

ANNUAL REPORT
AEROSOL COLLECTION AND COMPOSITIONAL
ANALYSIS FOR IMPROVE
University of California, Davis
NPS Contract C2350990001
JANUARY-DECEMBER 2002

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1. Introduction

In the 1977 amendments to the Clean Air Act, Congress established mandatory Class I visibility areas where visibility must be protected from existing and future manmade air pollution. The responsibility of protecting the air quality at these areas was given to the Federal Land Managers: the National Park Service (NPS), the Forest Service (USFS), the Fish and Wildlife Service (FWS), and the Bureau of Land Management (BLM). These Class I areas include national parks and national wilderness areas larger than around 20 square kilometers.

The NPS visibility monitoring program has been measuring particulate concentrations since 1982. In 1987, this program was expanded to include all Federal Land Managers and given the name Interagency Monitoring of Protected Visual Environments (IMPROVE). The operation of the network is performed by contractors to the NPS.

The basic goal of the visibility monitoring program is to protect the visibility at Class I areas. The objectives of the particulate component of the visibility monitoring program.

- Establish baseline data and trends of fine particulate concentrations.
- Determine the relationship between visibility impairment and various atmospheric particulate constituents.
- Determine the existing sources of particles producing visibility impairment.
- Determine the sensitivity of visibility impairment at individual sites to varying concentrations of particles.

In order to accomplish these objectives, the NPS/IMPROVE program took multiple approaches.

- For baseline data and trends, the program maintains continuous nationwide monitoring of particles.
- To understand the relationship between visibility impairment and particulate behavior, the program has conducted studies of the effects of humidity and acidity.
- To collect the data needed to examine possible sources in a region, the program has conducted regional intensive studies at IMPROVE sites throughout the country.

The Air Quality Group of Crocker Nuclear Laboratory, University of California, Davis (UC Davis), presents this report for the operation of the particulate component of the NPS/IMPROVE visibility monitoring program for the calendar year 2002.

We have separated the work into six tasks. Each task includes quality assurance/quality control procedures. The tasks are:

A. Field Operations

1. Train site operators
2. Monitor sampler flow rates and participate in third party audits
3. Perform annual sampler maintenance
4. Perform mail audits of flow rate
5. Correct sampler malfunctions
6. Conduct tests at the Davis Field Station
7. Maintain quality assurance documentation

B. Network Operations

1. Maintain computerized sample handling system
2. Maintain field operations database
3. Sample handling - before collection
4. Transport and postage
5. Sample changing at the site
6. Coordinate with site operators
7. Sample handling - after collection
8. Maintain quality assurance documentation

C. UC Davis Analysis of Teflon Filters

1. Perform gravimetric analysis
2. Perform optical absorption analysis
3. Perform elemental analysis
 - Perform PIXE (Particle Induced X-ray Emission) analysis: Na to Mn
 - Perform PESA (Proton Elastic Scattering Analysis) analysis: H
 - Perform XRF (X-ray Fluorescence) analysis: Fe to Pb
4. Maintain quality assurance documentation

D. Coordination with Cooperating Contractors

1. Transfer filters to the external contractors
2. Receive results from external contractors
3. Oversee the quality assurance procedures of the contractors

E. Data Processing and Database Management

1. Enter collection parameters from field log sheets
2. Calculate artifacts and precision of artifacts
3. Calculate concentrations and precision of concentrations
4. Include concentrations and precisions in database
5. Prepare seasonal summaries
6. Maintain primary database
7. Transfer data to other agencies
8. Maintain quality assurance documentation

F. Data Validation

1. Level I Validation
 - Validate collection parameters
 - Validate results of analyses
2. Level II Validation
 - Intercompare variables (scatter plots)
 - Examine time plots for sites and maps for network
3. Maintain quality assurance documentation

UC Davis operated 160 monitoring sites as of the end of 2002. Of these 160 sites, 110 were IMPROVE program sites. The remaining 50 sites were IMPROVE Protocol sites, operated by Federal, state, and tribal agencies using IMPROVE sampling protocols. Of these 50 sites, two were quality assurance sites collocated with samplers of the EPA's Speciation Trends Network (STN) at urban locations in Phoenix and Seattle, and one was a special site at Mauna Loa,

Hawaii. The Mauna Loa site is not, strictly speaking, an IMPROVE Protocol site because it does not have all of the standard IMPROVE sampling equipment and it operates on a modified schedule. The IMPROVE and IMPROVE Protocol sites are listed in Table 1 and Table 2 (along with the funding agency for each) and are shown on the map in Figure 1.

Table 1. IMPROVE Sites, CY 2002**National Park Service**

ACAD	Acadia, ME
BADL	Badlands, SD
BAND	Bandelier, NM
BIBE	Big Bend, TX
BRCA	Bryce Canyon, UT
CANY	Canyonlands, UT
CAPI	Capitol Reef, UT
CHIR	Chiricahua, AZ
CRLA	Crater Lake, OR
CRMO	Craters of the Moon, ID
DENA	Denali, AK
EVER	Everglades, FL
GLAC	Glacier, MT
GRSA	Great Sand Dunes, CO
GRSM	Great Smoky Mtns., TN
GUMO	Guadalupe Mtns., TX
HALE	Haleakala, HI
HANC	Hance (Grand Canyon), AZ
HAVO	Hawaii Volcanoes, HI
ISLE	Isle Royale, MI
JOSH	Joshua Tree, CA
LABE	Lava Beds, CA
LAVO	Lassen Volcanic, CA
MACA	Mammoth Cave, KY
MEVE	Mesa Verde, CO
MORA	Mount Rainier, WA
NOCA	North Cascades, WA
OLYM	Olympic, WA
PEFO	Petrified Forest, AZ
PINN	Pinnacles, CA
PORE	Point Reyes, CA
REDW	Redwood, CA
ROMO	Rocky Mountain, CO
SAGU	Saguaro, AZ
SEQU	Sequoia, CA
SHEN	Shenandoah, VA
THRO	Theodore Roosevelt, ND
VIIS	Virgin Islands, USVI
VOYA	Voyageurs, MN
WICA	Wind Cave, SD
YELL	Yellowstone, WY
YOSE	Yosemite, CA
ZION	Zion, UT

Forest Service

AGTI	Agua Tibia, CA
BALD	Mount Baldy, AZ
BLIS	Bliss, CA
BOWA	Boundary Waters, MN
BRID	Bridger, WY
CABI	Cabinet Mountains, MT
CACR	Caney Creek, AR
COHU	Cohutta, GA
DOME	Dome Land, CA
DOSO	Dolly Sods, WV
GAMO	Gates of the Mtns., MT

GICL	Gila, NM
GRGU	Great Gulf, NH
HECA	Hells Canyon, ID
HEGL	Hercules-Glades, MO
HOOV	Hoover, CA
IKBA	Ike's Backbone, AZ
JARB	Jarbridge, NV
JARI	James River Face, VA
KAIS	Kaiser, CA
KALM	Kalmiopsis, OR
LIGO	Linville Gorge, NC
LYBR	Lye Brook, VT
MOHO	Mount Hood, OR
MONT	Monture, MT
MOZI	Mount Zirkel, CO
NOAB	North Absaroka, WY
PASA	Pasayten, WA
RAFA	San Rafael, CA
SAGA	San Gabriel, CA
SAGO	San Geronio, CA
SAPE	San Pedro Parks, NM
SAWT	Sawtooth, ID
SHRO	Shining Rock, NC
SIAN	Sierra Ancha, AZ
SIPS	Sipsey, AL
SNPA	Snoqualmie Pass, WA
STAR	Starkey, OR
SULA	Sula, MT
SYCA	Sycamore Canyon, AZ
THSI	Three Sisters, OR
TONT	Tonto, AZ
TRIN	Trinity, CA
UPBU	Upper Buffalo, AR
WEMI	Weminuche, CO
WHIT	White Mountain, NM
WHPA	White Pass, WA
WHPE	Wheeler Peak, NM
WHRI	White River, CO

Fish and Wildlife Service

BOAP	Bosque del Apache, NM
BRET	Breton, LA
BRIG	Brigantine, NJ
CHAS	Chassahowitzka, FL
LOST	Lostwood, ND
MELA	Medicine Lake, MT
MING	Mingo, MO
MOOS	Moosehorn, ME
OKEF	Okefenokee, GA
ROMA	Cape Romain, SC
SACR	Salt Creek, NM
SAMA	Saint Marks, FL
SENE	Seney, MI
SIME	Simeonof, AK
SWAN	Swanquarter, NC
TUXE	Tuxedni, AK
ULBE	UL Bend, MT
WIMO	Wichita Mtns., OK

Table 2. IMPROVE Protocol Sites, CY 2002

National Park Service

DEVA Death Valley, CA
 GRBA Great Basin, NV
 INGA Indian Gardens, AZ
 MALO Mauna Loa, HI
 TRCR Trapper Creek, AK
 WASH Washington, DC

Forest Service

BRLA Brooklyn Lakes, WY
 COGO Columbia Gorge, WA
 CORI Columbia River Gorge, WA

US EPA

AREN Arendtsville, PA
 BOND Bondville, IL
 CADI Cadiz, KY
 COHI Connecticut Hill, NY
 LIVO Livonia, IN
 MKGO MK Goddard, PA
 PHOE Phoenix, AZ
 PUSO Seattle, WA
 QUCI Quaker City, OH
 SIKE Sikes, LA

Tribes

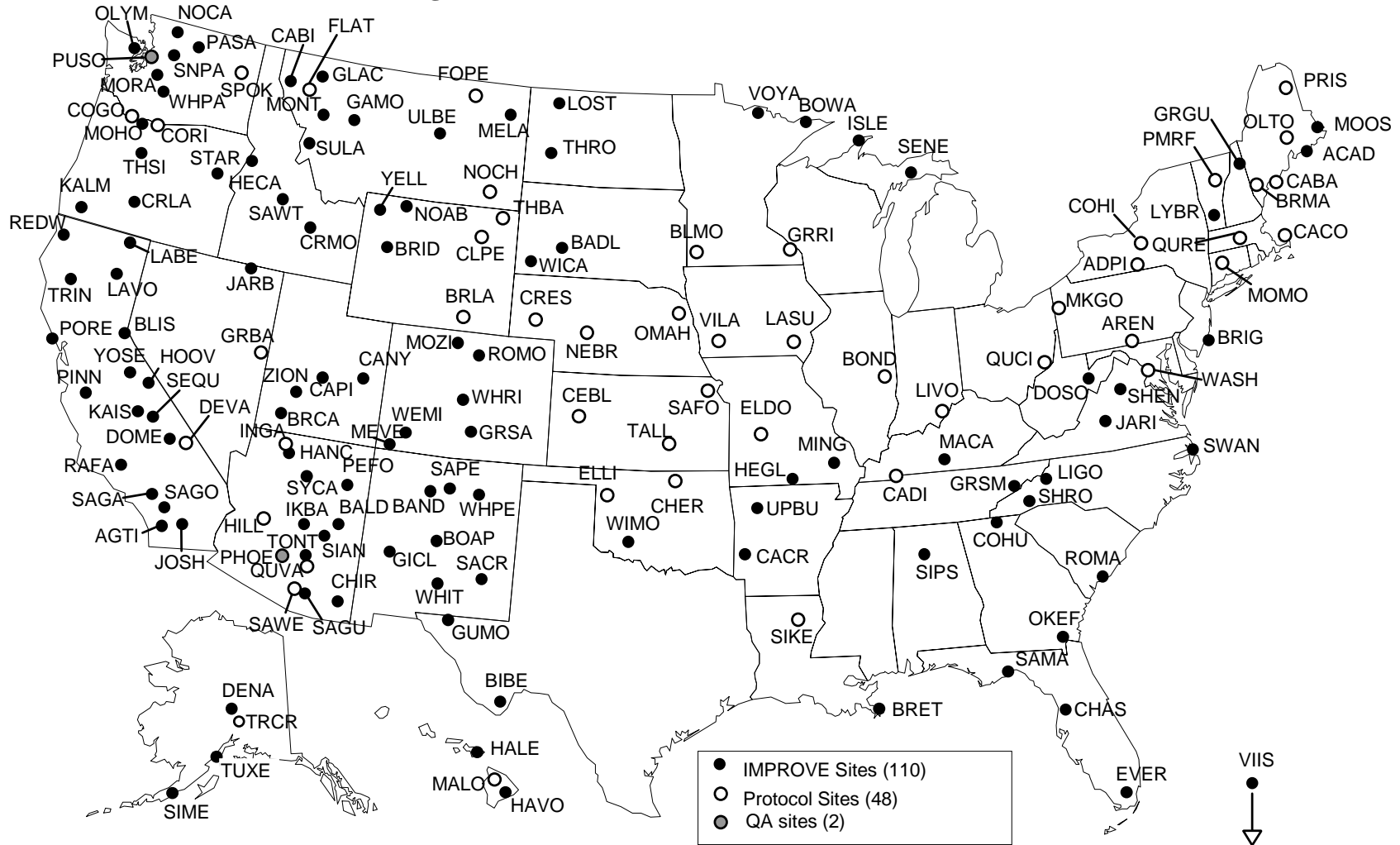
CHER Cherokee, OK
 FLAT Flathead, MT
 FOPE Fort Peck, MT
 NOCH Northern Cheyenne, MT
 OLTO Old Town, ME

OMAH Omaha, NE
 PRIS Presque Isle, ME
 SAFO Sac and Fox, KS
 SPOK Spokane, WA

States

ADPI Addison Pinnacle, NY
 BLMO Blue Mounds, MN
 BRMA Bridgton, ME
 CABA Casco Bay, ME
 CACO Cape Cod, MA
 CEBL Cedar Bluff, KS
 CLPE Cloud Peak, WY
 CRES Crescent Lake, NE
 ELDO El Dorado Springs, MO
 ELLI Ellis, OK
 GRRI Great River Bluffs, MN
 HILL Hillside, AZ
 LASU Lake Sugema, IA
 MOMO Mohawk Mtn., CT
 NEBR Nebraska Natl. Forest, NE
 PMRF Proctor Research, VT
 QURE Quabbin Reservoir, MA
 QUVA Queen Valley, AZ
 SAWE Saguaro West, AZ
 TALL Tallgrass Prairie, KS
 THBA Thunder Basin, WY
 VILA Viking Lake, IA

Figure 1. IMPROVE Network, CY 2002



2. Network Operations

The performance of the IMPROVE network operations can be judged by the following criteria:

1. Performing accurate and precise measurements of the total volume of air through the filters.

The flow rate is measured once every minute for each filter, and every fifteen minutes the average is recorded on a flash memory card. The primary flow measurement for the PM_{2.5} modules uses the pressure drop across the cyclone; the flow rate is a function of the pressure drop. The primary flow measurement for the PM₁₀ module uses the pressure drop across an orifice behind the filter; the flow rate is a function of the pressure drop. The secondary technique on the PM_{2.5} modules measures the pressure drop across the filter. Having two measurements assures that the cassettes for the PM_{2.5} modules are properly installed. The two gauges are calibrated by a separate orifice meter during annual maintenance, which is calibrated by a reference flow device maintained at Davis. The flow rates are normally audited by the site operator at least once each year between annual visits using an audit orifice meter. The volume of air through the filter is obtained from the mean flow rate times the duration measured by elapsed time meters.

