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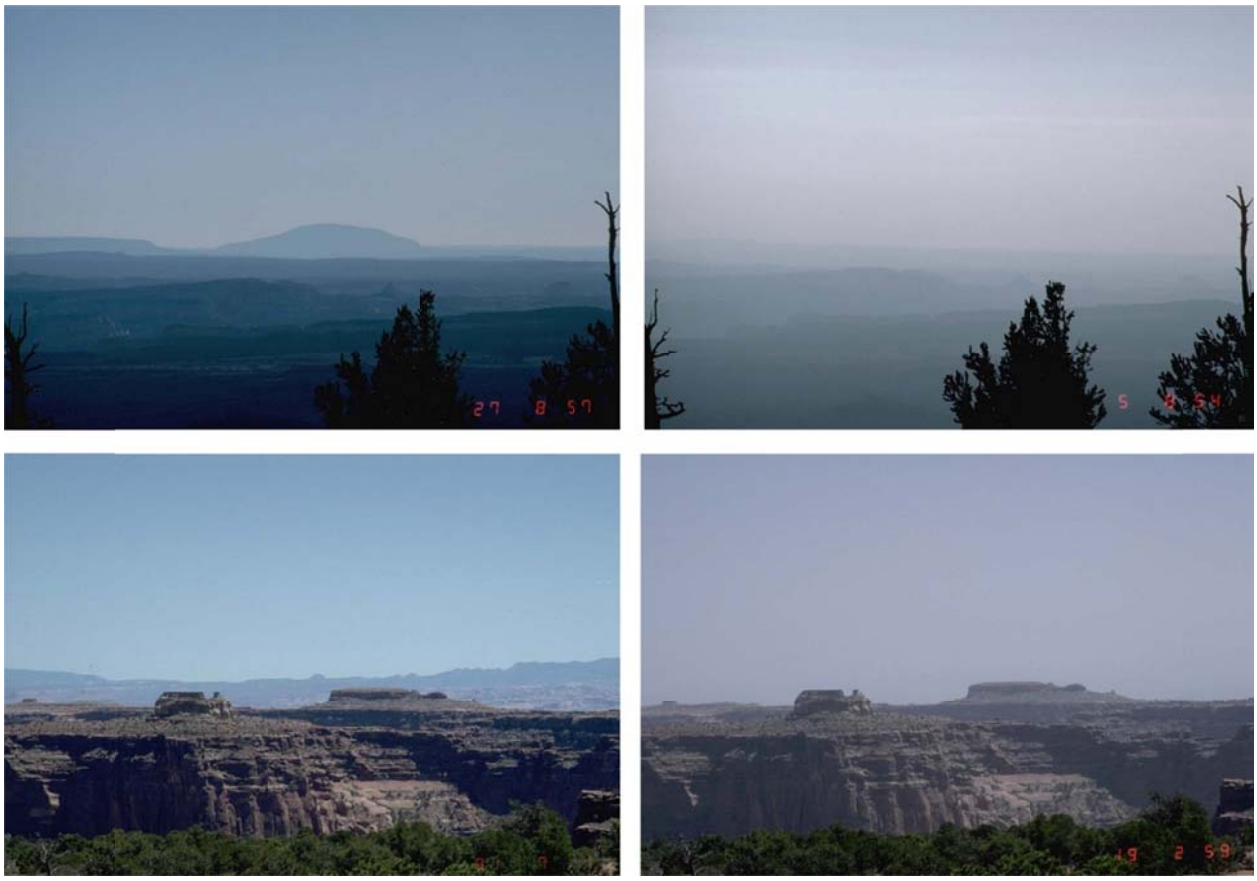
Air Quality Monitoring Protocol and Standard Operating Procedures for the Northern Colorado Plateau Network

Natural Resource Report NPS/NCPN/NRR–2010/239



ON THE COVER
Representative photos showing variation in visibility based on haziness index, light extinction, and visual range (the distance [km] at which a large black object just disappears from view). Top row: Navajo Mountain from Bryce Canyon National Park. Bottom row: Cathedral Butte, Canyonlands National Park.
Source: http://vista.cira.colostate.edu/improve/Data/IMPROVE/Data_IMPRPhot.htm

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Contents

Figures

Tables

Pdfs Packaged with This Protocol

File name: 01-NTN_Site_Manual.pdf
Bibliographic information: National Atmospheric Deposition Program. 1999-01c (revised). National Trends Network site operation manual. Champaign, Ill.
Web location: http://nadp.sws.uiuc.edu/lib/

File name: 02-CASTNet_Operations.pdf
Bibliographic information: Clean Air Status and Trends Network (CASTNET). 2009. Quality assurance project plan, appendix 1, field standard operating procedures, revision 6.0. Prepared for the U.S. Environmental Protection Agency by MACTEC Engineering and Consulting, Inc. November.
Web location: http://www.epa.gov/castnet/docs.html

File name: 03-POMS_Operators_Guide.pdf
Bibliographic information: National Park Service–Air Resources Division. 2008. Portable ozone monitoring station (POMS) operator's guide. Prepared by Air Resource Specialists, Inc., Ft. Collins, Colo.
Web location: http://www.nature.nps.gov/air/studies/portO3.cfm

File name: 04-NPS_Ozone_Protocol.pdf
Bibliographic information: National Park Service–Air Resources Division. 2004. Ozone monitoring protocol: Guidance on selecting and conducting ozone monitoring. Lakewood, Colorado. June.
Web location: http://www.nature.nps.gov/air/Monitoring/docs/FinalOzoneProtocol.pdf

File name: 05-Ozone_Operations.pdf
Bibliographic information: Air Resource Specialists, Inc. 2003. Calibration and routine maintenance of 2B Technologies, Inc. Model 202 ozone analyzers. Technical instruction manual 3100-2005. May.
Web location: http://www.nature.nps.gov/air/studies/portO3.cfm

File name: 06-IMPROVE_Sampler_Maintenance.pdf
Bibliographic information: Crocker Nuclear Laboratory. No date. IMPROVE standard operating procedure 201, version 3 (SOP 201-3): Sampler maintenance by site operators. Davis, Ca.: Crocker Nuclear Laboratory.
Web location: http://vista.cira.colostate.edu/improve/Publications/SOPs/ucdsop.asp

File name: 07-IMPROVE_Operating_Procedures.pdf
Bibliographic information: Crocker Nuclear Laboratory. 2001. Version II IMPROVE sampler operating procedures manual for use in the IMPROVE monitoring network, v2.01.01, Technical Information Document TI 201A. Davis, Ca.: Crocker Nuclear Laboratory. January.
Web location: http://vista.cira.colostate.edu/improve/Publications/SOPs/ucdsop.asp

File name: 08-NTN_Lab_Procedures.pdf
Bibliographic information: National Atmospheric Deposition Program. 2009-09. NADP network quality assurance plan: Central Analytical Laboratory. Champaign, Ill.
Web location: http://nadp.sws.uiuc.edu/lib/

