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Natural Resource Program Center

Air Quality Monitoring Protocol and Standard Operating Procedures for the Sonoran Desert, Southern Plains, and Chihuahuan Desert Networks

Natural Resource Report NPS/SODN/NRR—2011/390
Version 2.00

ON THE COVER
Clockwise from left: Fort Larned National Historic Site, Kansas; Big Bend National Park, Texas; Chiricahua National Monument, Arizona. NPS photos.

Air Quality Monitoring Protocol and Standard Operating Procedures for the Sonoran Desert, Southern Plains, and Chihuahuan Desert Networks

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Acronyms

General

ACM	Aerochem Metrics 301 precipitation collector
CAL	Central Analytical Laboratory, Illinois State Water Survey
CASTNet	Clean Air Status and Trends Network
CNL	Crocker Nuclear Laboratory, University of California–Davis
EPA	Environmental Protection Agency
GPMP	Gaseous Pollutant Monitoring Program
GPRA	Government Performance and Results Act
HNO_3	nitric acid
IMPROVE	Interagency Monitoring of Protected Visual Environments
LCAS	Learning Center of the American Southwest
MVT	Master Version Table
NADP/NTN	National Atmospheric Deposition Program, National Trends Network
NH_3	ammonia
NM	national monument
NP	national park
NO_3	nitrate
NOx	nitrogen oxides
NPS	National Park Service
NPS-ARD	National Park Service–Air Resources Division
QA/QC	Quality Assurance/Quality Control
SO_2	sulfur dioxide
SO_4	sulfate
SOP	Standard Operating Procedure
SWNC	Southwest Network Collaboration
VIEWS	Visibility Information Exchange Web System
VK#	Version Key Number

Sonoran Desert Network

CAGR	Casa Grande Ruins National Monument
CHIR	Chiricahua National Monument
CORO	Coronado National Memorial
FOBO	Fort Bowie National Historic Site
GICL	Gila Cliff Dwellings National Monument
MOCA	Montezuma Castle National Monument
ORPI	Organ Pipe Cactus National Monument
SAGU	Saguaro National Park
SODN	Sonoran Desert Network
TONT	Tonto National Monument
TUMA	Tumacácori National Historical Park
TUZI	Tuzigoot National Monument

Southern Plains Network

BEOL	Bent's Old Fort National Historic Site
CAVO	Capulin Volcano National Monument
FOLS	Fort Larned National Historic Site
PECO	Pecos National Historical Park
SOPN	Southern Plains Network
WABA	Washita Battlefield National Historic Site

Chihuahuan Desert Network

BIBE	Big Bend National Park
CAVE	Carlsbad Caverns National Park
CHDN	Chihuahuan Desert Network
GUMO	Guadalupe Mountains National Park

Authors' Note

This air quality monitoring protocol and standard operating procedures have undergone major changes since their last iteration, published in the Natural Resource Technical Report Series as NPS/SODN/NRTR—2007/003. Specifically, the protocol narrative has been simplified to be more relevant to network activities (e.g., significant portions of the Methods section describing how air quality data are collected have been replaced with links to the protocols used by the agencies that actually collect that data), and information has been incorporated such that the protocol can now be shared among the three networks of the Southwest Network Collaboration: the Sonoran Desert Network, Southern Plains Network, and Chihuahuan Desert Network. The Southwest Network Collaboration (SWNC) is a joint effort between those three networks to share not only monitoring protocols, but also data collection and reporting duties. The goal of the SWNC is to improve effectiveness and efficiency across all three networks.

The underlying principles of this protocol remain the same: the networks will harvest information collected and presented by other agencies, as well as the National Park Service Air Resources Division, and report on that information on a park-by-park basis for SWNC parks where air quality is monitored. The networks will conduct no air quality monitoring of their own. More information on the SWNC can be found at http://inpchdnms03/SWNCCP/SitePages/Home.aspx.