2. Maintaining the particle cut point (50 percent aerodynamic diameter) near the designated value: 2.5 μm for Modules A, B, and C and 10 μm for Module D.

The PM_{2.5} cut point depends on the volume flow rate at the cyclone. The flow rate is controlled by an orifice between the filter and the pump. The performance of Modules A, B, and C for each site in the IMPROVE network during the period of January to December 2002 is shown in Table 3, Table 4, and Table 5, and in Figure 2, Figure 3, and Figure 4. The tables give the mean and standard deviation of the average flow rates for the sampling period. Also shown is the standard deviation expressed as a percentage of the mean. The final column gives the 50 percent aerodynamic diameter (and standard deviation) for 2.5 μm separation, based on laboratory measurements of the IMPROVE cyclone. This includes the annual variation associated with change in temperature. In some cases, a large standard deviation was produced by a change in nominal flow rate with a change in orifices during annual maintenance. For the entire IMPROVE network, the mean flow rate is shown as the last line in each table. Note that the order of sites is not the same in each of the figures.

The PM₁₀ cut point depends on the flow rate through the PM₁₀ inlet. Two different inlets are used in the IMPROVE network. The Sierra-Anderson inlet is used at most sites and operates at 16.7 lpm. The Wedding inlet is used at 27 sites and operates at 19 lpm. There is no established relationship between the flow rate and the cut point for the PM₁₀ inlets, so Figure 5 shows only the flow rate information for each site in the IMPROVE network during the period of January to December 2002.

3. Retaining a high fraction of the possible samples in the final database. The performance of the IMPROVE network during 2002 is shown in the Table 7. The

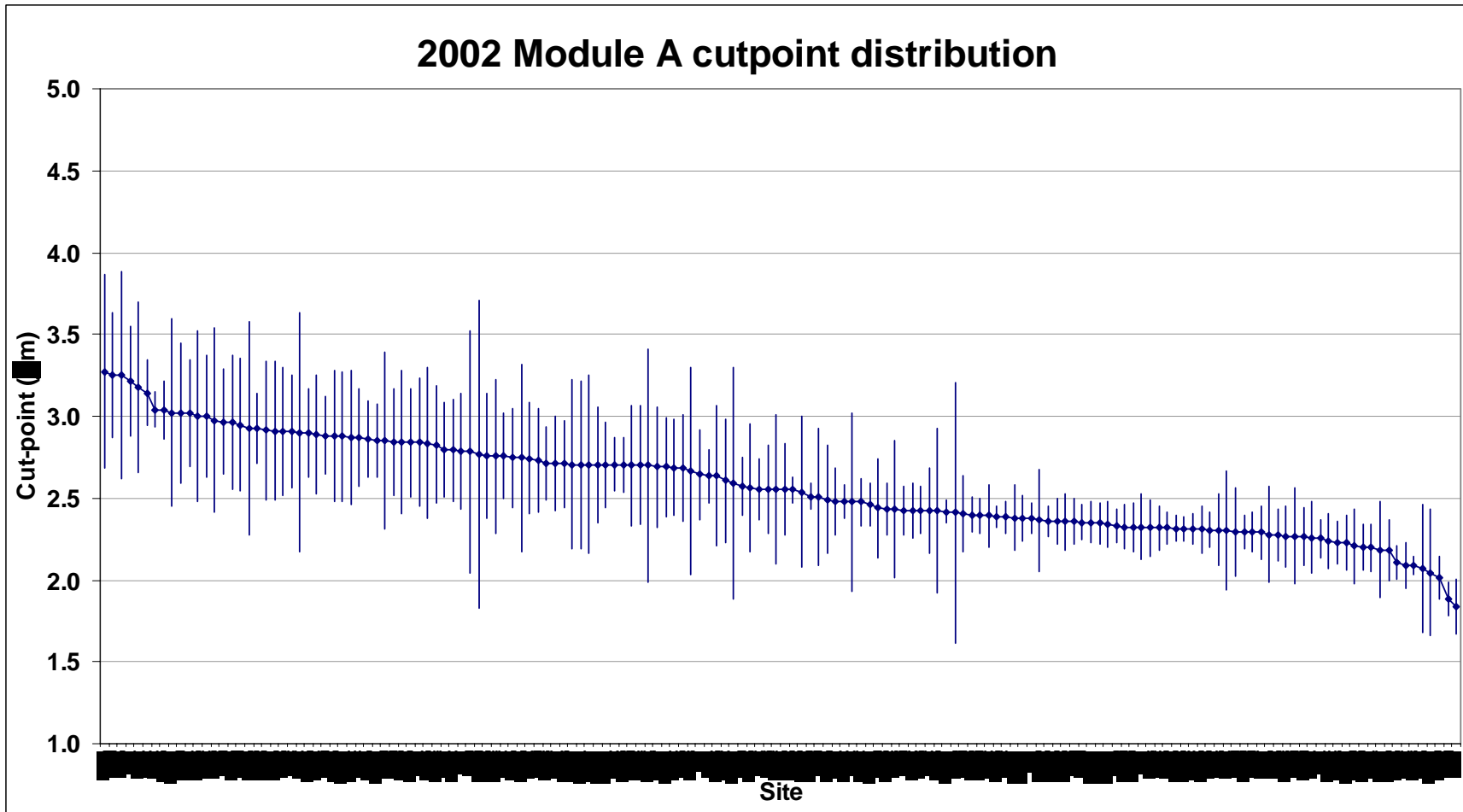
percentages in Table 7 represent sample periods for which valid A-Channel samples were returned (PM_{2.5} Teflon). The percentage of sample periods for which all four channels yielded valid data is typically slightly lower. The overall A-Channel recovery rate of the year was 94%, and the overall recovery for all channels (ABCD) was 91%. The Mauna Loa site is not included in these statistics because it operates on a non-standard schedule.

The two largest factors in sample loss were (1) the inability of the operator to change the sample during the designated 3-day period, and (2) power outages and surges, generally associated with thunderstorms. In some cases, the power surges required that the controllers be replaced.

Table 3. Flow rate and cut point for Teflon filter module

Site	Teflon Flow Rate	SD%	Cut-point	Site	Teflon Flow Rate	SD%	Cut-point
ACAD1	23.3 ± 0.2	1%	2.5 ± 0.2	GLAC1	22.7 ± 1.3	6%	2.6 ± 0.5
ADPI1	23.1 ± 0.7	3%	2.7 ± 0.4	GRBA1	21.7 ± 1.2	5%	2.9 ± 0.4
AGTI1	23.0 ± 0.4	2%	2.7 ± 0.3	GRGU1	23.4 ± 0.3	1%	2.3 ± 0.1
AREN1	23.5 ± 0.5	2%	2.4 ± 0.3	GRI1	23.0 ± 0.9	4%	2.4 ± 0.3
BADL1	21.3 ± 0.9	4%	3.0 ± 0.3	GRSA1	21.7 ± 0.8	4%	2.9 ± 0.3
BALD1	21.8 ± 1.3	6%	2.8 ± 0.2	GRSM1	23.2 ± 0.4	2%	2.4 ± 0.1
BAND1	21.8 ± 1.0	4%	2.9 ± 0.2	GUMO1	24.1 ± 1.1	5%	2.0 ± 0.4
BIBE1	23.0 ± 0.8	3%	2.5 ± 0.5	HALE1	22.2 ± 0.5	2%	2.7 ± 0.2
BLIS1	21.6 ± 1.0	5%	2.8 ± 0.2	HANC1	22.1 ± 1.4	6%	2.8 ± 0.5
BLMO1	23.2 ± 0.9	4%	2.7 ± 0.2	HAVO1	21.6 ± 0.6	3%	2.9 ± 0.2
BOAP1	21.7 ± 1.2	5%	2.2 ± 0.2	HECA1	21.8 ± 1.3	6%	2.8 ± 0.5
BOND1	23.7 ± 0.5	2%	2.7 ± 0.3	HEGL1	23.7 ± 0.4	2%	2.2 ± 0.1
BOWA1	22.2 ± 1.0	5%	2.6 ± 0.2	HILL1	20.7 ± 1.0	5%	3.2 ± 0.3
BRCA1	22.4 ± 1.2	6%	2.5 ± 0.1	HOOV1	21.6 ± 1.2	6%	2.9 ± 0.4
BRET1	22.9 ± 0.6	3%	2.8 ± 0.3	IKBA1	21.6 ± 1.1	5%	2.9 ± 0.4
BRID1	22.3 ± 0.9	4%	2.6 ± 0.2	INGA1	20.6 ± 1.8	9%	3.3 ± 0.6
BRIG1	22.6 ± 0.8	3%	2.9 ± 0.2	ISLE1	22.0 ± 1.0	5%	2.8 ± 0.4
BRLA1	21.6 ± 1.2	6%	2.0 ± 0.2	JARB1	22.2 ± 1.1	5%	2.7 ± 0.4
BRMA1	23.3 ± 0.4	2%	2.3 ± 0.1	JARI1	23.2 ± 0.4	2%	2.4 ± 0.1
CABA1	23.1 ± 0.2	1%	3.1 ± 0.4	JOSH1	21.3 ± 1.2	6%	3.0 ± 0.4
CABI1	20.6 ± 1.1	5%	2.4 ± 0.3	KAIS1	21.7 ± 0.9	4%	2.9 ± 0.3
CACO1	23.2 ± 0.4	2%	2.3 ± 0.3	KALM1	22.0 ± 2.7	12%	2.8 ± 0.9
CACR1	23.5 ± 0.5	2%	2.5 ± 0.3	LABE1	21.6 ± 2.1	10%	2.9 ± 0.7
CADI1	23.2 ± 0.3	1%	2.8 ± 0.3	LASU1	24.2 ± 0.4	2%	2.0 ± 0.1
CANY1	22.3 ± 1.1	5%	2.7 ± 0.2	LAVO1	23.1 ± 2.3	10%	2.4 ± 0.8
CAP1	21.5 ± 1.2	6%	2.3 ± 0.2	LIGO1	23.3 ± 0.3	1%	2.3 ± 0.1
CEBL1	21.2 ± 0.3	1%	2.4 ± 0.5	LIVO1	23.5 ± 0.3	1%	2.3 ± 0.1
CHAS1	23.6 ± 0.5	2%	2.5 ± 0.6	LOST1	23.3 ± 0.5	2%	2.3 ± 0.2
CHER1	24.0 ± 0.2	1%	2.3 ± 0.2	LYBR1	22.2 ± 0.8	4%	2.7 ± 0.3
CHIR1	23.0 ± 1.2	5%	2.3 ± 0.1	MACA1	23.0 ± 0.2	1%	2.4 ± 0.1
CLPE1	23.5 ± 0.6	3%	2.7 ± 0.3	MALO1	22.2 ± 0.5	2%	2.7 ± 0.2
COGO1	23.0 ± 0.4	2%	2.6 ± 0.3	MALO2	21.2 ± 0.5	2%	3.0 ± 0.2
COHI1	23.5 ± 0.9	4%	2.7 ± 0.4	MELA1	21.7 ± 0.7	3%	2.9 ± 0.2
COHU1	23.3 ± 0.4	2%	2.6 ± 0.3	MEVE1	21.4 ± 1.1	5%	3.0 ± 0.4
CORI1	23.4 ± 0.8	3%	2.7 ± 0.5	MING1	23.0 ± 0.4	2%	2.4 ± 0.1
CRES1	23.3 ± 0.3	1%	2.7 ± 0.5	MKGO1	23.2 ± 0.4	2%	2.4 ± 0.1
CRLA1	21.6 ± 1.9	9%	2.3 ± 0.1	MOHO1	23.2 ± 0.6	2%	2.4 ± 0.2
CRMO1	22.2 ± 1.5	7%	2.2 ± 0.0	MOMO1	22.6 ± 0.5	2%	2.6 ± 0.2
DENA1	21.4 ± 1.5	7%	2.9 ± 0.3	MONT1	22.2 ± 1.6	7%	2.7 ± 0.5
DEVA1	23.4 ± 0.8	4%	2.8 ± 0.2	MOOS1	23.3 ± 0.4	2%	2.3 ± 0.1
DOME1	22.2 ± 2.1	9%	2.9 ± 0.4	MORA1	22.2 ± 0.8	3%	2.7 ± 0.3
DOSO1	23.3 ± 0.2	1%	2.9 ± 0.3	MOZI1	21.7 ± 0.7	3%	2.9 ± 0.2
ELDO1	23.3 ± 0.3	1%	2.2 ± 0.1	NEBR1	23.6 ± 0.4	2%	2.2 ± 0.1
ELLI1	23.2 ± 0.3	1%	2.9 ± 0.2	NOAB1	21.9 ± 1.0	5%	2.8 ± 0.4
EVER1	23.4 ± 0.6	3%	2.4 ± 0.2	NOCA1	22.8 ± 1.0	4%	2.5 ± 0.3
FLAT1	24.7 ± 0.5	2%	2.8 ± 0.6	NOCH1	23.3 ± 0.4	2%	2.3 ± 0.1
FOPE1	24.0 ± 0.4	2%	2.6 ± 0.1	OKEF1	23.4 ± 0.5	2%	2.3 ± 0.2
GAMO1	21.8 ± 0.7	3%	2.3 ± 0.5	OLTO1	23.4 ± 0.3	1%	2.3 ± 0.1
GICL1	21.8 ± 1.1	5%	2.6 ± 0.3	OLYM1	22.2 ± 1.1	5%	2.7 ± 0.4

