

## **Ancillary Uses of IMPROVE Monitoring Data – Potentially Affected by Funding Reductions**

The primary objective of IMPROVE monitoring is to support implementation of the 1999 EPA Regional Haze Rule. This includes establishing baseline (2000-2004) visibility conditions and tracking progress toward the national goal of preventing any future impairment and remedying any existing man-made impairment of visibility in each of 156 protected Class I federal areas in the U.S. Baseline and future visibility conditions are based on “reconstructed light extinction” calculations which combine aerosol species measurements with dry species light extinction efficiencies and hygroscopic growth functions, as specified in the IMPROVE algorithm.

IMPROVE aerosol species measurements are currently conducted in 110 of 156 Class I federal areas using 24-hour filter samples run once every 3 days. From these data, annual averages of the haziest and the clearest 20% days are calculated and averaged into 5-year blocks. Under the Regional Haze Rule, the 2000-2004 baseline conditions for the clearest days are not allowed to deteriorate over time, while the worst days are expected to improve to the level of “natural conditions” over a 60-year time period (2004-2064).

Future reductions in the IMPROVE program which diminish the available data (number of sites, species, sample frequency, quality assurance, etc.) will diminish the program’s ability to meet these primary objectives. In addition, the long-term operation of IMPROVE (since 1988), consistent measurements of multiple species at multiple, regionally representative sites, high level of data quality, and active involvement of multiple federal and state agencies and the academic community in collection and analysis of the data – have resulted in many “ancillary benefits” which over time have become important secondary objectives of the IMPROVE program, and which may also be compromised by future funding reductions. These include, but are not limited to:

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Gaps between IMPROVE funding resources and network costs might potentially be addressed by reductions in: quality assurance, species sampled, number of sites and/or sampling frequency. Most of the ancillary uses of IMPROVE data would be proportionally affected by any of these general cost reduction measures, but some cost reduction options may compromise important data uses more severely than others.

### **Reductions in Quality Assurance / Quality Control**

There may be occasional opportunities (such as recent decision to collect single, rather than double, quartz field blanks) which can reduce QA costs without compromising data quality. But generally, elimination of any measurements which compromise the quality of the data is the least desirable means of reducing costs, as reductions or uncertainties in data quality compromise all current and potential future uses of the data.

Conversely, the very active historical and continuing QA/QC program, continually challenges and improves the data quality and consistency, and leads to improved sampling, analytical and data processing methods. These include the strong benefits to EPA's largely urban chemical speciation network (CSN) and other aspects of the air quality management programs to achieve the National Ambient Air Quality Standards for PM<sub>2.5</sub>.

### **Reductions in Species Sampled**

Discontinuing measurements of species not employed in the regional haze metrics is one way to reduce costs, as has recently been done for PESA measurements of hydrogen. It should be noted, however, that the PESA H data did provide a valuable QA check (Organic Matter by Hydrogen or OMH) which in the past led to detection of a subtle measurement artifact, which would likely not have been otherwise detected. Other measured species not currently used in the RHR metrics include sulfate ion, filter light absorption ( $F_{abs}$ ) and non-soil and non-S (XRF) elements.

**Sulfate ion** is important as a QA check on measured S and as a back-up for calculating  $(NH_4)_2SO_4$  when S data are missing. This backup use is important for calculating RHR metrics, and also for nearly all the ancillary uses of the data (except [K](#) and [P](#)). However, this use as a substitute for S is also relatively rare, as sulfate was present when sulfur data was missing on less than 5% of samples across the network since 2000, and on only about 2% of samples in the past 5 years. The relatively few samples with missing S are also likely to be missing soil elements, other trace elements and fine (and coarse) mass. So losing this backup option would have a relatively minimal effect on the RHR metrics and most ancillary data uses. A greater concern would be loss of the redundant sulfur/sulfate comparison which provides an important QA check on a critical species, and also reveals occasional flow rate, particle cut size or analytical problems on the A or B sample modules. In addition, the enhanced QA/QC procedures showed that the sulfate ion measurement is a more accurate and stable measure of the particulate sulfate. The recommendation to data users is to use sulfate ion instead of S. S is used in the regional haze rule for historical reasons. Last, nitrate and chloride ion concentrations are needed to estimate particulate nitrate and sea salt. If measurements of these two ions are to continue then the addition of sulfate is a minor cost.