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Protocol Narrative

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April 20, 2011

Revision History Log

Previous Version #	Revision date	Author	Changes made	Reason for change	New Version #
1.00	11/13/09	A. W. Biel	Replaced Table 1 to include all SWNC networks	New table shows only relevant information, includes all parks	2.00
1.00	11/13/09	A. W. Biel	Deleted Sampling Design section	Unnecessary	2.00
1.00	11/13/09	A. W. Biel	Deleted references to nephelometers and transmissometers	Those instruments not used for long-term monitoring	2.00
1.00	11/13/09	A. W. Biel	Deleted park listings in Section 3	Redundant with Section 1	2.00
1.00	11/13/09	A. W. Biel	Updated external SOP names and dates	Some were outdated	2.00
1.00	11/13/09	A. W. Biel	Changed personnel responsibilities	Responsibilities reassigned	2.00
1.00	11/13/09	A. W. Biel	Moved document into Word from InDesign	To facilitate future changes and make hyperlinks operational for report writing	2.00
1.00	7/26/10	A. W. Biel	Updated VIEWS data-harvesting protocol, SOP #1	VIEWS changed website again	2.00
1.00	3/4/11	A. W. Biel	Incorporated material relevant to SOPN and CHDN	Southwest Network Collaboration	2.00
1.00	3/9/2011	A. Wondrak Biel	Removed all references to Coronado NMem	Park is further from IMPROVE station than the distance determined allowable by ARD	2.00

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 Sonoran Desert Network (SODN), Southern Plains Network (SOPN), and Chihuahuan Desert Network (CHDN), together known as the Southwest Network Collaboration (SWNC), have 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 SWNC is incorporating into this program (NPS-ARD 2002).

Three main components comprise the NPS air quality monitoring program: atmospheric deposition, ozone, and visibility. Information relative to these three vital signs supports evaluation of compliance with legislative requirements of the Clean Air Act's Regional Haze Guidelines and National Environmental Policy Act, and facilitates interpretation of plot-based vegetation and water-quality measurements. Section 1.2 is a review of that monitoring as it is conducted in and near SWNC parks.

This protocol documents the methods used for collecting air quality data in SWNC parks and provides for regular review of changes in those methods. It describes how these data are retrieved, managed, analyzed, and presented for regular reporting to SWNC parks.

1.2 Monitoring conducted in and near SWNC parks

The types of air quality monitoring conducted in and near each SWNC network park are shown in Table 1-1. The locations of air quality monitoring stations in the SWNC region are shown in Figures 1-1, 1-2, and 1-3.

In the Sonoran Desert Network, on-site air quality monitoring is conducted at Chiricahua National Monument (CHIR), Gila Cliff Dwellings National Monument (GICL), Organ Pipe Cactus National Monument (ORPI), Saguaro National Park (SAGU), and Tonto National Monument (TONT). In the Southern Plains Network, on-site air quality monitoring is conducted only at Capulin Volcano National Monument (CAVO). In the Chihuahuan Desert Network, on-site air quality monitoring is conducted at Big Bend National Park (BIBE) and Guadalupe Mountains National Park (GUMO).

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 the park's air quality (NPS-ARD 2010). Under these guidelines, SODN also reports on status for Fort Bowie National Historic Site (FOBO) and Tumacácori National Historical Park (TUMA) (Table 1-1). The Southern Plains Network also reports on status for Bent's Old Fort National Historic Site (BEOL), Fort Larned National Historic Site (FOLS), Pecos National Historical Park (PECO), and Washita Battlefield National Historic Site (WABA). The Chihuahuan Desert Network also reports on status for Carlsbad Caverns National Park (CAVE).

Table 1-1. Summary of ambient air quality monitoring in SWNC parks.

Park code	State	Site number			
		Wet deposition (NADP/NTN)	Dry deposition (CASTNet)	Ozone (GPMP)	Visibility (IMPROVE)
Sonoran Desert Network					
Parks with monitoring stations within their boundaries					
CHIR	AZ	AZ98	CHA467	04-003-8001	CHIR1
GICL	NM	NM01			GICL1
ORPI	AZ	AZ06			ORPI1
SAGU	AZ			04-019-0021	SAGU1, SAWE
TONT	AZ				TONT1
Parks with monitoring stations close enough to be reasonably considered representative of the park					
FOBO	AZ	AZ98	CHA467	Chiricahua NM 10 km S 04-003-8001	Chiricahua NM (CHIR1) 10 km S
TUMA	AZ				Saguaro NP (west) (SAWE) 60 km N
Southern Plains Network					
Parks with monitoring stations within their boundaries					
CAVO	NM	NM12			
Parks with monitoring stations close enough to be reasonably considered representative of the park					
BEOL	CO	CO01 Las Animas Fish Hatchery 13 km NE			
FOLS	KS				Cedar Bluff (CEBL1) 81 km NW
PECO	NM				Bandelier NM (BAND1) 58 km NW
WABA	OK				Ellis (ELLI1) 64 km SW
Chihuahuan Desert Network					
Parks with monitoring stations within their boundaries					
BIBE	TX	TX04	BBE401	48-043-0101	BIBE1
GUMO	TX	TX22			GUMO1
Parks with monitoring stations close enough to be reasonably considered representative of the park					
CAVE	NM				Guadalupe Mountains NP (GUMO1) 52 km SW