<u>Site</u>	<u>Teflon Flow Rate</u>	<u>SD%</u>	<u>Cut-point</u>	<u>Site</u>	<u>Teflon Flow Rate</u>	<u>SD%</u>	<u>Cut-point</u>
PASA1	22.1 ± 1.7	8%	2.7 ± 0.6	SNPA1	22.6 ± 1.1	5%	2.6 ± 0.4
PEFO1	21.4 ± 1.6	8%	3.0 ± 0.6	SPOK1	22.9 ± 0.4	2%	2.5 ± 0.1
PHOE1	22.5 ± 1.1	5%	2.6 ± 0.4	STAR1	22.3 ± 1.8	8%	2.7 ± 0.6
PINN1	24.6 ± 0.3	1%	1.9 ± 0.1	SULA1	22.1 ± 0.9	4%	2.7 ± 0.3
PMRF1	23.7 ± 0.8	4%	2.2 ± 0.3	SWAN1	23.6 ± 0.5	2%	2.2 ± 0.2
PORE1	22.3 ± 0.8	4%	2.7 ± 0.3	SYCA1	20.6 ± 1.7	8%	3.3 ± 0.6
PRIS1	23.3 ± 0.4	2%	2.3 ± 0.1	TALL1	22.4 ± 0.5	2%	2.6 ± 0.2
PUSO1	23.4 ± 0.4	2%	2.3 ± 0.1	THBA1	23.9 ± 0.3	1%	2.1 ± 0.1
QUCI1	23.4 ± 0.4	2%	2.3 ± 0.1	THRO1	22.7 ± 0.8	4%	2.6 ± 0.3
QURE1	23.0 ± 0.5	2%	2.4 ± 0.2	THS11	22.8 ± 1.2	5%	2.5 ± 0.4
QUVA1	23.0 ± 1.5	6%	2.4 ± 0.5	TONT1	20.8 ± 1.5	7%	3.2 ± 0.5
RAFA1	21.5 ± 1.2	6%	3.0 ± 0.4	TRCR1	22.2 ± 0.6	3%	2.7 ± 0.2
REDW1	22.7 ± 1.3	6%	2.5 ± 0.5	TRIN1	22.0 ± 2.1	10%	2.8 ± 0.7
ROMA1	22.5 ± 2.1	9%	2.6 ± 0.7	TUXE1	22.1 ± 0.8	3%	2.8 ± 0.3
ROMO2	21.7 ± 1.2	5%	2.9 ± 0.4	ULBE1	22.1 ± 1.0	5%	2.7 ± 0.3
SACR1	22.2 ± 0.8	3%	2.7 ± 0.3	UPBU1	23.7 ± 0.4	2%	2.2 ± 0.1
SAFO1	22.7 ± 0.2	1%	2.5 ± 0.1	VIIS1	22.4 ± 0.8	4%	2.6 ± 0.3
SAGA1	22.0 ± 1.1	5%	2.8 ± 0.4	VILA1	23.3 ± 0.6	2%	2.3 ± 0.2
SAGO1	23.2 ± 0.3	1%	2.4 ± 0.1	VOYA1	24.0 ± 1.1	5%	2.1 ± 0.4
SAGU1	22.8 ± 0.2	1%	2.5 ± 0.1	WASH1	21.3 ± 1.7	8%	3.0 ± 0.6
SAMA1	22.9 ± 0.4	2%	2.5 ± 0.1	WEMI1	21.8 ± 1.6	7%	2.9 ± 0.5
SAPE1	21.7 ± 1.1	5%	2.9 ± 0.4	WHIT1	21.9 ± 0.8	4%	2.8 ± 0.3
SAWE1	22.9 ± 0.3	1%	2.5 ± 0.1	WHPA1	22.3 ± 0.9	4%	2.7 ± 0.3
SAWT1	22.2 ± 1.5	7%	2.7 ± 0.5	WHPE1	22.0 ± 0.9	4%	2.8 ± 0.3
SENE1	23.4 ± 1.1	5%	2.3 ± 0.4	WHRI1	21.8 ± 0.9	4%	2.8 ± 0.3
SEQU1	23.7 ± 0.7	3%	2.2 ± 0.2	WICA1	23.5 ± 0.5	2%	2.3 ± 0.2
SHEN1	23.1 ± 0.3	1%	2.4 ± 0.1	WIMO1	23.1 ± 0.3	1%	2.4 ± 0.1
SHRO1	23.2 ± 0.5	2%	2.4 ± 0.2	YELL1	22.9 ± 1.6	7%	2.5 ± 0.5
SIAN1	22.1 ± 0.9	4%	2.7 ± 0.3	YOSE1	23.1 ± 0.5	2%	2.4 ± 0.2
SIKE1	22.6 ± 0.5	2%	2.6 ± 0.2	ZION1	21.4 ± 0.9	4%	3.0 ± 0.3
SIME1	20.9 ± 0.6	3%	3.1 ± 0.2				
SIPS1	23.1 ± 0.3	1%	2.4 ± 0.1	Total	22.6 ± 1.3	6%	2.6 ± 0.4