**$F_{abs}$  measurements** are not used in RHR metrics but have occasionally been used to estimate LAC when direct measurements are missing, and are potentially important in several ancillary data uses ([A](#), [B](#), [E](#), [F](#), [K](#), [O](#)). Given continuing uncertainties in understanding the light adsorption (and other radiative properties) of carbonaceous (and crustal) aerosols; the importance of black (and brown) carbon to global radiation budgets and to human health effects; the relatively low cost of  $F_{abs}$  measurements; pending ability to add absorption measures at multiple wavelengths; and potential extension of similar measurements to other PM networks: eliminating  $F_{abs}$  measurements is not likely to be an efficient way to reduce costs. In addition,  $F_{abs}$  has proven

to be a stable measurement for long term trends and retrospective filter analysis. This makes the Fabs data a valuable resource for evaluating and checking trends in the elemental carbon measurements.

**XRF measurements of elements other than S and soil species** are not used in RHR metrics, but are important in several ancillary data uses ([A](#), [B](#), [C](#), [E](#), [I](#), [L](#), [P](#)). Elements like Se, As, Ni, V, K, Sr, Mn, Pb, and Zn provide useful “tracer” information on influence from specific source types and critical input for use in multivariate receptor modeling analyses ([I](#)). The incremental cost of quantifying these additional XRF elements is relatively small in proportion to the relatively large amount of useful information they provide.

**Eliminating “minor” species used in RHR metrics** might be a way to reduce costs with relatively minimal effects on implementation of the RHR (but requires revisions to the RHR Rule or associated EPA guidance).

**Fine soil (Al, Ca, Fe, Si, Ti), sea salt (Cl<sup>-</sup>, Cl), and coarse mass (PM<sub>10</sub>, PM<sub>2.5</sub>)** are all important contributors to RHR reconstructed light extinction in some regions and seasons. However, given their tendency to be emitted at high wind speeds (not conducive to secondary aerosol formation or buildup of anthropogenic pollutants) from locations (ocean surfaces and arid lands) where other emissions are often sparse, they typically tend to be relatively less important on the haziest days at a majority of sites. They all have a relatively large natural components to their emissions, and with some exceptions are not likely to be subject to effective control strategies during implementation of the RHR. Elimination of measurements associated with these components may alter the RHR metrics at some sites, but have relatively little influence on strategies developed to implement the RHR goals. However, Cl<sup>-</sup> and Cl are measured with other ions and elements respectively and the additional cost for these data are minimal. Both the fine soil and coarse mass have been increasing in the last 10 years. The cause of this increase is not known, but could be due to human activity such as increased building in arid regions. These increasing trends make these potentially important constituents to track.

Measurements of fine soil and sea salt elements and ions have also been quite valuable in a variety of ancillary data analyses ([B](#), [C](#), [D](#), [E](#), [F](#), [H](#), [I](#), [J](#), [L](#), [M](#)) and incur relatively small incremental costs. They are especially useful in identifying and quantifying transboundary and intercontinental transport influences, and in distinguishing between, and understanding complex interactions among, natural and anthropogenic sources. Soil and sea salt are also important components of the global aerosol, and are likely to be sensitive to, and good future indicators of influences of climate change on “natural” emissions. In addition, fine soil concentrations have increased in the last 10 years, making it an important constituent of fine mass to continue to track. Much useful information would be lost and little cost savings gained by eliminating these measurements.