NADP/NTN = National Atmospheric Deposition Program; CASTNet = Clean Air Status and Trends Network; GPMP = Gaseous Pollutant Monitoring Program; IMPROVE = Interagency Monitoring of Protected Visual Environments

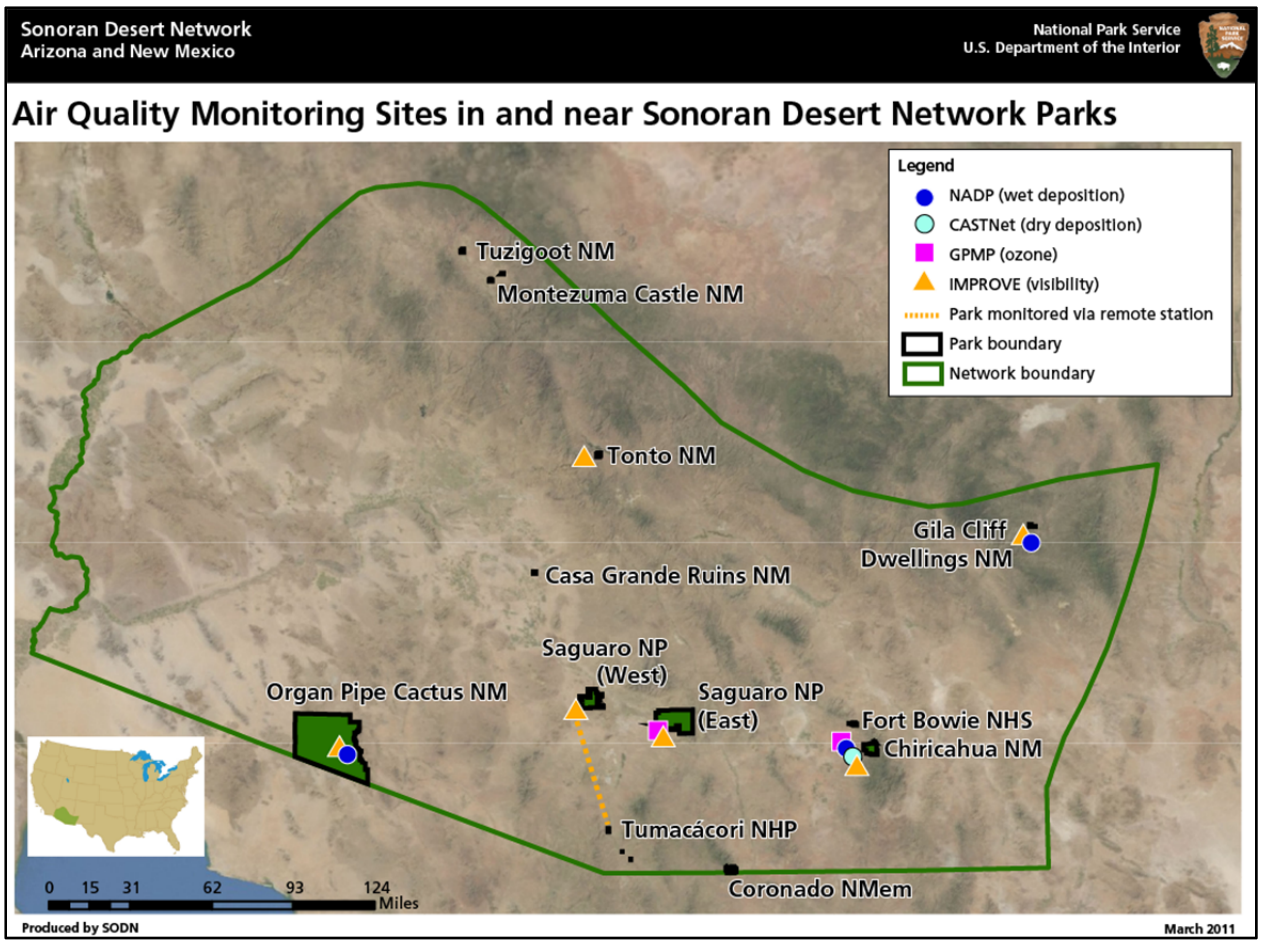

Figure 1-1. Air quality monitoring stations in the Sonoran Desert Network.