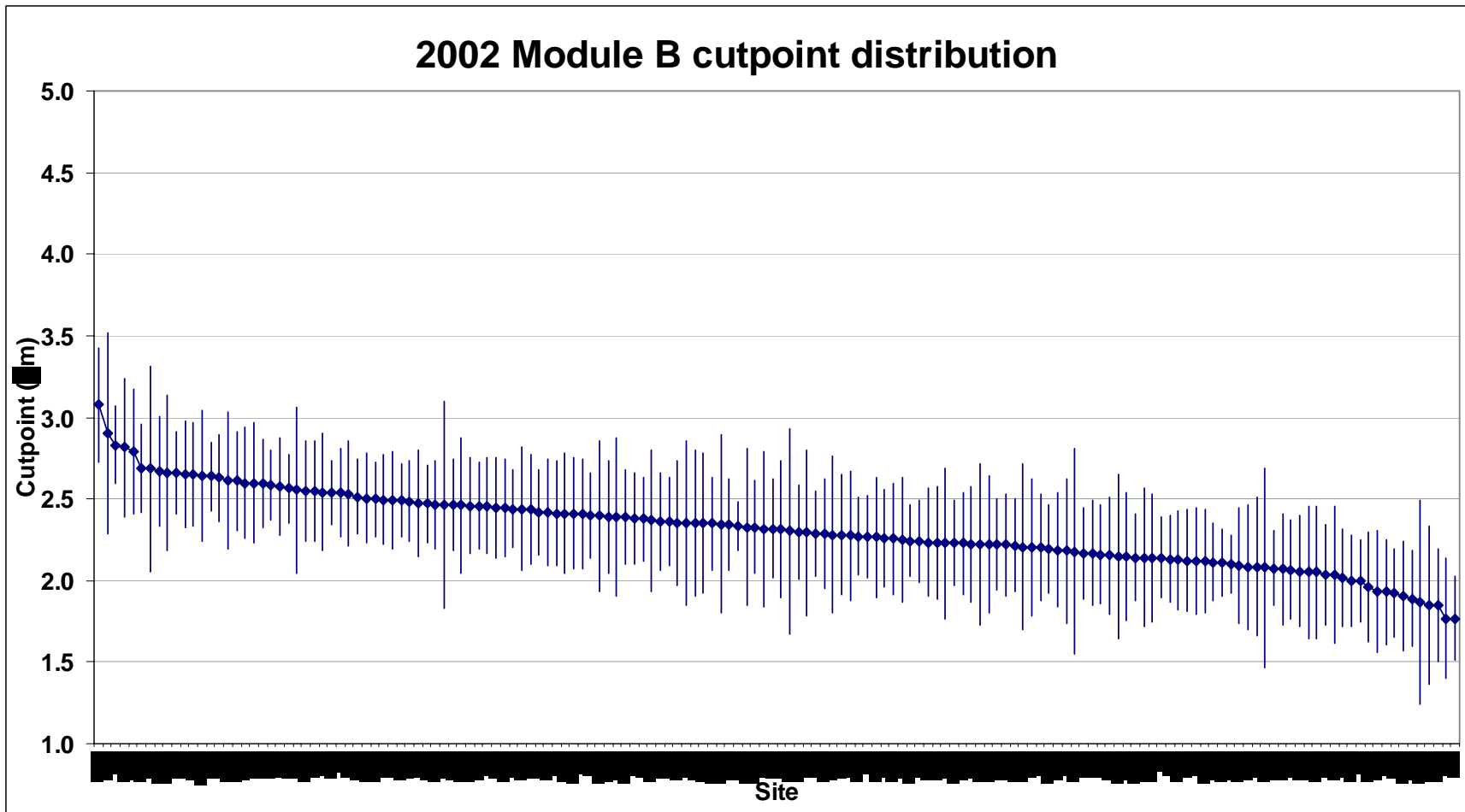


**Figure 2. Average cut point distribution for PM2.5 Teflon filters.
The bar represents one standard deviation.**

Table 4. Flow rate and cutpoint for Nylon filter module

Site	Nylon Flow Rate	SD%	Cut-point	Site	Nylon Flow Rate	SD%	Cut-point
ACAD1	23.0 ± 0.9	4%	2.4 ± 0.3	GLAC1	24.4 ± 1.1	4%	1.9 ± 0.4
ADPI1	22.8 ± 0.9	4%	2.5 ± 0.3	GRBA1	24.1 ± 1.2	5%	2.0 ± 0.4
AGTI1	23.1 ± 0.8	3%	2.4 ± 0.3	GRGU1	22.8 ± 0.7	3%	2.5 ± 0.2
AREN1	24.0 ± 1.1	5%	2.1 ± 0.4	GRR11	23.2 ± 1.5	6%	2.4 ± 0.5
BADL1	23.0 ± 1.1	5%	2.4 ± 0.4	GRSA1	23.2 ± 1.3	5%	2.4 ± 0.4
BALD1	22.5 ± 1.0	4%	2.6 ± 0.3	GRSM1	23.1 ± 0.8	4%	2.4 ± 0.3
BAND1	23.8 ± 1.2	5%	2.1 ± 0.4	GUMO1	23.9 ± 0.9	4%	2.1 ± 0.3
BIBE1	23.9 ± 0.8	3%	2.1 ± 0.3	HALE1	23.2 ± 0.9	4%	2.4 ± 0.3
BLIS1	23.1 ± 0.8	3%	2.4 ± 0.3	HANC1	23.2 ± 1.3	5%	2.4 ± 0.4
BLMO1	23.7 ± 1.8	8%	2.2 ± 0.6	HAVO1	23.4 ± 1.4	6%	2.3 ± 0.5
BOAP1	22.5 ± 0.9	4%	2.6 ± 0.3	HECA1	23.8 ± 1.1	5%	2.1 ± 0.4
BOND1	23.4 ± 0.8	4%	2.3 ± 0.3	HEGL1	22.4 ± 1.0	4%	2.7 ± 0.3
BOWA1	23.1 ± 1.0	4%	2.4 ± 0.3	HILL1	23.5 ± 0.7	3%	2.3 ± 0.3
BRCA1	23.7 ± 1.5	6%	2.2 ± 0.5	HOOV1	23.2 ± 1.3	6%	2.4 ± 0.4
BRET1	23.0 ± 0.8	3%	2.4 ± 0.3	IKBA1	23.5 ± 1.2	5%	2.3 ± 0.4
BRID1	23.2 ± 0.7	3%	2.4 ± 0.3	INGA1	23.4 ± 1.5	6%	2.3 ± 0.5
BRIG1	23.3 ± 1.4	6%	2.3 ± 0.5	ISLE1	24.3 ± 0.7	3%	2.0 ± 0.3
BRLA1	24.2 ± 1.2	5%	2.0 ± 0.4	JARB1	23.6 ± 1.0	4%	2.2 ± 0.3
BRMA1	23.1 ± 1.3	6%	2.4 ± 0.5	JARI1	22.7 ± 1.1	5%	2.5 ± 0.4
CABA1	22.9 ± 0.8	4%	2.5 ± 0.3	JOSH1	23.3 ± 0.8	4%	2.3 ± 0.3
CABI1	22.9 ± 1.0	4%	2.5 ± 0.3	KAIS1	22.7 ± 0.9	4%	2.5 ± 0.3
CACO1	22.8 ± 0.8	3%	2.5 ± 0.3	KALM1	24.7 ± 1.4	6%	1.9 ± 0.5
CACR1	22.9 ± 0.8	3%	2.5 ± 0.3	LABE1	23.0 ± 1.0	4%	2.4 ± 0.3
CADI1	23.0 ± 0.7	3%	2.4 ± 0.2	LASU1	22.8 ± 0.7	3%	2.5 ± 0.2
CANY1	24.1 ± 1.2	5%	2.1 ± 0.4	LAVO1	23.3 ± 1.2	5%	2.3 ± 0.4
CAPI1	23.8 ± 0.9	4%	2.2 ± 0.3	LIGO1	22.9 ± 0.8	4%	2.5 ± 0.3
CEBL1	22.6 ± 0.6	3%	2.6 ± 0.2	LIVO1	23.1 ± 1.0	4%	2.4 ± 0.3
CHAS1	23.5 ± 0.7	3%	2.3 ± 0.2	LOST1	22.5 ± 0.8	3%	2.6 ± 0.3
CHER1	23.3 ± 0.4	2%	2.3 ± 0.1	LYBR1	22.8 ± 0.7	3%	2.5 ± 0.2
CHIR1	23.8 ± 0.8	3%	2.2 ± 0.3	MACA1	22.3 ± 1.0	4%	2.7 ± 0.3
CLPE1	22.4 ± 0.6	3%	2.6 ± 0.2	MELA1	23.7 ± 1.0	4%	2.2 ± 0.4
COGO1	23.1 ± 1.1	5%	2.4 ± 0.4	MEVE1	22.6 ± 1.5	7%	2.6 ± 0.5
COHI1	23.5 ± 0.9	4%	2.3 ± 0.3	MING1	22.4 ± 0.8	3%	2.6 ± 0.3
COHU1	23.6 ± 0.8	4%	2.2 ± 0.3	MKGO1	23.2 ± 0.8	4%	2.3 ± 0.3
CORI1	23.9 ± 0.9	4%	2.1 ± 0.3	MOHO1	24.5 ± 1.0	4%	1.9 ± 0.3
CRES1	24.0 ± 0.7	3%	2.1 ± 0.2	MOMO1	22.4 ± 1.2	5%	2.6 ± 0.4
CRLA1	24.1 ± 1.0	4%	2.1 ± 0.3	MONT1	23.9 ± 0.9	4%	2.1 ± 0.3
CRMO1	23.7 ± 0.8	3%	2.2 ± 0.3	MOOS1	23.6 ± 0.8	3%	2.2 ± 0.3
DENA1	23.0 ± 1.0	4%	2.4 ± 0.3	MORA1	24.6 ± 1.8	7%	1.9 ± 0.6
DEVA1	23.5 ± 1.1	5%	2.2 ± 0.4	MOZI1	23.7 ± 1.2	5%	2.2 ± 0.4
DOME1	23.6 ± 1.2	5%	2.2 ± 0.4	NEBR1	24.6 ± 0.8	3%	1.9 ± 0.3
DOSO1	22.2 ± 0.8	4%	2.7 ± 0.3	NOAB1	23.4 ± 1.0	4%	2.3 ± 0.3
ELDO1	22.3 ± 0.7	3%	2.7 ± 0.3	NOCA1	24.0 ± 1.8	7%	2.1 ± 0.6
ELLI1	22.7 ± 0.8	3%	2.5 ± 0.3	NOCH1	23.9 ± 0.6	2%	2.1 ± 0.2
EVER1	24.0 ± 1.2	5%	2.1 ± 0.4	OKEF1	23.2 ± 0.8	3%	2.4 ± 0.3
FLAT1	24.9 ± 0.7	3%	1.8 ± 0.3	OLTO1	22.9 ± 1.8	8%	2.5 ± 0.6
FOPE1	22.7 ± 0.6	3%	2.5 ± 0.2	OLYM1	23.1 ± 1.4	6%	2.4 ± 0.5
GAMO1	23.3 ± 1.4	6%	2.3 ± 0.5	PASA1	24.0 ± 1.0	4%	2.1 ± 0.4
GICL1	23.9 ± 0.9	4%	2.1 ± 0.3	PEFO1	23.3 ± 0.9	4%	2.3 ± 0.3

<u>Site</u>	<u>Nylon Flow Rate</u>	<u>SD%</u>	<u>Cut-point</u>	<u>Site</u>	<u>Nylon Flow Rate</u>	<u>SD%</u>	<u>Cut-point</u>
PHOE1	23.6 ± 0.9	4%	2.2 ± 0.3	STAR1	23.6 ± 0.8	3%	2.2 ± 0.3
PINN1	24.1 ± 0.9	4%	2.0 ± 0.3	SULA1	22.9 ± 0.8	4%	2.5 ± 0.3
PMRF1	23.5 ± 1.1	5%	2.3 ± 0.4	SWAN1	23.8 ± 0.8	3%	2.1 ± 0.3
PORE1	21.6 ± 1.8	8%	2.9 ± 0.6	SYCA1	22.0 ± 1.1	5%	2.8 ± 0.4
PRIS1	22.6 ± 0.9	4%	2.6 ± 0.3	TALL1	22.8 ± 0.8	4%	2.5 ± 0.3
PUSO1	23.6 ± 1.4	6%	2.2 ± 0.5	THBA1	22.8 ± 0.6	3%	2.5 ± 0.2
QUCI1	24.1 ± 0.9	4%	2.1 ± 0.3	THRO1	23.2 ± 1.1	5%	2.4 ± 0.4
QURE1	23.6 ± 0.9	4%	2.2 ± 0.3	THSI1	24.5 ± 0.9	4%	1.9 ± 0.3
QUVA1	22.9 ± 0.7	3%	2.5 ± 0.2	TONT1	23.0 ± 0.9	4%	2.4 ± 0.3
RAFA1	24.1 ± 1.0	4%	2.1 ± 0.3	TRCR1	23.9 ± 0.7	3%	2.1 ± 0.2
REDW1	24.4 ± 1.0	4%	2.0 ± 0.3	TRIN1	24.9 ± 1.1	4%	1.8 ± 0.4
ROMA1	23.3 ± 0.8	4%	2.3 ± 0.3	TUXE1	23.4 ± 0.8	3%	2.3 ± 0.3
ROMO2	23.2 ± 1.6	7%	2.3 ± 0.5	ULBE1	22.3 ± 1.8	8%	2.7 ± 0.6
SACR1	24.3 ± 0.8	3%	2.0 ± 0.3	UPBU1	22.5 ± 1.2	5%	2.6 ± 0.4
SAFO1	24.0 ± 0.5	2%	2.1 ± 0.2	VIIS1	23.9 ± 0.7	3%	2.1 ± 0.2
SAGA1	22.9 ± 1.2	5%	2.5 ± 0.4	VILA1	21.8 ± 0.7	3%	2.8 ± 0.2
SAGO1	23.5 ± 1.0	4%	2.3 ± 0.3	VOYA1	22.5 ± 0.6	3%	2.6 ± 0.2
SAGU1	22.7 ± 0.9	4%	2.5 ± 0.3	WASH1	22.3 ± 1.4	6%	2.7 ± 0.5
SAMA1	23.5 ± 0.6	3%	2.2 ± 0.2	WEMI1	23.4 ± 1.1	5%	2.3 ± 0.4
SAPE1	23.6 ± 1.0	4%	2.2 ± 0.3	WHIT1	24.2 ± 0.9	4%	2.0 ± 0.3
SAWE1	21.1 ± 1.0	5%	3.1 ± 0.3	WHPA1	23.8 ± 1.5	6%	2.1 ± 0.5
SAWT1	23.9 ± 1.1	5%	2.1 ± 0.4	WHPE1	21.9 ± 1.2	6%	2.8 ± 0.4
SENE1	24.5 ± 0.8	3%	1.9 ± 0.3	WHRI1	23.6 ± 1.3	6%	2.2 ± 0.5
SEQU1	23.8 ± 1.0	4%	2.2 ± 0.4	WICA1	23.6 ± 1.0	4%	2.2 ± 0.4
SHEN1	22.9 ± 0.8	3%	2.5 ± 0.3	WIMO1	22.4 ± 0.9	4%	2.6 ± 0.3
SHRO1	23.1 ± 1.0	4%	2.4 ± 0.3	YELL1	23.7 ± 0.9	4%	2.2 ± 0.3
SIAN1	23.8 ± 0.9	4%	2.2 ± 0.3	YOSE1	22.5 ± 1.1	5%	2.6 ± 0.4
SIKE1	23.1 ± 0.9	4%	2.4 ± 0.3	ZION1	23.7 ± 1.3	5%	2.2 ± 0.4
SIME1	23.6 ± 0.7	3%	2.2 ± 0.2				
SIPS1	22.7 ± 0.9	4%	2.5 ± 0.3	Total	23.3 ± 1.2	5%	2.3 ± 0.4
SNPA1	24.7 ± 1.0	4%	1.8 ± 0.3				
SPOK1	23.4 ± 1.8	8%	2.3 ± 0.6				

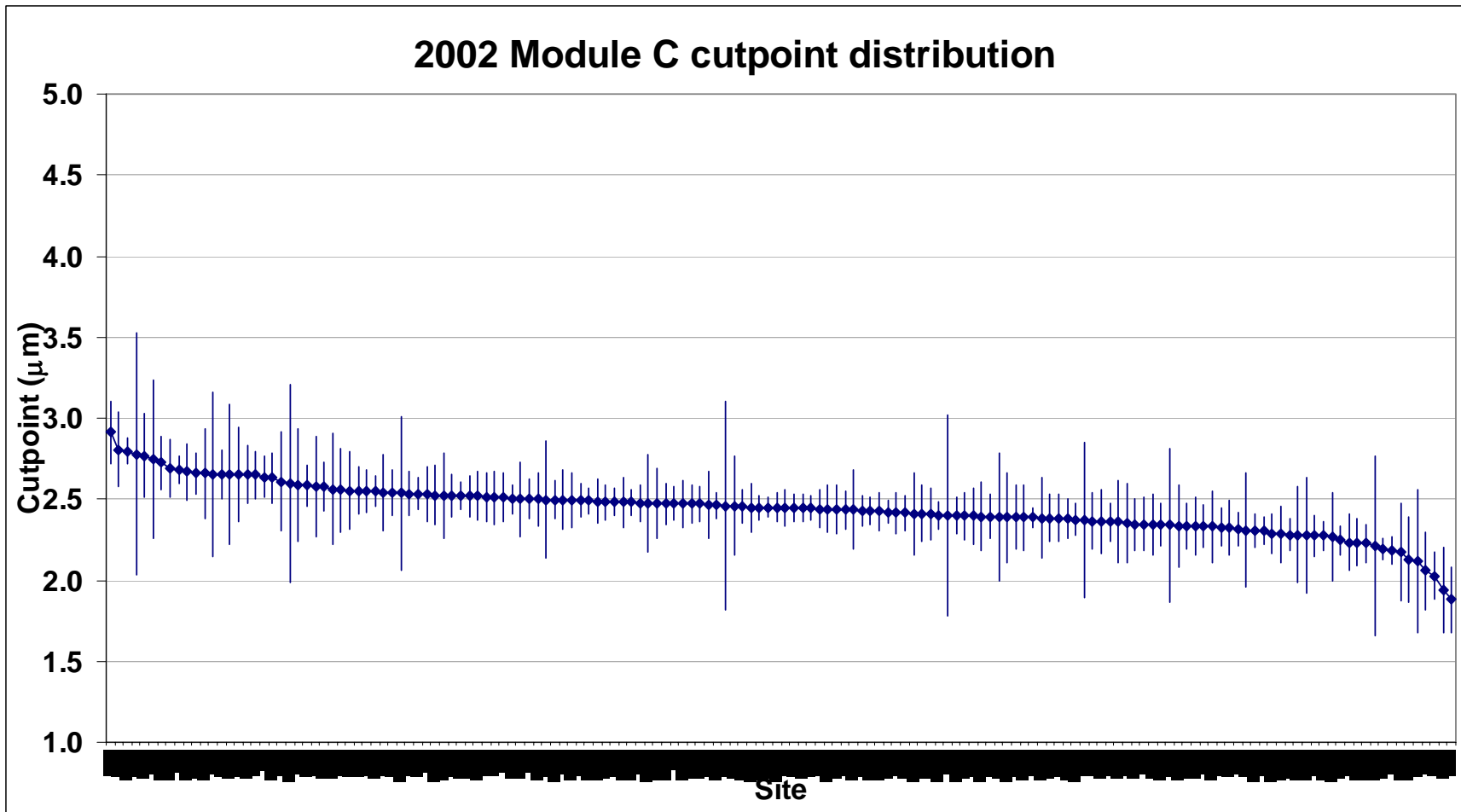


**Figure 3. Average cut point distribution for nylon filters.
The bar represents one standard deviation.**

Table 5. Flow rate and cutpoint for Quartz filter module.