File name: 09-IMPROVE_DP.pdf
Bibliographic information: Crocker Nuclear Laboratory. 2008. IMPROVE standard operating procedure 351, version 2 (SOP 351-2): Data processing and validation. July. Davis, Ca.: Crocker Nuclear Laboratory.
Web location: http://vista.cira.colostate.edu/improve/Publications/SOPs/ucdsop.asp

Acronyms

ACM	Aerochem Metrics 301 precipitation collector
ARS	Air Resource Specialists, Inc.
ARCH	Arches National Park
BLCA	Black Canyon of the Gunnison National Park
BRCA	Bryce Canyon National Park
CAL	Central Analytical Laboratory, Illinois State Water Survey
CANY	Canyonlands National Park
CARE	Capitol Reef National Park
CASTNet	Clean Air Status and Trends Network
CNL	Crocker Nuclear Laboratory
COLM	Colorado National Monument
DCP	data collection platform
DINO	Dinosaur National Monument
EPA	U.S. Environmental Protection Agency
GOES	Geostationary Orbiting Earth Satellite
HNO_3	nitric acid
IMPROVE	Interagency Monitoring of Protected Visual Environments
kg/ha/yr	kilograms per hectare per year
km	kilometers
MVT	Master Version Table
NADP/NTN	National Atmospheric Deposition Program/National Trends Network
NCPN	Northern Colorado Plateau Network
NH_3	ammonia
NH_4	ammonium
NO_3	nitrate
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NPS	National Park Service
NPS-ARD	National Park Service Air Resources Division
POMS	portable ozone monitoring system
SO_2	sulfur dioxide
SO_4	sulfate
TICA	Timpanogos Cave National Monument
USDA-ARS	U.S. Department of Agriculture Agricultural Research Service
VK#	Version Key Number
ZION	Zion National Park

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Protocol Narrative

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

1 Background and Objectives

1.1 Background

The National Park Service (NPS) is charged with maintaining parks and their resources unimpaired for the enjoyment of future generations. Park resources affected by air quality include scenery and vistas, vegetation, water, and wildlife. Both the Clean Air Act and the NPS Organic Act protect air resources in national parks. Additionally, the Northern Colorado Plateau Network (NCPN) has identified several aspects of air quality as high-priority vital signs for monitoring. Over the past three decades, the NPS has developed several internal and cooperative programs for monitoring various measures of air quality that the NCPN is incorporating into its program (NPS-ARD 2002).

Three main components comprise the NPS air quality monitoring program: atmospheric deposition, ozone, and visibility. Below is a review of that monitoring as it is conducted in NCPN parks. Table 1-1 lists air quality monitoring currently occurring in the NCPN; Figure 1-1 shows the locations of air quality monitoring stations in the NCPN region. At present, on-site air quality monitoring is conducted at Bryce Canyon National Park (BRCA), Canyonlands National Park (CANY), Capitol Reef National Park (CARE), Colorado National Monument (COLM), Dinosaur National Monument (DINO), and Zion National Park (ZION) (Table 1-1). Northern Colorado Plateau Network reporting will summarize information from these on-site monitors.

In addition, the NPS Air Resources Division (NPS-ARD) has determined that deposition and ozone monitors within 16.1 km (10 miles) of a park boundary, and particulate (visibility) monitors within 100 km (60 miles), may be reasonably considered representative of a park's air quality (NPS-ARD 2009). Under these guidelines, the NCPN also reports on status for Arches National Park (ARCH), Black Canyon of the Gunnison National Park (BLCA), Cedar Breaks National Monument (CEBR), Curecanti National Recreation Area (CURE), Natural Bridges National Monument (NABR), and Timpanogos Cave National Monument (TICA). A summary of past air quality monitoring in NCPN parks is shown in Table 1-2. If these stations become operational again, or if others are added in network parks, the NCPN will collect this information, as well.

This protocol documents the methods currently used for collecting air quality data in NCPN parks and describes how related data products are retrieved, managed, and analyzed for regular reporting to NCPN parks.

Table 1-1. Summary of ambient air quality monitoring in and nearby to NCPN parks.

Park code	Wet deposition	Dry deposition	Ozone	Visibility
Parks with monitoring stations within their boundaries				
BRCA	UT99 (NADP/NTN)	-	-	Bryce Canyon NP (BRCA1-IMPROVE)
CANY	UT09 (NADP/NTN)	CANY 407 (CASTNet)	CANY-IS (CASTNet)	Canyonlands NP (CANY1-IMPROVE)
CARE	-	-	-	Capitol Reef NP (CAPI1-IMPROVE)
COLM	-	-	COLM-MY (POMS)*	-
DINO	-	-	DINO-WE (POMS)*	-
ZION	-	-	ZION-DP (NPS-GPMP)	Zion NP (ZICA1-IMPROVE)
Parks with monitoring stations close enough to be reasonably considered representative of the park				
ARCH	-	-	-	Canyonlands NP (CANY1-IMPROVE)
BLCA	-	-	-	Weminuche Wilderness (WEMI1-IMPROVE)
CEBR	-	-	-	Bryce Canyon NP (BRCA1-IMPROVE)
CURE	-	-	-	Weminuche Wilderness (WEMI1-IMPROVE)
NABR	-	-	-	Canyonlands NP (CANY1-IMPROVE)
TICA	-	-	EPA Site # 490495008442011	-

*POMS sites are designated for short-term monitoring.
Source: http://www.nature.nps.gov/air/monitoring/MonHist/park.cfm

