hyslop and Warren H. White, "An Empirical Approach to Estimating Detection Limits Using Collocated Data," Environmental Science & Technology 42 (2008), pages 5235-5240.

For more information contact Chuck McDade at the University of California-Davis. Telephone: 530/752-7119. Fax: 530/752-4107. E-mail: mcdade@crocker.ucdavis.edu.

Tuxedni power *continued from page 2....*

It is hoped that with the new batteries, the fossil fuel generators will run even less. The goal is to go "green" in all areas of operation at Tuxedni, both with the IMPROVE sampler and with the lodge.

Alaska Homestead Lodge expects to have a section on its Web site by August 1, 2009, regarding their solar and wind generation initiatives. Check it out at: *http://www.alaskawildlife.com.*

For more information contact Pete Beveridge at the University of California-Davis. Telephone: 530/752-4106. Fax: 530/752-4107. E-mail: beveridge@crocker.ucdavis.edu.

The new battery bank is installed at the Alaska Homestead Lodge to help power the lodge and the IMPROVE monitoring site.

Visibility news *continued from page 3 ....*

Carbon Speciation Network sampler replacement nears completion

EPA's Carbon Speciation Network (CSN) began replacing its carbon sampling channel with an IMPROVE-type sampler three years ago. Installation at all 196+ monitoring sites is now nearing completion, and preliminary studies indicate the new CSN carbon sampler and the IMPROVE carbon module track well.

CSN data are often used in conjunction with IMPROVE data to increase spatial coverage and meet multiple data use needs. Changes in the CSN are being implemented to address inconsistencies in carbon sampling and analysis procedures, between the urban CSN and rural IMPROVE programs. The new CSN carbon sampler (URG3000N) manufactured by URG Corporation, is based on the IMROVE Version II Module C. Both the CSN and IMPROVE monitoring networks also utilize the IMPROVE_A Thermal Optical Reflectance (TOR) filter analysis method.

EPA performed its network conversion to the new sampler in three phases. Phase I involved conversion of 56 sites in May 2007. Phase II involved conversion of 62 sites in late 2008, and the final Phase III, is in the process of converting the remaining 78 sites this summer.

Only two sites had collocated URG3000N and IMPROVE Module C samplers (Birmingham, AL, and Bronx, NY). EPA prepared linear regression data plots following Phase I replacement for Birmingham, AL. Data collected by the old SASS samplers were compared to data collected by the new URG samplers, and showed good correlation. However, SASS organic carbon (OC) was higher than IMPROVE and SASS elemental carbon (EC) was lower than IMPROVE. Linear regression plots of OC and EC data collected with the new URG3000N (analyzed by the IMPROVE_A method) were compared to data collected with the IMPROVE Module C. Excellent correlations were obtained and the slope for both OC and EC comparisons were very close to one showing that the goal of consistency between the measurements made by both programs was met.

The URG3000N carbon sampler is based on the IMPROVE Version II sampler (Module C), with a few operational differences. Early analyses between two collocated samplers show excellent correlation in organic carbon and elemental carbon. The above photo is the URG3000N carbon sampler operating at the CSN Minneapolis, MN, monitoring site. Two SASS samplers are pictured in the photo's right.

For more information related to the URG3000N carbon sampler and TOR analysis in the CSN, visit *http://epa.gov/ttn/amtic/specurg3000.html*.

For more information contact David Shelow of the Environmental Protection Agency. Telephone: 919/541-3776. Fax: 919/541-1903. E-Mail: shelow.david@epamail.epa.gov.

Data advisory update released

Inconsistent bias in XRF sulfur

- Affects: Module A - Sulfur (S)
- Period: 2003-2008

Previous advisories have called attention to observable discontinuities in XRF sulfur data, including a sulfur/sulfate ratio shift during 2003-2004, which coincided with recalibrations of the XRF system, and an additional shift of 15% with early 2005 data, which was caused by a change in the value used for the calibration foil.

A new shift is apparent in sulfur/sulfate ratios due to a new calibration protocol applied to 2007-2008 data. The ratios drop about 10% from pre-2007 data. This new calibration protocol was based on a curve fit to several different elemental foils, and this fit assigned a value to the sulfur foil different from the manufacturer's quote. Additional shifts are also apparent, due to a change from helium flushing to vacuum operation, and a second vacuum system being added to the XRF process in 2005.