**Coarse mass** is occasionally a major component of reconstructed light extinction at some sites, particularly in the central and southwestern US. Like sea salt and fine soil, the relative importance in implementing the RHR is likely to be less than other measured species at most sites, given that coarse mass (often composed of soil and to a lesser extent of sea salt at coastal sites) can have a substantial natural component, and is often highest when other anthropogenic components are lowest. The fact that coarse mass requires two measurements (with PM<sub>2.5</sub> being more precise than PM<sub>10</sub>) makes it generally less precise than other species, and also increases the probability of missing data. Arguably, the regional representativeness of coarse mass data is also lower than for fine particle species, due to shorter transport distances and greater influence from nearby emissions. The light extinction contributions from coarse mass are less certain and less verifiable than those from fine fraction species, as the speciation is unknown and common optical measurements of light scattering (nephelometer) and absorption (Aethalometer) are less responsive to coarse particle effects. While the PM<sub>10</sub> Teflon filters are potentially available for elemental (or other) analysis (yielding partial coarse composition, by

subtraction), such analyses have rarely been conducted. For these reasons, the coarse mass data have been employed in relatively few ancillary data applications, and these ancillary data uses would likely not be severely compromised if the coarse mass data (PM<sub>10</sub> sampling) were discontinued.

### **Eliminating Module A**

If coarse mass (PM<sub>10</sub>) sampling and analysis were eliminated at some sites, the fine mass measurements from Module A would no longer be needed for RHR calculations of coarse mass. Fine soil is the only other RHR data uniquely provided by Module A, and is not likely to be an important contributor to extinction at sites where coarse mass is unimportant. Completely eliminating Module A sampling and analysis (at some or all sites where Module D was eliminated) could result in large cost savings.

However, as indicated above, losing all the trace metals and soil elements would be disruptive to most of the valuable ancillary data uses. Losing S removes a valuable routine QA check on, and occasional substitute for (missing) SO<sub>4</sub>. Losing fine mass removes a valuable QA check on all other measurements and cuts an important link to all other PM<sub>2.5</sub> mass and speciation sampling programs. Losing F<sub>abs</sub> removes an important QA check on EC, and an independent estimate of aerosol b<sub>abs</sub> which has proved to be quite stable and repeatable over time, which is readily transferable at low cost to other PM<sub>2.5</sub> mass sampling networks, and which will likely prove more useful in the future, pending planned transition to multi-wavelength HIPS. Recent reanalysis of archived Module A filters with the most recent XRF techniques is providing a clear picture of effects of methods changes over time, enhancing the quality of trends analysis in ways that are not possible for other modules and other networks. This reanalysis also demonstrates the important feature that Module A (and D) filters are the only IMPROVE samples which are analyzed by non-destructive methods (and which have not generally shown measured species losses over time) and are fully archived for potential future analyses.

It can also be noted that while there's a certain "logic" for dropping Module A measurements at sites where Module D is dropped, that approach also tends to assure that the valuable PM<sub>2.5</sub> mass, trace element and b<sub>abs</sub> data would be preferentially lost from the more polluted eastern sites (where coarse mass and fine soil are the least important contributors to light extinction). Overall, dropping Module A is likely the least desirable cost-cutting option, in terms of its effects on non-RHR ancillary uses of the data.

### **Reduction in sites**

Eliminating sites would reduce operating and maintenance costs (currently covered by the FLM agencies), as well as shipping, site-specific QA and analytical costs (currently supported by EPA). The relationship with analytical costs is not linear, and it would require a roughly 25% reduction in sites to incur a 15% reduction in analytical costs. Inter-site correlations have been considered in the past as a possible mechanism for removing sites with minimal effects on the RHR implementation. While most ancillary data uses would be proportionally diminished by removing sites, relatively few of these ancillary uses are uniquely sensitive to site reductions in general (compared to other cost-cutting options such as reducing sample frequency). The ability to accurately depict spatial patterns (E) would be affected, and some mathematical receptor models (I), driven by spatial inter-correlations, would be more limited. Several other data uses would be especially sensitive to exactly which sites were eliminated. For example, it would be least desirable to lose sites: collocated with or which pair well with sites in other networks (C), collocated with optical measurements (E, K), with long-term data records (E), in sparsely-covered or strong-spatial-gradient regions (E, H, J, K, M, N), near Canadian or Mexican borders, West coast and Southeast coast (L), or near to large existing (or anticipated new) sources (Q).