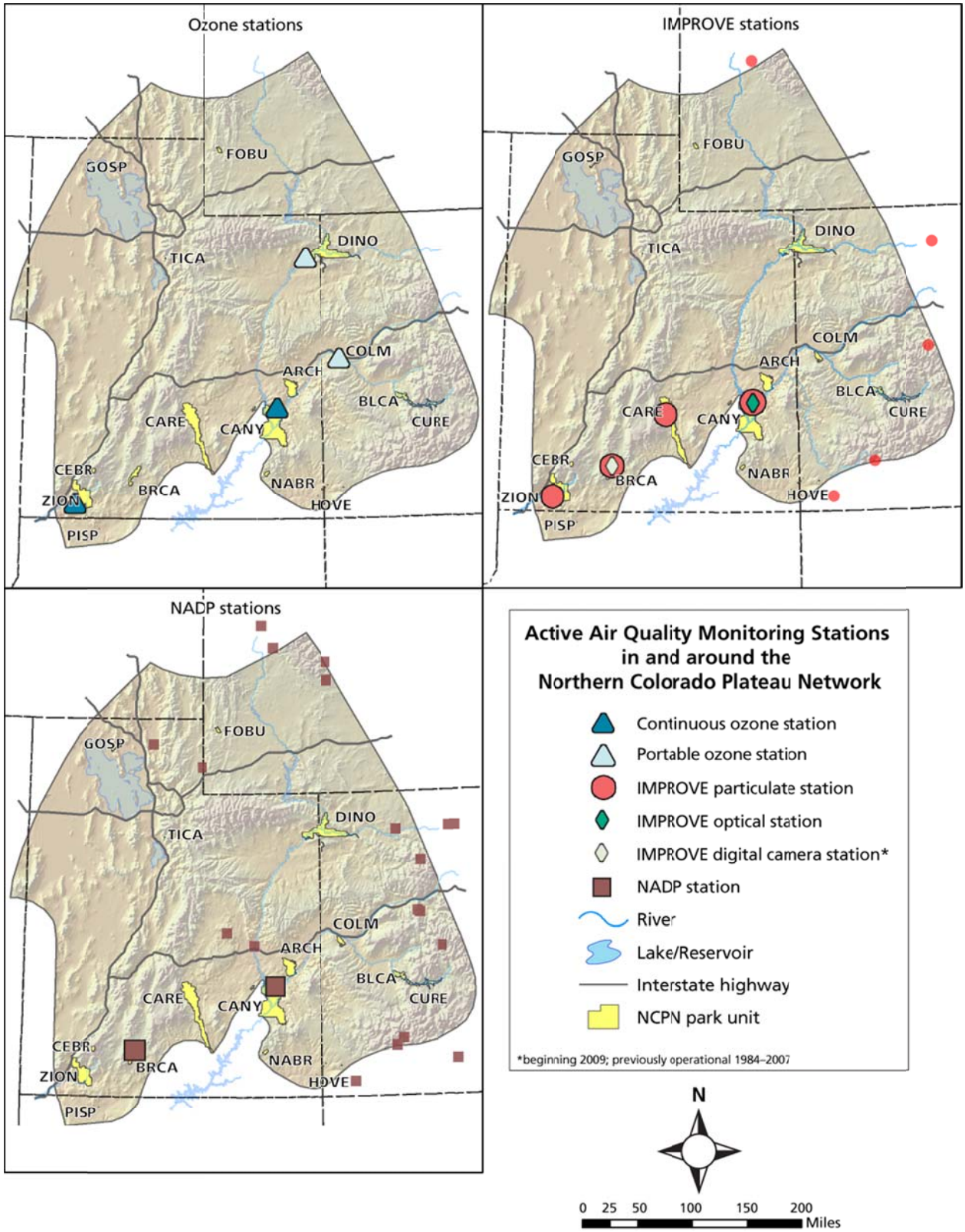

Figure 1-1. Air quality monitoring stations in the NCPN region.

Table 1-2. Inactive air quality monitoring sites in the NCPN as of 2010.

	Program (Location/s)		
Park code	**Gaseous**	**Ozone**	**Visibility**
ARCH	IMPROVE (SO_2) (Devils Garden Campground, 1988–1992)	NPS-GPMP (Devils Garden Campground, 1987–1992)	NPS-VIS (Balanced Rock, 1986–1992; Devils Garden Campground, 1979–1987) IMPROVE (Devils Garden Campground, 1988–1992)
BLCA		NPS-PASVO3 (Gravel Pit, 1995–2002) NPS-POMS (2003–2005)	NPS-VIS (BLCA NM, 1985–1993)
BRCA	IMPROVE (SO_2) (Bryce Point, 1988–1992)	NPS-PASVO3 (Science Peak, 1995–2004)	IMPROVE (Bryce Point, 1988–2000) NPS-VIS (Bryce Point, 1978–1987)
CANY	IMPROVE (SO_2) (Island in the Sky, 1988–1995)		NPS-VIS (Hans Flat, 1979–1981; Island in the Sky, 1978–1987; Island in the Sky–North, 1987–1995) IMPROVE (1988–2000; transmissometer 1986–2006)
CARE		NPS-PASVO3 (Cathedral, Peek-a-Boo, 1999; Passive O3 site, 1995–1999)	NPS-VIS (Cathedral, 1983–1986; Panorama Point, 1978–1983; Peek-a-Boo, 1986–1991)
COLM	NPS-GPMP (SO_2) (Bone Yard, 1984–1992)	NPS-GPMP (Bone Yard, 1984–1992)	NPS-VIS (Visitor Center–West, 1980–1991)
DINO			NPS-VIS (Scenic Overlook, 1979–1987)
ZION		NPS-PASVO3 (East Entrance, 1998–2002; Headquarters, 1995–2002; Kolob Canyons, 1998–2002)	NPS-VIS (Kolob Canyons Overlook, 1985–1991; Zion, teleradiometer, 1985) IMPROVE (Zion, 2000–2004)

Source: http://www.nature.nps.gov/air/monitoring/MonHist/park.cfm

1.1.1 Atmospheric deposition

Wet deposition occurs when air pollutant emissions, such as sulfur dioxide (SO_2), nitrogen oxides (NOx), and ammonia (NH_3) from power plants, automobiles, agriculture, and other sources are transported and transformed in the atmosphere and deposited to ecosystems as gases and particles (including sulfate [SO_4], nitrate [NO_3], and ammonium [NH_4] compounds) via rain or snow. Dry deposition of particles and gasses occurs through complex processes such as settling, impaction, and adsorption.

Atmospheric deposition can have a variety of effects on ecosystems, including acidification, fertilization or eutrophication, and accumulation of toxins. In freshwater lakes, streams, and watersheds, acid deposition from sulfur and nitrogen compounds can cause changes in water chemistry that affect algae, fish, submerged vegetation, and amphibian and aquatic invertebrate communities. Deposition also can cause changes in soil that affect soil microorganisms, plants, and trees. Because certain plants are better able to utilize nitrogen, nitrogen deposition can result in shifts in plant species composition. Excess nitrogen deposition can cause unwanted fertilization effects, leading to changes in plant community structure and diversity. Nitrogen additions also can result in higher plant biomass and, consequently, higher fire frequency and severity.

The NPS monitors the chemistry of precipitation in national park units as a partner in the National Atmospheric Deposition Program (NADP) National Trends Network (NTN). Rainwater samples collected weekly using standard methods are sent to a central laboratory for analysis. Measured constituents include hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (including calcium, magnesium, potassium, and sodium). In the NCPN, BRCA has participated in this program since 1985, and CANY since 1997. NO_2 and SO_2 are also contaminants for which "non-attainment" areas are designated for exceeding regulatory thresholds.

Dry deposition chemistry is monitored in CANY and DINO in conjunction with the Clean Air Status and Trends Network (CASTNet). Over a weeklong period, fine particles and gases suspended in the air are collected on filters that are analyzed at a central laboratory. Meteorological, vegetation, and land-use data from the sites are used to calculate deposition velocities, which are combined with the concentration measurements to estimate dry deposition in kilograms per hectare per year (kg/ha/yr) of ammonium, nitrate, nitric acid, sulfate, and sulfur dioxide. At DINO, dry deposition data are collected by a portable ozone monitoring system (POMS; see next section).

1.1.2 Ozone

Ozone is a gaseous constituent of the atmosphere produced by reactions of water and oxygen with anthropogenic pollutants—particularly NOx—and by lightning. Ground-level ozone is the major constituent in smog. Ozone in certain concentrations is toxic to humans, and some plant species are particularly sensitive to ozone damage (Porter 2003). The Environmental Protection Agency (EPA) has set a national standard for ozone to protect human health and the environment. Areas not meeting the standard are designated as non-attainment areas, and states are required to develop plans to bring such areas into attainment. No NCPN park units are in current non-attainment areas for ozone (EPA 2004).