Site	Quartz Flow Rate	SD%	Cut-point	Site	Quartz Flow Rate	SD%	Cut-point
ACAD1	23.6 ± 0.3	1%	2.2 ± 0.1	GLAC1	23.1 ± 0.4	2%	2.4 ± 0.1
ADPI1	23.2 ± 0.3	1%	2.4 ± 0.1	GRBA1	23.0 ± 0.7	3%	2.4 ± 0.2
AGTI1	22.6 ± 1.0	4%	2.6 ± 0.3	GRGU1	23.1 ± 0.6	3%	2.4 ± 0.2
AREN1	22.7 ± 0.4	2%	2.5 ± 0.1	GRR11	22.7 ± 0.4	2%	2.5 ± 0.1
BADL1	22.0 ± 0.8	3%	2.8 ± 0.3	GRSA1	23.8 ± 0.9	4%	2.2 ± 0.3
BALD1	22.4 ± 0.5	2%	2.6 ± 0.2	GRSM1	23.0 ± 0.4	2%	2.4 ± 0.1
BAND1	23.4 ± 1.0	4%	2.3 ± 0.4	GUMO1	22.7 ± 0.5	2%	2.5 ± 0.2
BIBE1	23.3 ± 0.5	2%	2.3 ± 0.2	HALE1	21.9 ± 0.7	3%	2.8 ± 0.2
BLIS1	23.3 ± 0.3	1%	2.3 ± 0.1	HANC1	23.6 ± 1.6	7%	2.2 ± 0.6
BLMO1	22.9 ± 0.4	2%	2.5 ± 0.1	HAVO1	23.1 ± 0.3	1%	2.4 ± 0.1
BOAP1	22.4 ± 0.4	2%	2.6 ± 0.2	HECA1	23.3 ± 0.4	2%	2.3 ± 0.1
BOND1	23.3 ± 0.7	3%	2.3 ± 0.3	HEGL1	22.9 ± 0.2	1%	2.5 ± 0.1
BOWA1	23.1 ± 0.8	3%	2.4 ± 0.3	HILL1	22.3 ± 0.2	1%	2.7 ± 0.1
BRCA1	22.3 ± 0.5	2%	2.7 ± 0.2	HOOV1	22.6 ± 0.4	2%	2.6 ± 0.2
BRET1	22.8 ± 1.0	5%	2.5 ± 0.4	IKBA1	22.7 ± 0.4	2%	2.5 ± 0.1
BRID1	22.8 ± 0.3	1%	2.5 ± 0.1	INGA1	22.6 ± 0.9	4%	2.6 ± 0.3
BRIG1	22.5 ± 0.9	4%	2.6 ± 0.3	ISLE1	22.8 ± 0.4	2%	2.5 ± 0.1
BRLA1	22.9 ± 0.9	4%	2.5 ± 0.3	JARB1	23.2 ± 0.6	2%	2.4 ± 0.2
BRMA1	22.9 ± 0.4	2%	2.4 ± 0.1	JARI1	22.9 ± 0.3	1%	2.5 ± 0.1
CABA1	22.9 ± 0.5	2%	2.5 ± 0.2	JOSH1	22.9 ± 0.3	1%	2.5 ± 0.1
CABI1	21.6 ± 0.6	3%	2.9 ± 0.2	KAIS1	23.6 ± 0.5	2%	2.2 ± 0.2
CACO1	22.8 ± 0.4	2%	2.5 ± 0.1	KALM1	23.4 ± 0.9	4%	2.3 ± 0.3
CACR1	22.7 ± 0.4	2%	2.5 ± 0.1	LABE1	23.1 ± 0.5	2%	2.4 ± 0.2
CADI1	22.8 ± 0.4	2%	2.5 ± 0.1	LASU1	22.9 ± 0.3	1%	2.5 ± 0.1
CANY1	23.3 ± 0.6	2%	2.3 ± 0.2	LAVO1	23.3 ± 0.5	2%	2.3 ± 0.2
CAPI1	23.2 ± 1.4	6%	2.4 ± 0.5	LIGO1	22.4 ± 1.5	7%	2.7 ± 0.5
CEBL1	23.0 ± 0.3	1%	2.4 ± 0.1	LIVO1	22.8 ± 0.4	2%	2.5 ± 0.2
CHAS1	23.0 ± 0.3	1%	2.4 ± 0.1	LOST1	23.1 ± 0.4	2%	2.4 ± 0.1
CHER1	23.7 ± 0.2	1%	2.2 ± 0.1	LYBR1	23.4 ± 1.0	4%	2.3 ± 0.3
CHIR1	24.6 ± 0.6	2%	1.9 ± 0.2	MACA1	23.1 ± 0.2	1%	2.4 ± 0.1
CLPE1	22.7 ± 0.4	2%	2.5 ± 0.1	MELA1	23.1 ± 0.5	2%	2.4 ± 0.2
COGO1	22.7 ± 0.8	3%	2.5 ± 0.3	MEVE1	23.0 ± 0.2	1%	2.4 ± 0.1
COHI1	23.5 ± 0.4	2%	2.3 ± 0.1	MING1	23.1 ± 0.6	2%	2.4 ± 0.2
COHU1	22.8 ± 0.2	1%	2.5 ± 0.1	MKGO1	23.1 ± 0.3	1%	2.4 ± 0.1
CORI1	23.2 ± 0.5	2%	2.4 ± 0.2	MOHO1	23.2 ± 0.3	1%	2.4 ± 0.1
CRES1	23.5 ± 0.2	1%	2.2 ± 0.1	MOMO1	22.4 ± 0.4	2%	2.6 ± 0.1
CRLA1	23.0 ± 0.4	2%	2.4 ± 0.2	MONT1	23.4 ± 0.5	2%	2.3 ± 0.2
CRMO1	23.4 ± 0.3	1%	2.3 ± 0.1	MOOS1	23.0 ± 0.3	1%	2.4 ± 0.1
DENA1	22.3 ± 0.4	2%	2.7 ± 0.1	MELA1	23.1 ± 0.5	2%	2.4 ± 0.2
DEVA1	22.4 ± 0.8	4%	2.7 ± 0.3	MEVE1	23.0 ± 0.2	1%	2.4 ± 0.1
DOVE1	22.8 ± 0.5	2%	2.5 ± 0.2	MING1	23.1 ± 0.6	2%	2.4 ± 0.2
DOSO1	23.3 ± 0.4	2%	2.3 ± 0.1	MKGO1	23.1 ± 0.3	1%	2.4 ± 0.1
ELDO1	22.7 ± 0.4	2%	2.5 ± 0.1	MOHO1	23.2 ± 0.3	1%	2.4 ± 0.1
ELLI1	22.4 ± 0.4	2%	2.6 ± 0.1	MOMO1	22.4 ± 0.4	2%	2.6 ± 0.1
EVER1	23.1 ± 0.2	1%	2.4 ± 0.1	MONT1	23.4 ± 0.5	2%	2.3 ± 0.2
FLAT1	24.2 ± 0.4	2%	2.0 ± 0.1	MOOS1	23.0 ± 0.3	1%	2.4 ± 0.1
FOPE1	22.9 ± 0.6	3%	2.5 ± 0.2	MORA1	22.9 ± 0.9	4%	2.5 ± 0.3
GAMO1	22.8 ± 0.3	1%	2.5 ± 0.1	MOZI1	22.6 ± 0.7	3%	2.6 ± 0.3
GICL1	24.1 ± 0.7	3%	2.1 ± 0.2	NEBR1	23.4 ± 0.3	1%	2.3 ± 0.1

<u>Site</u>	<u>Quartz Flow Rate</u>	<u>SD%</u>	<u>Cut-point</u>	<u>Site</u>	<u>Quartz Flow Rate</u>	<u>SD%</u>	<u>Cut-point</u>
NOAB1	22.8 ± 0.5	2%	2.5 ± 0.2	SNPA1	23.0 ± 0.2	1%	2.4 ± 0.1
NOCA1	23.9 ± 0.8	3%	2.1 ± 0.3	SPOK1	23.6 ± 0.4	2%	2.2 ± 0.1
NOCH1	22.9 ± 0.3	1%	2.5 ± 0.1	STAR1	23.1 ± 0.4	2%	2.4 ± 0.1
OKEF1	23.9 ± 1.3	5%	2.1 ± 0.4	SULA1	23.2 ± 0.7	3%	2.4 ± 0.3
OLTO1	22.9 ± 1.9	8%	2.5 ± 0.6	SWAN1	23.4 ± 0.4	2%	2.3 ± 0.1
OLYM1	22.6 ± 1.0	4%	2.6 ± 0.3	SYCA1	22.4 ± 1.3	6%	2.7 ± 0.4
PASA1	22.9 ± 0.6	3%	2.5 ± 0.2	TALL1	22.7 ± 0.7	3%	2.5 ± 0.2
PEFO1	22.0 ± 2.2	10%	2.8 ± 0.7	THBA1	24.4 ± 0.8	3%	1.9 ± 0.3
PHOE1	22.9 ± 0.3	1%	2.5 ± 0.1	THRO1	23.1 ± 0.5	2%	2.4 ± 0.2
PINN1	23.4 ± 0.2	1%	2.3 ± 0.1	THSI1	23.7 ± 0.2	1%	2.2 ± 0.1
PMRF1	23.1 ± 0.7	3%	2.4 ± 0.2	TONT1	22.6 ± 0.7	3%	2.6 ± 0.2
PORE1	23.0 ± 0.2	1%	2.4 ± 0.1	TRCR1	23.3 ± 0.5	2%	2.3 ± 0.2
PRIS1	23.0 ± 0.3	1%	2.4 ± 0.1	TRIN1	23.1 ± 1.8	8%	2.4 ± 0.6
PUSO1	22.2 ± 0.5	2%	2.7 ± 0.2	TUXE1	23.0 ± 0.4	2%	2.4 ± 0.1
QUCI1	23.0 ± 0.3	1%	2.4 ± 0.1	ULBE1	23.1 ± 0.4	2%	2.4 ± 0.1
QURE1	22.7 ± 0.3	1%	2.5 ± 0.1	UPBU1	22.9 ± 0.2	1%	2.5 ± 0.1
QUVA1	23.1 ± 1.1	5%	2.4 ± 0.4	VIIS1	22.9 ± 0.3	1%	2.5 ± 0.1
RAFA1	23.0 ± 0.2	1%	2.4 ± 0.1	VILA1	22.7 ± 0.5	2%	2.5 ± 0.2
REDW1	23.5 ± 0.3	1%	2.3 ± 0.1	VOYA1	22.6 ± 0.4	2%	2.6 ± 0.1
ROMA1	23.1 ± 0.6	3%	2.4 ± 0.2	WASH1	22.7 ± 1.4	6%	2.5 ± 0.5
ROMO2	22.5 ± 1.8	8%	2.6 ± 0.6	WEMI1	23.0 ± 0.2	1%	2.4 ± 0.1
SACR1	22.9 ± 0.2	1%	2.5 ± 0.1	WHIT1	22.8 ± 0.5	2%	2.5 ± 0.2
SAFO1	23.0 ± 0.2	1%	2.4 ± 0.1	WHPA1	23.5 ± 0.8	3%	2.3 ± 0.3
SAGA1	23.1 ± 0.4	2%	2.4 ± 0.1	WHPE1	22.3 ± 0.8	4%	2.7 ± 0.3
SAGO1	22.9 ± 0.2	1%	2.4 ± 0.1	WHRI1	22.4 ± 0.4	2%	2.7 ± 0.1
SAGU1	21.9 ± 0.2	1%	2.8 ± 0.1	WICA1	22.7 ± 0.3	1%	2.5 ± 0.1
SAMA1	23.1 ± 0.7	3%	2.4 ± 0.3	WIMO1	22.8 ± 0.7	3%	2.5 ± 0.2
SAPE1	22.7 ± 0.2	1%	2.5 ± 0.1	YELL1	22.8 ± 0.5	2%	2.5 ± 0.2
SAWE1	22.1 ± 0.5	2%	2.7 ± 0.2	YOSE1	23.3 ± 1.4	6%	2.3 ± 0.5
SAGA1	23.1 ± 0.4	2%	2.4 ± 0.1	ZION1	23.3 ± 0.4	2%	2.3 ± 0.1
SAGO1	22.9 ± 0.2	1%	2.4 ± 0.1				
SAGU1	21.9 ± 0.2	1%	2.8 ± 0.1	Total	23.0 ± 0.8	4%	2.4 ± 0.3
SAWT1	23.3 ± 0.6	3%	2.3 ± 0.2				
SENE1	22.7 ± 0.4	2%	2.6 ± 0.1				
SEQU1	22.8 ± 0.3	1%	2.5 ± 0.1				
SHEN1	23.2 ± 0.5	2%	2.3 ± 0.2				
SHRO1	22.9 ± 0.4	2%	2.5 ± 0.1				
SIAN1	23.0 ± 0.3	1%	2.4 ± 0.1				
SIKE1	22.1 ± 1.4	6%	2.7 ± 0.5				
SIME1	23.3 ± 0.3	1%	2.3 ± 0.1				
SIPS1	23.2 ± 0.7	3%	2.3 ± 0.2				