A complete discussion of this and all other data advisories can be found on the IMPROVE Web site at *http://vista.cira.colostate.edu/improve/Data/QA_QC/Advisory.htm.*

For more information or to submit an advisory, contact Bret Schichtel at CIRA. Telephone: 970/491-8581. Fax: 970/491-8598. E-mail: schichtel@cira.colostate.edu.

Monitoring update *continued from page 3 ....*

Outstanding sites

Data collection begins with those who operate, service, and maintain monitoring instrumentation. IMPROVE managers and contractors thank all site operators for their efforts in caring for IMPROVE and IMPROVE Protocol networks. Sites that achieved 100% data collection for 2nd Quarter 2009 are:

Aerosol (Channel A)

Acadia
Addison Pinnacle
Aqua Tibia
Arendtsville
Badlands

Birmingham
Bliss
Bondville
Boundary Waters
Bridgton

Brigantine
Bryce Canyon
Cape Cod
Cape Romain
Chassahowitzka

Cloud Peak
Cohutta
Columbia Gorge East
Columbia Gorge West
Crater Lake

Death Valley
Denali
Dolly Sods
Douglas
Egbert

El Dorado Springs
Flathead
Grand Canyon
Great River Bluffs
Great Smoky Mtns.

Hawaii Volcanoes
Hercules-Glades
Hoover
Ike's Backbone
Kalmiopsis

Lake Sugema
Lassen Volcanic
Linville Gorge
Livonia
Makah

Mammoth Cave
Medicine Lake
Mesa Verde
MK Goddard
Mohawk Mountain

Monture
Moosehorn
Mount Hood
Mount Rainier
Mount Zirkel

Nebraska
New York
North Cascades
Okefenokee
Olympic

Pack Monadnock
Pasayten
Penobscot
Phoenix

Presque Isle
Proctor Research Ctr
Quabbin Reservoir
Quaker City
Rocky Mountain

Saguaro West
San Gorgonio
San Rafael
Seney
Sequoia

Shenandoah
Sikes
Simeonof
Starkey
Sula

Sycamore Canyon
Tallgrass
Theodore Roosevelt
Tonto
Trapper Creek-Denali
Tuxedni

Viking Lake
Virgin Islands
Weminuche
White Pass

White River
Wichita Mountains
Yosemite
Zion Canyon

Nephelometer

Big Bend
Children's Park
Chiricahua
Craycroft
Dysart

Estrella
Glacier
Greer
Ike's Backbone
Indian Gardens

Phoenix
Queen Valley
Sierra Ancha
Tucson Mountain
Vehicle Emissions

Transmissometer

-- none --

Photographic

Gates of the Mountains
Monture

Sites that achieved at least 95% data collection for 2nd Quarter 2009 are:

Aerosol (Channel A)

Breton
Bridger
Cabinet Mountains
Canyonlands

Capitol Reef
Casco Bay
Great Basin
Great Gulf

Guadalupe Mountains
Hells Canyon
Jarbidge
Joshua Tree

Lostwood
Martha's Vineyard
Mount Baldy
Organ Pipe

Petrified Forest
Pinnacles
Puget Sound
Sac and Fox

San Pedro Parks
Shamrock Mines
Voyageurs
Wheeler Peak

Nephelometer

Great Basin
Great Smoky Mtns
Hance

Mammoth Cave
Mount Zirkel
National Capital

Rocky Mountain
Shenandoah
Sycamore Canyon

Transmissometer

Bridger
Cloud Peak

Photographic

Shamrock Mines

Sites that achieved at least 90% data collection for 2nd Quarter 2009 are:

Aerosol (Channel A)

Big Bend
Bosque del Apache
Caney Creek
Cedar Bluff

Cherokee
Chiricahua
Craters of the Moon
Dome Land

Ellis
Everglades
Frostburg Reservoir

Fort Peck
Gates of the Arctic
Gila
Haleakala Crater

James River
Kaiser
Lava Beds
Lye Brook

Point Reyes
Redwood
Saguaro

Salt Creek
San Gabriel
Sawtooth
Snoqualmie Pass

St. Marks
Swanquarter
Three Sisters
Trinity

Upper Buffalo
Washington DC
Wind Cave

Nephelometer

Acadia
Cloud Peak

Mount Rainier
Organ Pipe

Petrified Forest

Transmissometer

-- none --

Photographic

-- none --

Monitoring Site Assistance:

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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.

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Associate Membership in the IMPROVE Steering Committee is designed to foster additional comparable monitoring that will aid in understanding Class I area visibility, without upsetting the balance of organizational interests obtained by the steering committee participants. Associate Member representatives are:

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