Ozone is monitored using continuous samplers at CANY and ZION. Data from a nearby EPA site are interpolated for application to TICA. This method employs a gas analyzer that measures ultraviolet absorbance to produce hourly ozone concentration measurements. Continuous monitoring is done as part of the NPS Gaseous Pollutant Monitoring Program, in partnership with the EPA's CASTNet program. At COLM and DINO, ozone data are collected by POMS units, which are small, low-power ozone analyzers. Two POMS versions are available: one with and one without filter-pack sampling for dry deposition. POMS are generally used for survey and temporary monitoring projects (http://www.nature.nps.gov/air/studies/portO3.cfm).

The NPS-Air Resources Division completed an ozone risk assessment for NCPN parks in 2004, based on the concept that foliar ozone injury on plants is the result of the interaction of the plant, ambient ozone, and the environment. That is, the risk for foliar injury is high if three factors are present: species of plants that are genetically predisposed to ozone injury; concentrations of ambient ozone that exceed a threshold required for injury; and environmental conditions that foster gas exchange and the uptake of ozone by the plant. The assessment concluded that the risk of foliar injury to plants is low in all NCPN parks (NPS 2004). Several parks have ozone levels that exceed thresholds for foliar injury to plants, but these ozone levels tend to occur during drought conditions, which reduce the potential for injury.

1.1.3 Particulate matter and visibility

Visibility-obscuring particulate matter consists of dust, soot, and other fine solid materials that become suspended in the air. Major sources of particulates are burning of fossil fuels, fires, wood smoke, and wind-blown soil. Regulatory standards for particulates and visibility include designation of non-attainment areas and visibility standards for Class I areas designated by the Clean Air Act. Six NCPN park units are designated Class I areas: ARCH, BLCA, BRCA, CANY, CARE, and ZION. Although not a Class I area, TICA is located in Utah County, which is in non-attainment for PM_{10} (mass of particulates up to 10 µm in diameter) (http://www.epa.gov/air/oaqps/greenbk/pntc.html) and partial non-attainment for $PM_{2.5}$ (mass of particulates up to 2.5 µm in diameter) (http://www.epa.gov/pmdesignations/2006standards/final/region8.htm).

Visibility monitoring currently occurs in BRCA, CANY, CARE, and ZION as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) program.[1] As per the NPS-ARD (2009), data from CANY are interpolated for application to ARCH and NABR; data from BRCA are interpolated for application to CEBR; and data from the Weminuche Wilderness site in the San Juan National Forest are interpolated for application to BLCA and CURE. Fine particles of two size classes are collected on filters and sent for laboratory analysis of chemistry and mass. Samples are collected for a 24-hour period every third day. Particle samplers, used to calculate the mass and chemical composition of fine-particle matter ($PM_{2.5}$) and the mass of coarse particulate matter (PM_{10}) in the atmosphere, are located at all IMPROVE sampling sites.

At BRCA, a digital camera monitoring station was active at Yovimpa Point from 1984 to 2007, became active again beginning in 2009, when the park took over its funding. Similar stations were formerly operational at ARCH, BLCA, CANY (2), CARE (2), COLM, DINO, and ZION (see Table 1-2). The photographs acquired from these stations provide images representing the range of visibility conditions at each site. Representative images can be viewed at http://vista.cira.colostate.edu/improve/Data/IMPROVE/Data_IMPRPhot.htm.

1.2 Monitoring questions and measurable objectives

Air quality parameters are monitored in NCPN park units by the NPS in cooperation with national air quality monitoring programs. Air quality data are summarized and analyzed for conditions and trends by both the NPS-ARD and those national programs. Therefore, it is not the NCPN's objective to replicate these analyses. Instead, the network aims to compile the data summaries performed by these groups and provide them in a concise report to be analyzed in conjunction with other NCPN vital signs. In addition, the NCPN seeks to see how ozone, nitrogen deposition, sulfur deposition, and visibility-reducing

[1] The nearest visibility monitoring to ARCH is at CANY, 35 km to the south; the nearest visibility monitoring to BLCA is at White River National Forest, 65 km to the north.

pollutants vary with associated vital signs (e.g., integrated upland, integrated riparian, climate). NCPN air quality monitoring objectives are to:

1. Determine the seasonal and annual status and trends in concentrations of N- and S-containing ions from wet deposition at BRCA and CANY;

2. Determine the seasonal and annual status and trends in dry-deposition chemistry at CANY;

3. Determine the seasonal and annual status and trends in ozone concentration at CANY, COLM, DINO, and ZION, and make status estimates for TICA, which has a station in the vicinity of the park; and

4. Determine the seasonal and annual status and trends in concentrations of visibility-reducing pollutants at BRCA, CANY, CARE, and ZION from stations in the park and make status estimates for ARCH, BLCA, CEBR, CURE, and NABR based on stations from the vicinity.

Air quality monitoring in the NCPN is also conducted to allow the NPS to report on goals under the Government Performance and Results Act.

2 Methods

2.1 Sampling design

Criteria for selecting air quality monitoring sites are determined by NPS-ARD objectives for systemwide sampling. Monitoring equipment is generally sited subjectively rather than according to a specific sampling design. Therefore, sampling locations are not allocated so as to allow statistical inference to a broader population of sites.

2.2 Field methods

Most of the field collection of air quality samples and data is automated, the principal exceptions being the changing of sample collectors (filters, buckets) and the completion of the Field Observer Reporting Form (see Section 2.2.1.1). Field operations consist of weekly visits for inspection, routine maintenance, and sample collection by park staff, and semi-annual to annual maintenance by program specialists.

2.2.1 Atmospheric deposition

2.2.1.1 Wet deposition

The NPS conducts wet deposition monitoring through the NADP, which has more than 200 sites nationwide funded by federal, state, and other partners. The NPS sponsors almost 50 NADP sites, including sites in two NCPN parks (BRCA and CANY). Each site is equipped with a precipitation collector and a rain gauge. Weekly precipitation samples are collected and analyzed by the Central Analytical Laboratory (CAL), Illinois State Water Survey.

Each NADP site is required to use identical equipment: an Aerochem Metrics 301 precipitation collector (ACM) and a Belfort B5-780 rain gauge with event recorder. The electrically powered ACM automatically collects precipitation samples to be sent for analysis, while the Belfort gauge mechanically measures and records the amount of precipitation.

The NADP instrument is designed to parse wet deposition transported through precipitation from total particulate deposition. To sort these inputs, the collector employs one "dry-side" bucket, one "wet-side" bucket, and one mobile lid that prevents one bucket or the other from receiving deposition. In the absence of precipitation, the lid seals the wet-side bucket and allows accumulation of dry particulates in the dry-side bucket.[2] Incoming precipitation triggers a moisture sensor that in turn activates a motor that moves the lid from the wet-side to the dry-side bucket, allowing wet deposition to be collected in the former.

The rain gauge serves as an independent measure of precipitation, and its event recorder records the opening and closing of the wet-side bucket in a way that can be compared with precipitation events.