**Figure 4. Average cut point distribution for quartz filters.
The bar represents one standard deviation.**

Table 6. Flow Rate for Teflon PM10 module for CY 2002

Site	Teflon PM₁₀ Flow Rate	SD%	Site	Teflon PM₁₀ Flow Rate	SD%
ACAD1	18.7 ± 0.3	2%	GLAC1	16.4 ± 0.2	1%
ADPI1	16.9 ± 0.2	1%	GRBA1	16.6 ± 0.2	1%
AGT11	17.1 ± 0.4	2%	GRGU1	16.8 ± 0.3	2%
AREN1	16.6 ± 0.2	1%	GRR11	16.6 ± 0.2	1%
BADL1	16.4 ± 0.2	1%	GRSA1	16.9 ± 0.2	1%
BALD1	16.7 ± 0.1	1%	GRSM1	16.6 ± 0.2	1%
BAND1	16.8 ± 0.3	2%	GUMO1	16.7 ± 0.2	1%
BIBE1	17.3 ± 0.1	1%	HALE1	17.0 ± 0.1	1%
BLIS1	18.9 ± 0.2	1%	HANC1	16.7 ± 0.2	1%
BLMO1	16.3 ± 0.2	1%	HAVO1	16.7 ± 0.1	1%
BOAP1	17.0 ± 0.2	1%	HECA1	16.7 ± 0.2	1%
BOND1	16.8 ± 0.3	2%	HEGL1	16.8 ± 0.2	1%
BOWA1	16.4 ± 0.4	3%	HILL1	16.5 ± 0.1	1%
BRCA1	16.7 ± 0.1	1%	HOOV1	16.4 ± 0.2	1%
BRET1	18.2 ± 1.6	9%	IKBA1	16.9 ± 0.2	1%
BRID1	16.6 ± 0.2	1%	INGA1	18.7 ± 0.6	3%
BRIG1	17.1 ± 0.5	3%	ISLE1	16.3 ± 0.4	2%
BRLA1	18.9 ± 0.3	2%	JARB1	16.6 ± 0.2	1%
BRMA1	17.0 ± 0.4	2%	JARI1	18.6 ± 0.2	1%
CABA1	16.7 ± 0.1	1%	JOSH1	16.6 ± 0.3	2%
CABI1	19.3 ± 0.3	1%	KAIS1	16.5 ± 0.2	1%
CACO1	16.7 ± 0.2	1%	KALM1	16.4 ± 1.1	7%
CACR1	16.7 ± 0.2	1%	LABE1	16.4 ± 0.5	3%
CADI1	16.6 ± 0.2	1%	LASU1	16.2 ± 0.2	1%
CANY1	16.6 ± 0.2	1%	LAVO1	18.5 ± 0.4	2%
CAPI1	16.9 ± 0.1	1%	LIGO1	16.5 ± 0.2	1%
CEBL1	16.9 ± 0.3	2%	LIVO1	16.8 ± 0.2	1%
CHAS1	19.0 ± 0.2	1%	LOST1	16.6 ± 0.5	3%
CHER1	16.4 ± 0.1	1%	LYBR1	18.7 ± 1.3	7%
CHIR1	17.3 ± 0.1	1%	MACA1	18.5 ± 0.2	1%
CLPE1	16.0 ± 0.2	2%	MELA1	16.5 ± 0.3	2%
COGO1	16.8 ± 0.2	1%	MEVE1	16.7 ± 0.2	1%
COHI1	17.0 ± 0.3	2%	MING1	18.6 ± 0.2	1%
COHU1	19.1 ± 0.2	1%	MKGO1	16.7 ± 0.2	1%
CORI1	18.9 ± 0.2	1%	MOHO1	16.5 ± 0.2	1%
CRES1	16.3 ± 0.2	1%	MOMO1	16.7 ± 0.3	2%
CRLA1	18.8 ± 0.3	1%	MONT1	16.6 ± 0.2	1%
CRMO1	16.7 ± 0.2	1%	MOOS1	16.9 ± 0.2	1%
DENA1	18.4 ± 1.2	6%	MORA1	17.0 ± 0.2	1%
DEVA1	16.6 ± 0.3	2%	MOZI1	16.6 ± 0.3	2%
DOME1	16.4 ± 0.2	1%	NEBR1	16.4 ± 0.2	1%
DOSO1	16.8 ± 0.2	1%	NOAB1	16.6 ± 0.3	2%
ELDO1	16.5 ± 0.4	2%	NOCA1	17.3 ± 0.5	3%
ELLI1	16.9 ± 0.2	1%	NOCH1	16.6 ± 0.2	1%
EVER1	19.0 ± 0.2	1%	OKEF1	18.9 ± 0.3	1%
FLAT1	17.6 ± 0.3	2%	OLTO1	16.9 ± 0.2	1%
FOPE1	16.3 ± 0.2	1%	OLYM1	16.6 ± 0.2	1%
GAMO1	19.5 ± 1.5	7%	PASA1	16.7 ± 0.2	1%
GICL1	17.0 ± 0.1	1%	PEFO1	16.9 ± 0.3	2%

<u>Site</u>	<u>Teflon PM₁₀ Flow Rate</u>	<u>SD%</u>	<u>Site</u>	<u>Teflon PM₁₀ Flow Rate</u>	<u>SD%</u>
PHOE1	16.7 ± 1.1	7%	SNPA1	16.9 ± 0.1	1%
PINN1	16.5 ± 0.2	1%	SPOK1	16.6 ± 0.2	1%
PMRF1	16.7 ± 0.2	1%	STAR1	16.4 ± 0.8	5%
PORE1	20.2 ± 0.3	2%	SULA1	18.7 ± 0.3	2%
PRIS1	17.2 ± 0.3	2%	SWAN1	19.0 ± 0.2	1%
PUSO1	16.7 ± 0.2	1%	SYCA1	15.9 ± 0.4	3%
QUCI1	16.6 ± 0.1	1%	TALL1	17.1 ± 0.5	3%
QURE1	16.6 ± 0.2	1%	THBA1	16.5 ± 0.2	1%
QUVA1	16.8 ± 0.2	1%	THRO1	16.8 ± 0.2	1%
RAFA1	16.5 ± 0.2	1%	THSI1	16.7 ± 0.1	1%
REDW1	18.9 ± 0.3	2%	TONT1	17.4 ± 0.3	2%
ROMA1	19.0 ± 0.2	1%	TRCR1	18.7 ± 0.1	1%
ROMO2	16.7 ± 0.2	1%	TRIN1	18.6 ± 0.5	3%
SACR1	17.6 ± 0.7	4%	TUXE1	18.9 ± 0.2	1%
SAFO1	16.6 ± 0.2	1%	ULBE1	16.6 ± 0.2	1%
SAGA1	16.7 ± 0.4	3%	UPBU1	16.7 ± 0.2	1%
SAGO1	18.8 ± 0.2	1%	VIIS1	18.9 ± 0.3	2%
SAGU1	16.3 ± 0.2	1%	VILA1	16.2 ± 0.5	3%
SAMA1	19.1 ± 0.4	2%	VOYA1	16.9 ± 0.2	1%
SAPE1	16.6 ± 0.2	1%	WASH1	18.7 ± 0.5	3%
SAWE1	16.8 ± 0.1	1%	WEMI1	16.6 ± 0.2	1%
SAWT1	16.9 ± 0.3	2%	WHIT1	16.8 ± 0.5	3%
SENE1	16.9 ± 0.3	2%	WHPA1	16.7 ± 0.2	1%
SEQU1	16.3 ± 0.2	1%	WHPE1	16.8 ± 0.3	2%
SHEN1	16.5 ± 0.2	1%	WHRI1	16.6 ± 0.3	2%
SHRO1	16.9 ± 0.2	1%	WICA1	16.5 ± 0.2	1%
SIAN1	16.9 ± 0.3	2%	WIMO1	16.6 ± 0.2	1%
SIKE1	15.9 ± 0.5	3%	YELL1	18.7 ± 1.0	5%
SIME1	16.9 ± 0.1	0%	YOSE1	16.7 ± 0.1	1%
SIPS1	16.8 ± 0.1	1%	ZION1	16.8 ± 0.2	1%

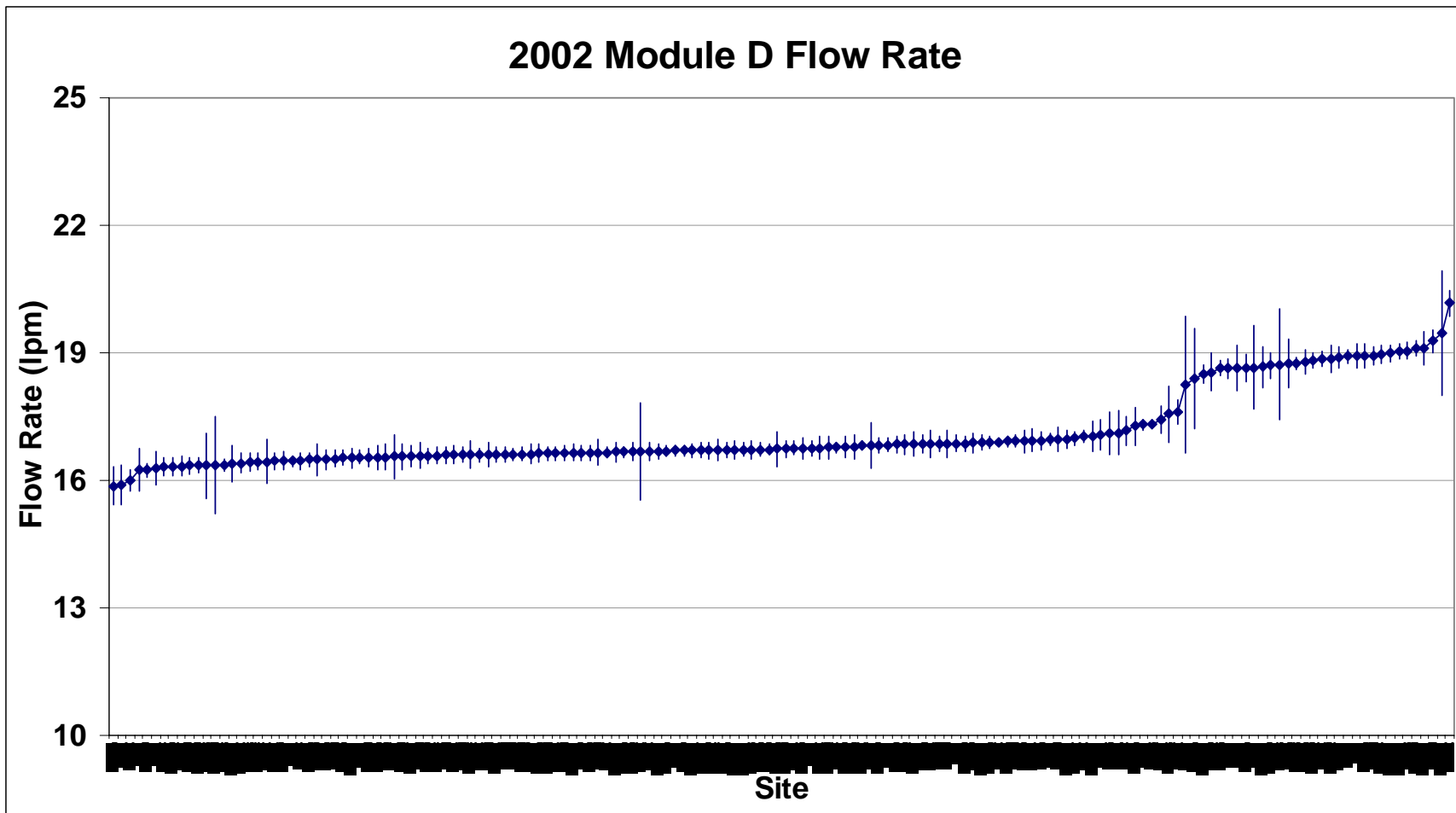


Figure 5. Average flow rate distribution for PM10 Teflon filters.
The bar represents one standard deviation. Note that two different inlets are used in the network. The Sierra-Anderson inlet operates at 16.7 lpm, while the Wedding inlet operates at 19 lpm.

Table 7. Sample Recovery Percentages in 2002.