## Reduction in sample frequency

Reducing sample frequency would reduce analytical costs at a similar, non-linear “per-sample” rate as eliminating sites, but would be less efficient at reducing operating, maintenance, shipping and site-specific QA costs. Reducing sampling frequency from the current 1-in-3 day basis to 1-in-4, 1-in-5, or 1-in-6 day frequency would reduce the number of samples analyzed by 25%, 40% and 50%, respectively. A variation on this might be to put subsets of sites on a reduced sampling frequency (or analytical frequency). For example, maintaining the 1-in-3 day frequency at some sites but going to 1-in-6 day frequency at 1/5, 1/4, 1/3, or 1/2 of sites would reduce total samples by 10%, 12.5%, 17.5% or 25% respectively. Running half the sites on a 1-in-3 basis and half on 1-in-4 day, would reduce total samples by 12.5%. There would then be 30 "common" days a year when all sites would be running (compared to 122 days in the current 1-in-3 day mode), but there would also be 61 "new days" captured where the 1-in-4 samplers were running but the 1-in-3 were not, and half the samplers would be running somewhere on 183 days (half the year - compared to the third of a year currently captured).

Most ancillary data uses would be proportionately compromised by a reduced sample frequency. Comparisons, synthesis (or determining the “urban excess”) with the predominantly 1-in-3-day CSN and PM<sub>2.5</sub> FRM and (predominantly 1-in-6 day) PM<sub>10</sub> networks (D) could be severely limited by changes in sample frequency, although this disruption would be minimized by 1-in-6 day sampling at some or all IMPROVE sites. Reduced sample frequency adds uncertainty to analysis of long-term trends (E), and would be especially disruptive to evaluation of seasonal or monthly trends. Receptor modeling (I) analyses of single-site data by models like PMF and Unmix requires large sample sizes and would be less effective with reduced sample frequency. The ability to detect and analyze natural or anthropogenic pollution episodes (J) would also be jeopardized.

Use of the data for model performance evaluation and refinement (H), inverse modeling (N), or for synthesis with remote sensing data (M) would be similarly limited by either reductions in sites or sample frequency, but reduced frequency would likely be more disruptive considering that inter-site correlations are generally much stronger than serial correlations between adjacent sample dates at individual sites even at the current 1-in-3 day frequency.

## Increasing Sites

Just as reducing sites or samples yields a non-linear (lower) proportionate reduction in costs, new sites can be added at lower incremental costs per site, lowering average site costs network-wide. Per-site analytical costs for the EPA Chemical Speciation Network (CSN) are significantly higher than for IMPROVE. Total CSN costs and per-site IMPROVE costs could be decreased if some of the CSN sites were switched to the IMPROVE program. Issues that would need to be resolved include: sample shipping procedures (ice currently required for CSN), sample turn-around time (currently required to be faster for CSN than for IMPROVE), cation measurements (NH<sub>4</sub><sup>+</sup>, Na<sup>+</sup>, K<sup>+</sup> - currently conducted in CSN but not IMPROVE) and carbon blank correction methods.

Cation analysis could presumably be added to routine IMPROVE laboratory analyses for CSN filters at modest incremental cost, although it would also require different filter extraction procedures than used for IMPROVE. Assuming those differences could be resolved, It might be an interesting option to consider for selected IMPROVE sites. The NH<sub>4</sub><sup>+</sup> data would provide an imperfect, but occasionally quite useful indicator of aerosol acidity, and the NA<sup>+</sup> and K<sup>+</sup> data would provide helpful indicators of sea salt and wood smoke, and potentially useful QA checks for comparing to the elemental Na and K measurements and for anion/cation comparisons. Cation data would also allow more refined calculations of organic matter (on the Teflon filters) using the

SANDWICH method and could provide a useful QA check for IMPROVE OC. Such SANDWICH calculations of organic matter are currently being made for both IMPROVE and CSN data, for use in EPA's Modeled Attainment Test Software (MATS), and could be especially useful routine calculations for IMPROVE, given the recent discontinuation of PESA analysis and associated OMH calculations.

None of the ancillary IMPROVE data uses are critically dependent on the sample turn-around time, and arguably now that a substantial record of CSN data exists (and now that EPA has decided not to employ the CSN data to determine compliance with a secondary PM standard), high-speed data are less critical for CSN sites. Several ancillary data uses could be slightly strengthened if exactly the same methods and laboratories were employed for CSN and IMPROVE ([A](#), [B](#), [C](#), [D](#), [E](#), [H](#), [M](#), [O](#), [P](#)).

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