The site operator is responsible for weekly site and equipment inspection, sample collection, and completion of the Field Observer Reporting Form, where details on the sample timing, precipitation, and the status and maintenance of the equipment are recorded. Also, CAL staff may call upon the site operator

[2] Note: The dry-side bucket is not used to sample dry deposition, as the bucket method is not effective at sampling this fraction of the particulate spectrum. Instead, dry deposition is measured to NPS and EPA standards using the CASTNet system described in Section 2.3.2. The purpose of the dry-side bucket is to protect the rubber seal on the lid during dry periods and to serve as a fallback estimation of wet deposition and precipitation if the lid–motor system fails to operate properly.

to troubleshoot and repair malfunctioning equipment. Weekly sample collection procedures and routine maintenance and testing, as well as biennial site-visit procedures, are described in 01-NTN_Site_Manual.pdf, packaged with this protocol.[3]

2.2.1.2 Dry deposition

EPA's CASTNet is the nation's primary monitoring network for estimating dry atmospheric deposition of pollutants, including SO_4, NO_3, NH_4, SO_2, and nitric acid (HNO_3). For one-week intervals, a pump pulls air through filter packs that are then sent a central analytical laboratory in Gainesville, Florida, for analysis. CASTNet uses NADP data in conjunction with dry deposition data to report total deposition. Canyonlands National Park has the only CASTNet sampler in the NCPN. The SOPs used for the CASTNet sampler at CANY are described in 02-CASTNet_Operations.pdf, packaged with this protocol. Dry deposition at DINO is sampled by a POMS, according to CASTNet protocols. The POMS SOP is described in 03-POMS_Operators_Guide.pdf, packaged with this protocol.

2.2.2 Ozone

Ozone monitoring is conducted at CANY and ZION as part of the NPS Gaseous Pollutant Monitoring Network (GPMN). The GPMN uses continuous ozone analyzers configured as a reference or equivalent method specified by the EPA in Appendix D of 40 CFR Part 50. The NPS ozone monitoring protocol is described in 04-NPS_Ozone_Protocol, packaged with this protocol.

At COLM and DINO, POMS units are used for ozone monitoring. The portable ozone analyzers operate on the same principle as the instruments described above: UV absorption by ozone. To reduce the size and power, miniaturized electronics and subsystems are used in the analyzers. In the configuration used by the NPS, a primary analyzer samples ambient air all the time and a secondary analyzer is turned on briefly at night to check the first instrument. A datalogger controls the systems, collects all the data, and is used for the communications. Data is extracted from the system using a data transfer module, by phone, or over a satellite link (http://www.nature.nps.gov/air/studies/portO3.cfm).

For both types of monitors, site operations are supervised by Air Resource Specialists, Inc. (Ft. Collins, Colorado) under contract with the NPS-ARD. Park staff visit sites weekly to maintain equipment, verify that it is functioning properly, and replace dry deposition filters. A log is maintained of all significant activity at the site. The site operator may also be called upon by Air Resource Specialists (ARS) staff to troubleshoot and repair malfunctioning equipment. Field site procedures for continuous ozone and dry deposition monitoring are described in the documents cited in Section 2.2.1.2, as well as in 05-Ozone_Operations.pdf, packaged with this protocol.

2.2.3 Visibility

IMPROVE monitoring protocols include three types of visibility monitoring: particle (or aerosol), scene, and optical. Particle samplers, used to calculate the mass and chemical composition of fine particle matter ($PM_{2.5}$) and the mass of coarse particulate matter (PM_{10}) in the atmosphere, are located at all IMPROVE sampling sites. IMPROVE monitoring sites in the NCPN include particle samplers.

IMPROVE particulate site operations are supervised by the sample laboratory of the Crocker Nuclear Laboratory (CNL), University of California–Davis. Particle sampling stations employ four independent

[3] All procedural SOPs cited in and packaged with this protocol were valid as of September 2008. NCPN staff should periodically check the associated websites for updates.

sample filter modules, each with an independent pump. A single TERN 16-bit controller controls all four samplers. Operations involve weekly visits by park staff to change sample filters, verify normal operations, and inspect equipment. Park staff retrieve memory cards bi-weekly. CNL staff also may call upon the site operator to troubleshoot and repair malfunctioning equipment. Sample filters, memory cards, and datasheets are sent to the CNL for analysis. Biennial audits are performed at each site, and equipment is calibrated annually. Field-site procedures for particulate matter sampling are described in 06-IMPROVE_Sampler_Maintenance.pdf and 07-IMPROVE_Operating_Procedures.pdf, packaged with this protocol.

Scene monitoring has been part of the IMPROVE program and its predecessor networks for two decades. Beginning again in 2009 (after being discontinued in 2007), a digital camera monitoring station at BRCA will collect color photographs to document visual conditions at Yovimpa Point, near the park's southern boundary.

3 Data handling and reporting

3.1 Data entry, verification, and editing

Data entry and data verification/validation are the responsibility of the various monitoring programs and their contractors. Each has a quality assurance plan. Their procedures are reviewed briefly below and detailed in the referenced documents.

3.1.1 Atmospheric deposition

Upon receipt of samples at the CAL, data from the Field Observer Reporting Forms are entered into an R:BASE relational database. After sample processing and analysis, data from Laboratory Observer Reporting Forms are entered into the database. In each case, double-entry procedures are followed and discrepancies are resolved by the NADP database manager. Results of chemical analyses are loaded into the R:BASE database and merged with the descriptive information and metadata contained in the Field Observer Reporting Form. These procedures are reviewed in 08-NTN_Lab_Procedures.pdf, packaged with this protocol.

Laboratory data collection for dry deposition chemistry is automated. The data management center of MACTEC Engineering & Consulting, in Gainesville, Florida, performs the laboratory analyses on the filter packs for CASTNet dry deposition chemistry. Quality Assurance/Quality Control (QA/QC) for these data (detailed in MACTEC 2003) consists, among other procedures, of verifying that values are reasonable.

3.1.2 Ozone

Continuous ozone measurements are recorded by dataloggers attached to the analyzers. These data are downloaded to the USDA-ARS Information Management Center daily, by modem, and e-mailed, monthly, to the MACTEC data management center, which provides them to the EPA after QA/QC procedures are completed. For POMS units, data validation, storage, and reporting follow a similar sequence to that described above.

3.1.3 Visibility

Particulate data processing and validation are performed in parallel, principally at the CNL, where the samples are processed (field-site operators verify flow rates of sampler modules). The CNL data management group reviews and finalizes data, and places them on an anonymous ftp site for retrieval by end users. These procedures are detailed in 09-IMPROVE_DP.pdf, packaged with this protocol.

Since 1998, the IMPROVE program has been storing images from monitoring sites with more than five years of data on CD-ROM "spectrums," intended to capture the range, or "spectrum" of visual conditions at each site. A spectrum typically includes 40 to 80 digital images. Each CD also contains a site-specific map, a summary of the scene monitoring history of the site, and related data. The images are provided in high resolution .PCD and .JPG formats, and represent four categories: (1) spectrums ranging from good to poor visual air quality for both a morning and afternoon time period, (2) layered hazes, (3) visual air quality episodes, and (4) scenic views (IMPROVE 1998). Spectrums can also be viewed at http://vista.cira.colostate.edu/improve/Data/IMPROVE/Data_IMPRPhot.htm.