SITE	NAME	Q102	Q202	Q302	Q402	ANNUAL
		% A data	% A data	% A data	% A data	AVERAGE
ACAD1	Acadia	100	100	100	100	100
ADPI1	Addison Pinnacle	97	97	100	100	99
AGTI1	Agua Tibia	73	83	87	100	86
AREN1	Arendtsville	100	100	100	100	100
BADL1	Badlands	97	87	100	100	96
BALD1	Mount Baldy	97	100	77	100	94
BAND1	Bandelier	100	87	100	100	97
BIBE1	Big Bend	97	97	100	100	99
BLIS1	Bliss	100	100	100	90	98
BLMO1	Blue Mounds			96	90	93
BOAP1	Bosque del Apache	100	97	100	90	97
BOND1	Bondville	97	100	100	100	99
BOWA1	Boundary Waters	70	87	100	100	89
BRCA1	Bryce Canyon	100	97	84	71	88
BRET1	Breton	97	37	68	100	76
BRID1	Bridger	97	87	97	100	95
BRIG1	Brigantine	73	100	90	100	91
BRLA1	Brooklyn Lakes	67	83	97	100	87
BRMA1	Bridgton	100	80	100	94	94
CABA1	Casco Bay	97	100	90	97	96
CABI1	Cabinet Mountains	97	100	100	100	99
CACO1	Cape Cod Natl Seashore	97	80	74	100	88
CACR1	Caney Creek	63	100	100	100	91
CADI1	Cadiz	87	87	100	100	94
CANY1	Canyonlands	93	100	84	100	94
CAPI1	Capitol Reef	37	77	74	97	71
CEBL1	Cedar Bluff		100	84	87	90
CHAS1	Chassahowitzka	90	93	90	100	93
CHER1	Cherokee			100	94	97
CHIR1	Chiracahua	97	100	100	100	99
CLPE1	Cloud Peak		100	97	100	99
COGO1	Columbia Gorge West	90	93	81	97	90
COHI1	Connecticut Hill	100	100	97	97	99
COHU1	Cohutta	92	63	100	100	89
CORI1	Columbia Gorge East	97	100	100	90	97
CRES1	Crescent Lake			86	97	92
CRLA1	Crater Lake	97	100	97	84	95
CRMO1	Craters of the Moon	90	90	90	100	93
DENA1	Denali	97	97	100	100	99
DEVA1	Death Valley	80	100	97	100	94
DOM1	Dome Land	87	80	81	87	84
DOSO1	Dolly Sods	100	100	68	100	92
ELDO1	El Dorado Springs		91	97	100	96
ELLI1	Ellis		100	97	87	95
EVER1	Everglades	100	100	94	100	99
FLAT1	Flathead		100	100	100	100
FOPE1	Ft Peck		100	100	100	100
GAMO1	Gates of the Mountains	100	80	100	97	94
GICL1	Gila	90	100	100	100	98
GLAC1	Glacier	90	100	77	100	92
GRBA1	Great Basin	100	100	100	97	99
GRGU1	Great Gulf	97	100	94	97	97

GRR11	Great River Bluffs			100	84	92
GRSA1	Great Sand Dunes	97	100	90	84	93
GRSM1	Great Smoky Mtns	100	100	100	100	100
GUMO1	Guadalupe Mountains	97	97	100	94	97
HALE1	Haleakala	60	93	100	90	86
HANC1	Grand Canyon	100	100	100	100	100
HAVO1	Hawaii Volcanoes	93	100	100	100	98
HECA1	Hells Canyon	100	97	100	94	98
HEGL1	Hercules-Glades	100	100	100	100	100
HILL1	Hillside	93	83	87	94	89
HOOV1	Hoover	100	100	90	100	98
IKBA1	Ike's Backbone	83	100	97	87	92
INGA1	Indian Gardens	52	67	29	94	61
ISLE1	Isle Royale	100	100	100	100	100
JARB1	Jarbidge	97	77	90	100	91
JARI1	James River	97	100	97	100	99
JOSH1	Joshua Tree	93	90	100	100	96
KAIS1	Kaiser	67	60	81	87	74
KALM1	Kalmiopsis	100	90	100	97	97
LABE1	Lava Beds	97	100	100	94	98
LASU1	Lake Sugema		100	100	100	100
LAVO1	Lassen Volcanic	97	100	97	77	93
LIGO1	Linville Gorge	93	83	74	100	88
LIVO1	Livonia	97	97	87	100	95
LOST1	Lostwood	100	97	100	100	99
LYBR1	Lye Brook	97	93	84	94	92
MACA1	Mammoth Cave	100	100	100	100	100
MELA1	Medicine Lake	97	93	100	100	98
MEVE1	Mesa Verde	97	90	90	97	94
MING1	Mingo	80	97	94	90	90
MKGO1	MK Goddard	100	100	100	100	100
MOHO1	Mount Hood	100	100	100	100	100
MOMO1	Mohawk Mountain	97	93	100	100	98
MONT1	Monture	100	90	97	100	97
MOOS1	Moosehorn	97	100	100	97	99
MORA1	Mount Rainier	77	97	97	100	93
MOZI1	Mount Zirkel	97	93	58	90	85
NEBR1	Nebraska			100	97	99
NOAB1	North Absaroka	97	100	65	97	90
NOCA1	North Cascades	97	100	94	100	98
NOCH1	Northern Cheyenne	0	100	94	100	98
OKEF1	Okefenokee	83	93	100	100	94
OLTO1	Old Town	70	53	84	77	71
OLYM1	Olympic	93	100	100	100	98
OMAH1	Omaha (off line)					
PASA1	Pasayten	100	100	97	100	99
PEFO1	Petrified Forest	100	100	100	100	100
PHOE1	Phoenix	90	97	97	100	96
PINN1	Pinnacles	93	100	97	100	98
PMRF1	Proctor Research Center	87	93	100	100	95
PORE1	Point Reyes	63	100	90	74	82
PRIS1	Presque Isle	100	100	97	100	99
PUSO1	Seattle	97	100	97	100	99
QUCI1	Quaker City	100	90	100	100	98
QURE1	Quabbin Reservoir	93	100	100	100	98
QUVA1	Queen Valley (Superstitio	93	100	100	97	98

RAFA1	San Rafael	53	97	90	100	85
REDW1	Redwood	90	97	97	97	95
ROMA1	Cape Romain	97	100	97	100	99
ROMO2	Rocky Mountain	100	100	100	97	99
SACR1	Salt Creek	100	93	84	100	94
SAFO1	Sac and Fox		75	100	100	92
SAGA1	San Gabriel	97	100	94	100	98
SAGO1	San Gorgonio	90	93	94	90	92
SAGU1	Saguaro	100	100	97	100	99
SAMA1	St. Marks	90	100	90	87	92
SAPE1	San Pedro Parks	73	97	90	77	84
SAWE1	Saguaro west	100	100	100	100	100
SAWT1	Sawtooth	100	93	94	77	91
SENE1	Seney	100	100	94	100	99
SEQU1	Sequoia	93	100	100	48	85
SHEN1	Shenandoah	100	93	94	100	97
SHRO1	Shining Rock	90	70	87	84	83
SIAN1	Sierra Ancha	97	93	84	74	87
SIKE1	Sikes	97	83	90	100	93
SIME1	Simeonof	100	100	100	97	99
SIPS1	Sipsey	87	90	87	94	90
SNPA1	Snoqualamie Pass	100	100	97	100	99
SPOK1	Spokane	93	100	97	71	90
STAR1	Starkey	100	100	97	100	99
SULA1	Sula	97	100	84	100	95
SWAN1	Swanquarter	90	97	94	97	95
SYCA1	Sycamore Canyon	83	100	97	100	95
TALL1	Tallgrass			100	81	91
THBA1	Thunder Basin		100	100	97	99
THRO1	Theodore Roosevelt	83	70	87	100	85
THSI1	Three Sisters	100	100	100	100	100
TONT1	Tonto	100	100	100	100	100
TRCR1	Trapper Creek-Denali	93	93	100	100	97
TRIN1	Trinity	100	77	87	74	85
TUXE1	Tuxedni	87	67	90	74	80
ULBE1	UL Bend	87	97	77	94	89
UPBU1	Upper Buffalo	97	100	94	94	96
VIIS1	Virgin Islands	63	87	100	90	85
VILA1	Viking Lake		100	87	87	91
VOYA1	Voyageurs	100	90	94	100	96
WASH1	Washington DC	100	83	100	100	96
WEMI1	Weminuche	90	97	87	97	93
WHIT1	White Mountain	100	100	87	100	97
WHPA1	White Pass	100	83	90	97	93
WHPE1	Wheeler Peak	100	97	97	100	99
WHRI1	White River	63	93	100	100	89
WICA1	Wind Cave	97	100	100	97	99
WIMO1	Wichita Mountain	100	100	87	100	97
YELL1	Yellowstone	77	97	97	94	91
YOSE1	Yosemite	93	100	100	90	96
ZION1	Zion	97	100	100	90	97
	AVERAGE	92	94	94	95	94
	STD DEV	±12	±10	±10	±8	±6

3. Analysis of Filters by UC Davis and Cooperating Contractors

Compositional data on the filters is obtained by three different contractors using a total of 7 different techniques. Each contractor is responsible for internal quality assurance.

1. Module A - Teflon filter - PM_{2.5} - Contractor: UC Davis

<i>variables</i>	<i>technique</i>
mass	Gravimetric
coefficient of absorption	Hybrid Integrating Plate/Sphere Method (HIPS)
hydrogen	Proton Elastic Scattering Analysis (PESA)
Na - Fe	X-ray Fluorescence (XRF), Cu Anode
Ni - Pb	X-ray Fluorescence (XRF), Mo Anode

calibration: appropriate NIST and/or commercial standards

precision: Gravimetric analysis is monitored by laboratory controls. For all other methods, a set of samples originally analyzed during that season's analytical session is reanalyzed during the next season's session before any normal analyses are performed. In addition, the results from PIXE and XRF are compared for selected elements.

2. Module B - nylon filter - PM_{2.5} - Contractor: Research Triangle Institute

variables: Nitrate, Sulfate, Chloride, Nitrite; also Ammonium at selected sites

technique: Ion chromatography (IC)

calibration: appropriate EPA and/or commercial standards

precision: Separate aliquots from the desorbed filter are analyzed.

3. Module C - quartz filters - PM_{2.5} - Contractor: Desert Research Institute

variables: carbon in 8 temperature ranges, summed for organic and elemental carbon

technique: Thermal Optical Reflectance Method (TOR)

calibration: appropriate commercial standards

precision: Separate punches from the same filter are analyzed.

4. Module D - Teflon filter - PM₁₀ - Contractor: UC Davis

All samples are analyzed for mass by gravimetric analysis.

4. Data Processing: Concentration, Precision, and Composite Variables

The general equation for the concentration of a given measured variable is

$$c = \frac{A - B}{V},$$

where A is the measured mass of the variable, B is the artifact mass determined from field blank or secondary filters, and V is the volume determined from the average flow rate and the sample duration. The artifact B may be produced by contamination in the filter material, and in handling and analysis, and by adsorption of gas during collection. The artifact is negligible for all Teflon measurements, including gravimetric analysis. It is determined from designated field blanks for ions and from secondary filters for carbon.

Nylon filter field blanks are collected periodically at all sites, and they represent about 3% of the total sampled filters during a season. During each data reporting period, the median field blank value is determined for each ion for the entire network, and this median value is subtracted from each measured value as the artifact correction. Through May 2002 (season A02), data were reported seasonally and the medians were determined for each three-month seasonal period. Beginning in June 2002 the data were reported monthly, so monthly median values were used for artifact correction. At that time the percentage of field blanks was increased to about 5% to provide a sufficient number of filters during the month to determine a statistically meaningful median.

Quartz secondary filters (also called afterfilters) are collected along with each sample at six sites: Chiricahua, Grand Canyon, Mount Rainier, Okefenokee, Shenandoah and Yosemite. These secondary filters represent about 4% of the total sampled filters. During each data reporting period, the median secondary filter value is determined for each of the components of organic and elemental carbon for the entire network, and this median value is subtracted from each measured value as the artifact correction. As with the nylon filters, the averaging period switched from seasons to months beginning in June 2002.

The artifact corrections used for each species during 2002 are shown in Table 8.

Table 8. Artifact Corrections for 2002.

Artifact subtractions, CY02

Ions

Period	Designation	Cl	DCl	NO2	DNO2	NO3	DNO3	SO4	DSO4	NH4	DNH4
12/1/01 - 2/28/02	D01	24.585	1.019	0.000	0.156	0.409	0.550	1.602	0.723	0.010	0.000
3/1/02 - 5/31/02	A02	24.304	1.084	0.000	0.225	1.011	0.466	1.992	0.415	0.010	0.035
6/1/02 - 6/30/02	Jun-02	24.108	1.046	0.000	0.224	0.465	0.427	1.647	0.425	0.000	0.048
7/1/02 - 7/31/02	Jul-02	24.385	1.221	0.000	0.262	0.902	0.564	1.847	0.363	0.000	0.000
8/1/02 - 8/31/02	Aug-02	23.481	2.023	0.000	0.296	0.477	0.386	1.581	0.624	0.000	0.000
9/1/02 - 9/30/02	Sep-02	20.738	1.714	0.000	0.373	0.330	0.564	0.437	2.714	0.000	0.000
10/1/02 - 10/31/02	Oct-02	23.471	1.108	0.000	0.563	0.431	0.303	1.536	1.253	0.000	0.000
11/1/02 - 11/30/02	Nov-02	23.222	1.033	0.000	0.400	0.553	0.193	0.566	0.563	0.000	0.000
12/1/02 - 12/31/02	Dec-02	24.286	2.130	0.000	0.491	0.649	0.354	0.263	0.368	0.010	0.008

Carbon

Period	Designation	O1	DO1	O2	DO2	O3	DO3	O4	DO4	OP	DOP	E1	DE1	E2	DE2	E3	DE3
12/1/01 - 2/28/02	D01	1.5	0.7	1.8	0.8	3.2	1.8	0.6	0.8	0.0	0.2	0.0	0.2	0.0	0.3	0.0	0.1
3/1/02 - 5/31/02	A02	1.2	0.6	1.8	1.3	3.6	2.7	0.6	0.8	0.0	0.3	0.0	0.2	0.0	0.3	0.0	0.1
6/1/02 - 6/30/02	Jun-02	1.9	1.1	2.6	2.0	5.3	3.4	1.2	1.1	0.0	0.8	0.0	0.4	0.2	0.4	0.0	0.1
7/1/02 - 7/31/02	Jul-02	1.7	0.9	3.0	1.6	6.6	2.7	1.4	0.8	0.0	0.8	0.0	0.5	0.3	0.5	0.0	0.1
8/1/02 - 8/31/02	Aug-02	1.6	1.0	3.0	0.8	6.4	2.2	1.4	0.7	0.2	0.9	0.0	0.4	0.4	0.5	0.0	0.1
9/1/02 - 9/30/02	Sep-02	1.8	0.7	2.9	1.1	5.4	2.3	1.2	0.9	0.0	1.0	0.0	0.7	0.3	0.7	0.0	0.1
10/1/02 - 10/31/02	Oct-02	1.7	0.6	2.8	0.7	5.6	1.9	1.0	0.4	0.0	0.3	0.0	0.1	0.3	0.3	0.0	0.0
11/1/02 - 11/30/02	Nov-02	1.3	0.5	2.4	0.7	4.6	2.1	0.9	0.5	0.0	0.3	0.0	0.2	0.1	0.2	0.0	0.0
12/1/02 - 12/31/02	Dec-02	1.6	1.1	2.3	0.6	4.1	1.7	0.7	0.5	0.0	0.4	0.0	0.2	0.1	0.3	0.0	0.1

The first seasonal quarter overlaps 2001.