3.2 Data acquisition

Data products from the various air quality monitoring programs are acquired from web-based program archives. Wet deposition data are archived by the NADP/NTN. Dry deposition data are archived by the EPA CASTNet program. Ozone data from in-park monitors are archived by the NPS-ARD. Visibility data are archived by the IMPROVE program. Because these data are readily available online, the NCPN

will routinely collect only the data products (e.g., charts and graphics derived from the raw data) provided by the programs, for use in the network's air quality monitoring report (see SOP #1 and Appendix A). Should it prove necessary for the network to download archived raw data and associated metadata, the appropriate SOPs are contained in Appendix B.

3.3 Metadata procedures

All changes to this protocol narrative and SOPs are noted in a Master Version Table (MVT), which is maintained in SOP #2. Any time the narrative or an SOP version changes, a new Version Key Number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The VK# is essential for project information to be properly interpreted and analyzed. The protocol narrative, SOPs, and data should not be distributed independently of this table. Other metadata will be created for the data products according to NCPN metadata procedures (refer to the NCPN Metadata Guidance Document for details).

3.4 Data archival procedures

The NCPN locally archives all data products downloaded from air quality monitoring stations in their native format, designated as read-only.

3.5 Data analysis and reporting

NCPN air quality reports are prepared for parks with any type of air quality monitoring—currently ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, NABR, TICA, and ZION. Specific instructions for preparing reports are found in SOP #1. Appendix A is an example of an air quality report. These reports include assessments of air quality status and trends at individual sites and in comparison with the rest of the region.

4 Personnel Requirements and Training

Personnel are required for on-site maintenance as well as for data downloading, processing, analysis, and reporting.

4.1 Roles and responsibilities

On-site personnel, responsible for weekly visits, are staff at parks where air quality monitoring stations occur. Technical support is provided by the NPS-ARD or EPA employees and affiliated contractors. Downloading, analyses, and reporting of NCPN air quality data products will be completed by NCPN staff.

4.2 Training procedures

Contractors are required to provide staff with adequate training to perform equipment inspections and calibrations. Park staff is typically trained on the job by other staff experienced with the procedures. This on-the-job training is supplemented with additional training, as needed, during site inspection and calibration visits by contractors. All laboratory analyses are performed under contract, with contractors being responsible for training their employees.

5 Operational Requirements

5.1 Annual workload and field schedule

Depending on the air quality monitoring equipment present, weekly visits for routine maintenance require one person for up to eight hours per week. Additional time for emergency repairs or unscheduled equipment checks (due to observed problems with data) also can require up to eight hours per week. These costs are currently incurred by the host parks, with financial support from the NPS-ARD. The costs of semiannual inspections, laboratory analyses, shipping and handling of samples, and data management are not known; these are incurred by the NPS-ARD and the EPA at a scale that is difficult to differentiate at the network level. Data retrieval, archiving, analysis, and report preparation will require approximately one pay period per every other year of NCPN staff time.

5.2 Facility and equipment needs

This protocol describes several ongoing programs, and is based on the assumption that the programs will continue to be externally funded. Facilities and equipment are described in the narrative above and in the SOPs. The NCPN does not plan to fund additional air quality monitoring in the network park units.

5.3 Startup costs and budget commitments

There are no startup costs associated with this program at the network level. It is anticipated that this protocol will require approximately one-half of one pay period per every other year each for the network ecologist, data technician, and writer-editor.

5.4 Procedures for making changes to and archiving previous versions of the protocol

Revisions to the protocol narrative and SOPs will be inevitable over time. Explicit documentation of these changes is critical for proper acquisition, processing, interpretation, and analysis of air quality data. Procedures for changing the protocol narrative and related SOPs are documented in SOP #2. The protocol narrative and all SOPs are labeled with version numbers and included in a revision history log. Changes to either document type are to be accompanied by changes in version numbers. The version numbers, dates, changes, reason for the changes, and author of the changes are to be recorded in the revision history log for each SOP. The updated version numbers must be recorded in the Air Quality Master Version Table (see SOP #2) and conveyed to the network data manager for proper updating of the MVT database. Previous versions of the protocol narrative and SOPs will be housed at “Archive on Inpcanyimms2” (R:\Archive\Monitoring_Archive\Air_Quality\Protocol).

6 References

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Standard Operating Procedures

SOP #1:
Preparing an Air Quality Report

Version 1.00
September 26, 2008

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This SOP gives step-by-step instructions for producing air quality monitoring reports for the NCPN. Efficient reporting of monitoring results is critical in assisting park resource managers with management decisions. An example report in the proper format is provided as Appendix A of this document. The text and tables from this report are stored on the NCPN X drive and can be used as a template for preparing future reports.

NCPN air quality reports include data for parks with any type of air quality monitoring—currently ARCH, BLCA, BRCA, CANY, CARE, CEBR, COLM, CURE, DINO, NABR, TICA, and ZION. ARCH, BLCA, BRCA, CANY, CARE, and ZION are Class I air quality areas.

It is not necessary for individuals preparing annual NCPN air quality reports to have strong backgrounds in air quality, but the preparer is required to interpret graphs acquired from external sources. If the preparer desires more in-depth interpretation, s/he should contact NPS Air Resources Division personnel for more information (http://www.nature.nps.gov/contact/; Ellen_Porter@nps.gov; or John_D_Ray@nps.gov).

Report format

Follow NPS Technical Report Series Guidelines, available at http://www.nature.nps.gov/publications/NRPM/index.cfm. Reports shall be entered into the NRTR numbered series. Report numbers are provided by WASO I&M staff.

Create a folder for files that will be used to create the annual report that includes the reporting year (e.g., *2010_AQ_Report*) in "i&m on Inpcanyimms2" (X:\Active_Monitoring_Projects\Air_Quality\Reports). Maintain all report files here.

Report content

Reporting for each park will include air quality parameters monitored in that park. Table 1-1 in the protocol narrative shows which parameters are monitored in NCPN parks.

Introduction

This section should not change appreciably from one reporting interval to the next.

Methods

This section will not change appreciably from one reporting interval to the next unless monitoring methods are changed.

Results

The following sections contain instructions on how to collect the information and graphics required to populate the Results section of the report.

NPS-ARD summary. The NPS-ARD reports trends in air quality parameters, with associated statistical significance, in compliance with the Government Performance and Results Act (GPRA) for NPS sites with long-term monitoring.

To download the NPS-ARD summary:

1. Direct the web browser to http://www2.nature.nps.gov/air/who/npsPerfMeasures.htm.
2. Download and save the most recent trends report to the folder you created in "i&m on Inpcanyimms2" (X:\Active_Monitoring_Projects\Air_Quality\Reports) using the existing file name.
3. Collect information from the trends report for the parks of interest. Use this information to prepare first paragraph of the report's "Results" section (see Appendix A for an example).

Deposition

Wet deposition (NADP).

Concentration data—. Because concentration is not dependent on precipitation amount, concentration data are useful for examining spatial and temporal trends.