The overall precision is a quadratic sum of four components of precision. These are:

- (1) Fractional volume precision, f_v , primarily from the flow rate measurement. A value of 3% is used, based on third-party audits.
- (2) Fractional analytical precision associated with calibration, f_a . This is zero for gravimetric analysis. The values for all other methods are determined from replicate analyses. Most variables have an fractional analytical precision of around 4%, so that the combined volume and analytical precision is around 5%.
- (3) Constant mass per filter precision, σ_a , from either the analysis or artifact subtraction. These are determined from the standard deviations in the designated field blanks, secondary filters, or system control filters. For large concentrations, this is small compared to the fractional terms. This is zero for XRF, PIXE, and PESA.
- (4) Statistical precision based on the number of counts in the spectrum, σ_{stat} . This is used for XRF, PIXE, and PESA. For large concentrations, this is small compared to the fractional terms.

The equation for the total precision is:

$$[\sigma(c)]^2 = [f_v c]^2 + [f_a c]^2 + \left[\frac{\sigma_a}{V} \right]^2 + \left[\frac{\sigma_{stat}}{V} \right]^2$$

The relative precision depends on the concentrations. For large concentrations, only the fractional terms (1 and 2) are important, so the relative precision is around 5%. For small concentrations, the constant analysis/artifact term (3) or the statistical term (4) is important. At the mdl, the precision increases to 50%.

Table 9 lists the relative precisions of measured variables, as defined by the ratio of mean uncertainty to mean concentration. In the calculation for PIXE and XRF elements, if the peak was too small to be identified, the concentrations and uncertainties are both assumed to be equal to one-half of the minimum detectable limit, or a relative uncertainty of 100%. Most variables are in the most precise group, 4% to 7%. No key variables have a relative precision exceeding 15%. All key variables are found on at least 75% of the samples.

The percentage uncertainty is ratio of mean uncertainty to mean concentration. The percentage of significant samples gives the fraction of cases with concentration greater than twice the uncertainty (uncertainty less than than 50%). The first set gives key elements by PIXE/PESA, the second gives key elements by XRF, the third gives variables by other methods, and the fourth gives minor elements by PIXE and XRF. Not included are P, Zr, and Mo, which are found on less than 10% of the samples.

Table 9. Percentage uncertainty and percentage significant of key variables for all samples collected during CY 2002.

Cu-XRf/PESA			Mo-XRF elements			Other species			Minor elements		
	σ	$>2 \sigma$		σ	$>2 \sigma$		σ	$>2 \sigma$		σ	$>2 \sigma$
H	6%	100%	Fe	5%	100%	PM _{2.5}	4%	96%	Mg	29%	6%
Na	26%	20%	Cu	9%	86%	PM ₁₀	4%	98%	Cl	5%	14%
Al	9%	52%	Zn	6%	100%	Cl ⁻	-94%	6%	V	17%	75%
Si	6%	92%	Pb	10%	97%	NO ₃ ⁻	5%	90%	Cr	23%	28%
S	5%	100%	Se	9%	77%	SO ₄ ⁼	4%	97%	Mn	8%	92%
K	5%	99%	Br	6%	100%	OC	15%	100%	Ni	11%	47%
Ca	5%	100%	Sr	10%	72%	EC	29%	99%	Rb	26%	46%
Ti	7%	94%									

5. Data Validation Correlation Plots

Level I validation procedures for sample collection include comparison of the two measurements of flow rate. Level I validation procedures for sample analysis include comparison to recognized standards and periodic replicate measurements. Level II validation procedures include comparison of selected variables measured by different methods. Figure 6, Figure 7, and Figure 8 show annual level II comparisons. These are also performed each season.

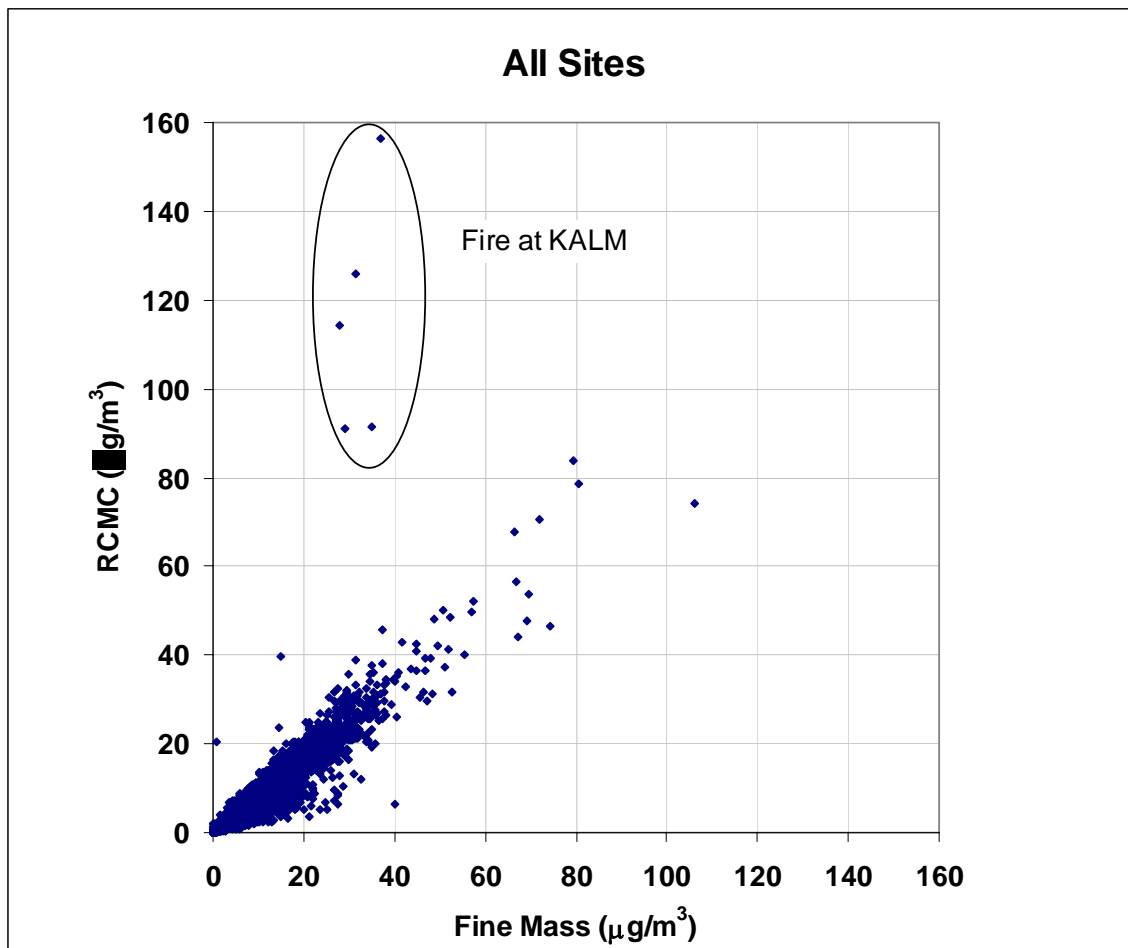


Figure 6. Comparison of reconstructed (RCMC) and gravimetric mass (MF) for all sites in the network.

RCMC uses the carbon measurements from the quartz filter, plus the other measurements from the Teflon filter.

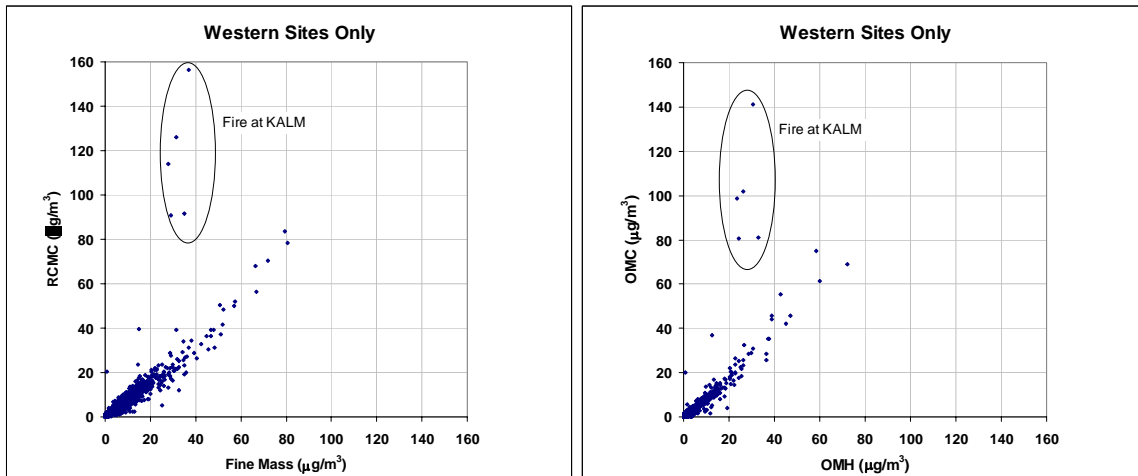


Figure 7. Comparison of reconstructed mass (RCMC) and gravimetric mass (MF) and of organic mass from hydrogen (OMH) and from carbon (OMC) at those sites without high acidity, high nitrate, or marine air.

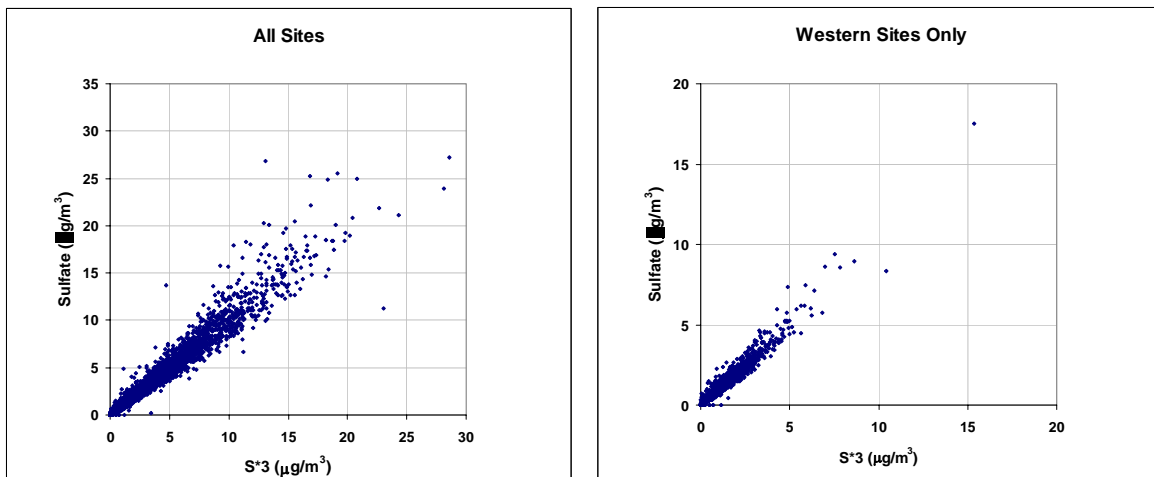


Figure 8. Comparison of sulfur on Teflon times 3 (S*3) and sulfate on nylon (Sulfate). The left plot is for all sites in the network, while the right is for all western sites.

Figure 6 compares reconstructed mass (RCMC, using the carbon measurements from the quartz filter) with the gravimetric mass (MF) measured on the Teflon filter for March 1996 to February 1997 for all sites. Note that if the sulfur were all sulfuric acid, RCMC would overestimate reconstructed mass by 1.1 times the sulfur concentration. The difference between the gravimetric and reconstructed mass is primarily associated with lightly bound water. The RCMC estimate does not include the nitrate that remains on the Teflon filter after collection. (This is generally much less than the ambient nitrate measured by the nylon filter.)

Figure 7 is only for those western sites at which organic mass can be reliably calculated from the hydrogen measurement. The eastern sites are not included because of the occasional presence of sulfuric acid. Western sites with elevated nitrate or with marine influences are also omitted. The left plot compares the reconstructed mass (RCMA, using organic by hydrogen and the coefficient of absorption) with the gravimetric mass (MF). The right plot compares organic mass estimated from hydrogen (OMH) measured on the Teflon filter with the organic mass estimated from carbon (OMCN) measured on the quartz filter.

Figure 8 compares sulfur times 3 measured by PIXE on the Teflon filter with sulfur measured by IC on the nylon filter. The left plot is for all sites, while the right is for the western sites, including those with high nitrate and marine aerosols. There is significant disagreement for some eastern sites, especially during the summer.

6. List of Publications: January-December 2002

- “Characterization of organic aerosol in Big Bend National Park, Texas,” S.G. Brown, P. Herckes, L. Ashbaugh, M.P. Hannigan, S.M. Kreidenweis, J.L. Collett, *Atmospheric Environment*, 36(38):5807-5818, 2002.
- “Composition of PM_{2.5} dust generated from Texas soil at BRAVO sampling sites,” Lowell L. Ashbaugh, Omar F. Carvacho, Michael S. Brown, Robert G. Flocchini, presented at AAAR 2002 Annual Conference, Charlotte, NC, October 7-11, 2002.