To download concentration graphics:

1. Direct the web browser to the NADP homepage (http://nadp.sws.uiuc.edu/).
2. In the bright blue box, under the Map Access tab, select Network: NTN, Map Type: Concentration, Analyte: NO_3, and Year of interest.
3. Click Submit. (You may have to tell your computer to allow pop-ups.)
4. Click the "Download as .pdf" button.
5. Save the files in the folder for that year's reports, adding the year and "conc" to the file name (e.g., *2010_NO3conc.pdf*).
6. Repeat steps 2–5 for both SO_4 and NH_4. See Appendix A, Figure 3-1 for an example.

Deposition data—. Deposition data are useful for evaluating the amount of pollutant that is delivered to an ecosystem. Deposition is dependent on precipitation amounts (deposition = concentration × precipitation), and therefore may differ significantly from year to year.

To download deposition graphics:

1. Follow the steps above, but for Map Type, select Deposition instead of Concentration.
2. Save the files in the the folder for that year's reports, adding the year to the file name (e.g., *2010_SO4dep.pdf*). See Appendix A, Figure 3-2 for an example. (There should be a third figure showing ammonium deposition.)

Use this information to prepare the "Atmospheric deposition/Regional patterns" portion of the "Results" section.

Site summary—. To download site summary data:

1. Direct the web browser to the NADP homepage (http://nadp.sws.uiuc.edu/).
2. In the bright blue box, under the Data Access tab, select Network: NTN, click submit.
3. On the pop-up map, click on Utah.
4. Select the appropriate site (Bryce Canyon NP, UT99; Canyonlands NP, UT09).
5. Select "Annual Data Summaries", then select the appropriate year. Save this pdf file to the report file as *ParkName_Year_NADP_Summary.pdf* (e.g., *BRCA_2010_NADP_Summary.pdf*).

Site trends—. As noted above, concentrations are useful for temporal trends, as they are not significantly influenced by yearly fluctuations in rainfall.

To download site trend data:

1. Repeat steps 1–4 above.
2. Select "Trend Plots."
3. Select NO3, "kg/ha" for units, Graph Size: Large, and click "Create Plot."
4. Right-click on the graph, select "Copy" and paste into a Word file (BRCA_2010_no3_trends.docx).
5. Repeat steps 1–4 for NH_4 and SO_4, "kg/ha" for units. Name the files appropriately (e.g., *BRCA_2010_nh4_trends.pdf, BRCA_2010_so4_trends.pdf*). See Appendix A, Figures 3-7, 3-8, and 3-9 for an example.

A link to "Trends notes" describes how the trend lines were created and discusses data completeness criteria. Use this information to prepare the "Atmospheric deposition/Site trends" portion of the "Results" section.

Dry deposition (CASTNet).

To download dry deposition trends and composition data:

1. Direct the web browser to CASTNet's homepage (http://www.epa.gov/castnet/), select "Site Information," then select CAN407/Canyonlands National Park from the site list or from the map.
2. Click on the graph labeled "Trends in total nitrogen deposition."
3. Right-click on the graph, select Save Picture As, and choose bmp. **Do not save as a .gif file.** Save as *CANY_Year_totalN_castnet.bmp*.
4. Select Back, repeat steps 2–3 for the graph labeled, "Trends in total sulfur deposition." Save this image as *CANY_Year_totalS_castnet.bmp*. See Appendix A, Figure 3-16 for an example.
5. Select Back, repeat steps 2–3 for the pie chart labeled, "Composition of total nitrogen deposition by species." Save this image as *ParkName_Year_ndep_castnet* (e.g., *CANY_2010_ndep_ castnet.bmp*).
6. Select Back, repeat steps 2–3 for the pie chart labeled, "Composition of total sulfur deposition by species." Save this image as *ParkName_Year_sdep_castnet.bmp* (e.g., *CANY_2010_sdep_castnet.bmp*). See Appendix A, Figure 3-17 for an example.
7. Select Back, repeat steps 2–3 for the bar chart labeled, "Trends in wet and dry nitrogen deposition." Save this image as *ParkName_Year_nwetdry_castnet* (e.g., *CANY_2010_nwetdry_ castnet.bmp*).
8. Select Back, repeat steps 2–3 for the bar chart labeled, "Trends in wet and dry sulfur deposition." Save this image as *ParkName_Year_swetdry_castnet* (e.g., *CANY_2010_swetdry_ castnet.bmp*). See Appendix A, Figure 3-18 for an example.

Use this information to prepare the "Atmospheric deposition/Site trends" portion of the "Results" section (see Appendix A for an example).

Ozone

The NPS-ARD reports ozone and meteorological data annually for the Gaseous Pollutant Monitoring Network and parks with state-operated ozone monitoring. Ground-level ozone is reported upon in four NCPN park units: CANY, COLM, DINO, and ZION.

To download ozone data:

1. Direct the web browser to http://www2.nature.nps.gov/air/Monitoring/ads/ADSReport.cfm.
2. Select the desired year and Submit.
3. Save the file in the report folder ""i&m on Inpcanyimms2" (X:\Active_Monitoring_Projects\Air_Quality\Reports) with the file name *ARD_Annual_Data_Summary_year.pdf*.

In a table like the one shown in Table 3-1 of Appendix A, fill in the listed values found in the NPS-ARD tables, "Summary of 8-hour average ozone concentrations (ppb)" (# Days with 8-Hour Average, 1st Highest, 2nd Highest, and 4th Highest) and "Summary of Indices for Resource Injury" (SUM06 and W126).

To download ozone trend plots:

1. Direct the web browser to http://www.nature.nps.gov/air/Monitoring/network.cfm.
2. Under the Results tab, select Interactive Trend Plotter.
3. Select Number of Daily Max 8hr Exceedances (O3> 75 ppb).
4. Select Canyonlands and Zion national parks, then Plot Data.
5. Right-click on each chart, select Save Picture As, and choose bmp. **Do not save as a .gif file.** Save in "i&m on Inpcanyimms2" (X:\Active_Monitoring_Projects\Air_Quality\Reports\Parkname_year_ozone_exceed.bmp) with the file name *ParkName_Year_8hr_ard.bmp* (e.g., *CANY_2010_8hr_ard.bmp*).
6. Repeat steps 2–3 for
   a) "SUM06 for Annual Max 3 Month Period,"
   b) "Cumulative Sum W126 for Annual Max 3 Month Period," and
   c) "Number of Daily Max 8hr Exceedances (O3 > 75 ppb)."

See Appendix A, Figures 3-19, 3-20, and 3-21 for examples. There should be a fourth figure showing the Number of Daily Max 8hr Exceedances (O3 > 75 ppb).

Use this information to prepare the "Ozone" portion of the "Results" section.

IMPROVE (visibility).

Regional maps—. ***This section may be skipped—see Step 8 below.***

To download national visibility map:

1. Direct the web browser to the VIEWS website, http://vista.cira.colostate.edu/web/. At the top, under Tools, select "Data Query Wizard."
2. On the Reports tab, select Contour Maps.
3. On the Datasets tab, select IMPROVE Aerosol.
4. On the Sites tab, click in the box in front of Select All.
5. On the Parameters tab, select Aerosol extinction.
6. On the Dates tab, select the year of interest.
7. On the Options tab, under Display Options/Show Values, click False.
8. Click SUBMIT. If no map shows up in the Results box, then choose the year previous to the one you're interested in until a map appears. (As of 7/26/2010, the most recent map that would properly display was for 2004. If that is still true, skip this section.)
9. Right-click on the map. Save As "Regional_visibility_year.bmp".

See Appendix A, Figure 3-3 for an approximate example. Use this information to prepare the "Regional trends" portion of the "Results" section.

Site trends—. To download site trends data:

1. Direct the web browser to the VIEWS website, http://vista.cira.colostate.edu/web/. At the top, under Tools, click "Trends Tool."
2. At the top under the Site Selection Panel select "show", then select Bryce Canyon NP, Canyonlands NP, Capitol Reef NP, Weminuche Wilderness, and Zion Canyon.
3. On the Chart panel, under Years, select all years available.
4. At left, under "Parameters," click Show, then select "aerosol_bext."
5. Under "Aggregations," select "Best 20%", "Worst 20%", and Moving average: "1 Year".
6. Under "Display Options," select "Timeline" and "Line."
7. On the Chart panel, select "Update!"
8. Right-click on each chart, select Save Picture As and choose bmp. **Do not save as a .png file.** Save in "i&m on Inpcanyimms2" (X:\Active_Monitoring_Projects\Air_Quality\Reports\Parkname_year_bext_bestworst20map.bmp).
9. On the Spreadsheet panel under the graphs, click Show. Download as an .xls file, then note value of aerosol_bext for 20% worst days for the most recent year of interest for each park. This value is the average light extinction value for the 20% worst days and can be used in

visibility discussion to summarize annual information. Also note the value of aerosol_bext for 20% best days.

Use this information to prepare the "Visibility/Site trends" portion of the "Results" section (see Appendix A, Figure 3-4 for an example).

Composition of visibility-reducing fine particles—. To download particle data and graphs:

1. Direct the web browser to the VIEWS website, http://vista.cira.colostate.edu/web/. At the top, under Tools, select "Composition Tool."
2. Under "Site Selection/Site Selection Panel," select "Show," then select Bryce Canyon NP Canyonlands NP, Capitol Reef NP, Weminuche Wilderness, and Zion Canyon.
3. On the Chart panel, under Years, select the most recent year.
4. On Timeline panel, select Update.
5. Right-click on each bar chart, select Save Picture As, and choose bmp. **Do not save as a .gif file.** Save in "i&m on Inpcanyimms2" (X:\Active_Monitoring_Projects\Air_Quality\Reports\Parkname_Year_hazecomp.bmp).
6. Repeat Step 4 for the pie charts. Save as *ParkName_hazecomp_pie_Date.bmp*.

Use this information to prepare the "Visibility/Composition" portion of the "Results" section (see Appendix A and Figures 3-5 and 3-6 for an example).

Spectrum photographs—. These can be downloaded as available from http://vista.cira.colostate.edu/improve/Data/IMPROVE/Data_IMPRPhot.htm, but this archive is not regularly updated. At the time of this writing, the means by which BRCA and NCPN staff will access the data from BRCA's Yovimpa Point camera was yet to be determined.

Discussion and Conclusions

Briefly describe the status and trends of each of the air quality parameters using the text in the example report (Appendix A) as a template. If you desire more in-depth discussion or interpretation of a particular parameter, contact Air Resources Division personnel for assistance (http://www.nature.nps.gov/contact/; Ellen_Porter@nps.gov, or John_D_Ray@nps.gov).

SOP #2: Revising the Protocol Narrative and SOPs

Version 1.00
June 13, 2008

Revision History Log

Previous Version #	Revision date	Author	Changes made	Section and paragraph	Reason for change	New Version #

This Standard Operating Procedure explains how to make and track changes to the Air Quality Monitoring Protocol Narrative and associated SOPs for the Northern Colorado Plateau Network (NCPN). The protocol narrative and SOPs were based on existing procedures for acquiring air quality data, and on current perceptions of the types of analyses and reports most useful to park managers and researchers. However, the protocol narrative and SOPs will require modifications as sensors, equipment, laboratory procedures, data retrieval capabilities, and information needs change. Changes should be evaluated first in terms of cost and benefit, then subjected to appropriate review and, if approved, implemented in a timely manner.

This SOP must be followed when making changes to ensure that previous data collection and processing procedures are clearly understood when using and interpreting historical datasets. Similarly, clearly articulating new methods is key to credible interpretation of data acquired since the implementation of changes. Personnel making changes must be familiar with this SOP to ensure that proper reviews are conducted and that documentation standards are followed.

Procedures

1. **Data collection and availability.** The NCPN air quality monitoring effort relies on existing stations that are sponsored by various national programs. Tracking changes in data collection methods and data availability will require data management staff to frequently review air quality station metadata and data availability. Station metadata should be reviewed at least once each year. Metadata sources are shown in the table below. Data access evaluation is accomplished through the annual acquisition of air quality data products (as outlined in SOP #1) and documentation of changes in data access policies.

Metadata sources for air quality programs in NCPN park units.

Air quality station	Source
National Trends Network (NADP)	http://nadp.sws.uiuc.edu/lib
CASTNet	http://www.epa.gov/castnet/
NPS Ozone	http://www2.nature.nps.gov/air/Monitoring/ads/ADSReport.cfm
IMPROVE	http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm

2. **Review.** Modifications must be reviewed for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by NCPN staff. An outside review is required for substantive changes to methods. Regional and national NPS staff and outside experts familiar with air quality monitoring and data analysis will review major changes.

3. **Documentation.** All changes must be documented. Updated protocol revisions must be recorded in the Revision History Log that accompanies the protocol narrative and each SOP. Changes are recorded only in the protocol narrative or the SOP being modified. Version numbers will increase incrementally by hundredths (e.g., version 1.01, version 1.02, etc.) for minor changes. Major revisions will be designated with the next whole number (e.g., version 2.0, 3.0, 4.0, etc.). The following must be recorded: previous version number, date of revision, author of revision, changes made, paragraphs and pages where changes are made, and reason for the changes along with the new version number.

4. **Master Version Table.** Narrative and SOP updates may occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs; a narrative update may not require SOP modifications. All narrative and SOP version changes must be noted in the Master Version Table (MVT), which is maintained in this SOP. Any time a narrative or an SOP version change occurs, a new Version Key Number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The VK# increases by increments of whole integers (e.g., 1, 2, 3, 4, 5). Updates to the MVT must also be provided to the NCPN data manager for inclusion in the master version table database. The VK# is essential for project information to be properly interpreted and analyzed. **The protocol narrative, SOPs, and data should not be distributed independently of this table.**

5. **Record-keeping.** Previous versions of the protocol narrative and SOPs must be archived in the NCPN Air Quality Protocol Library, "Archive on Inpcanyimms2" (R:\Archive\Monitoring_Archive\Air_Quality\Protocol).

Master Version Table

Version Key #	Date of change	Narrative	SOP #1	SOP #2	SOP #3	SOP #4	SOP #5	SOP #6

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 960/105552, September 2010

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