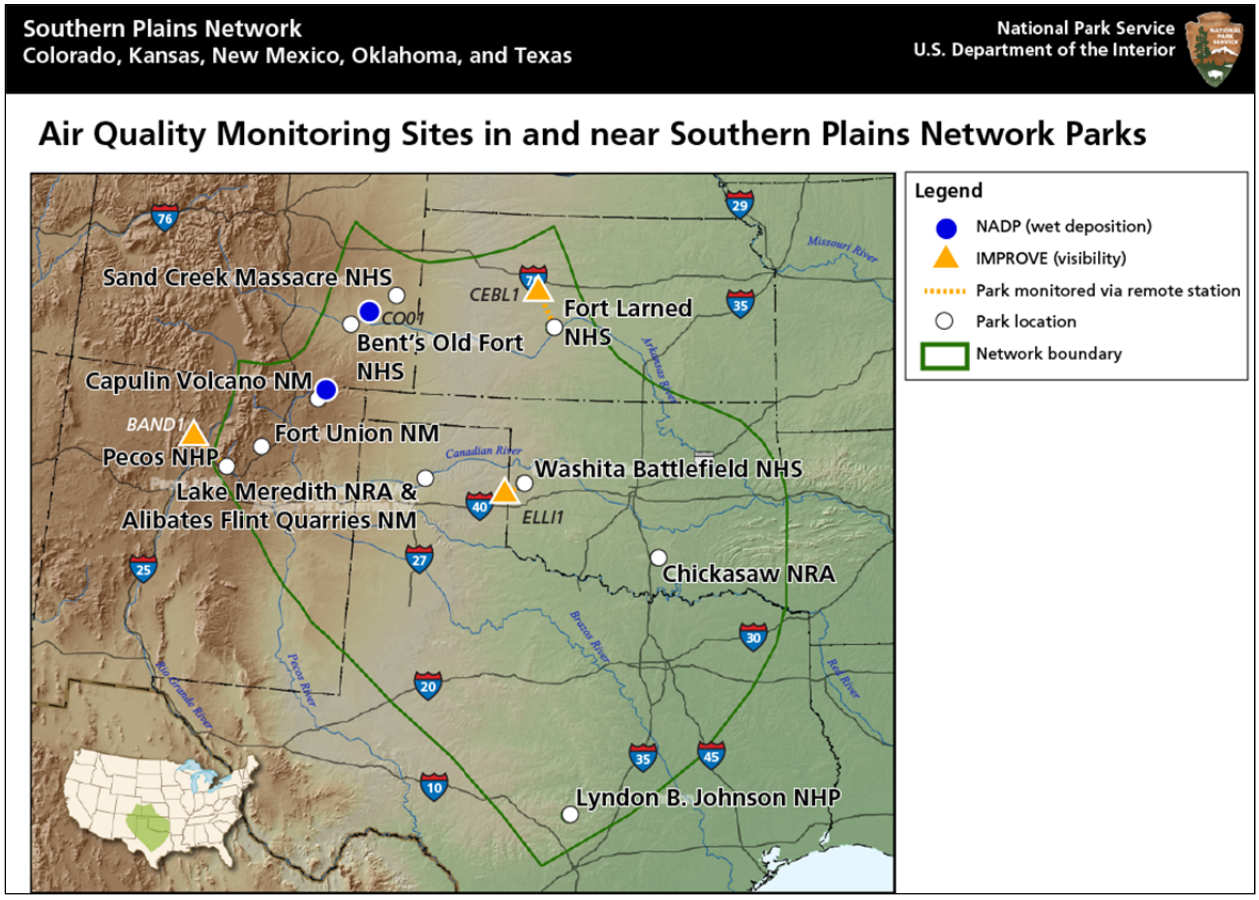

Figure 1-2. Air quality monitoring stations in the Southern Plains Network.

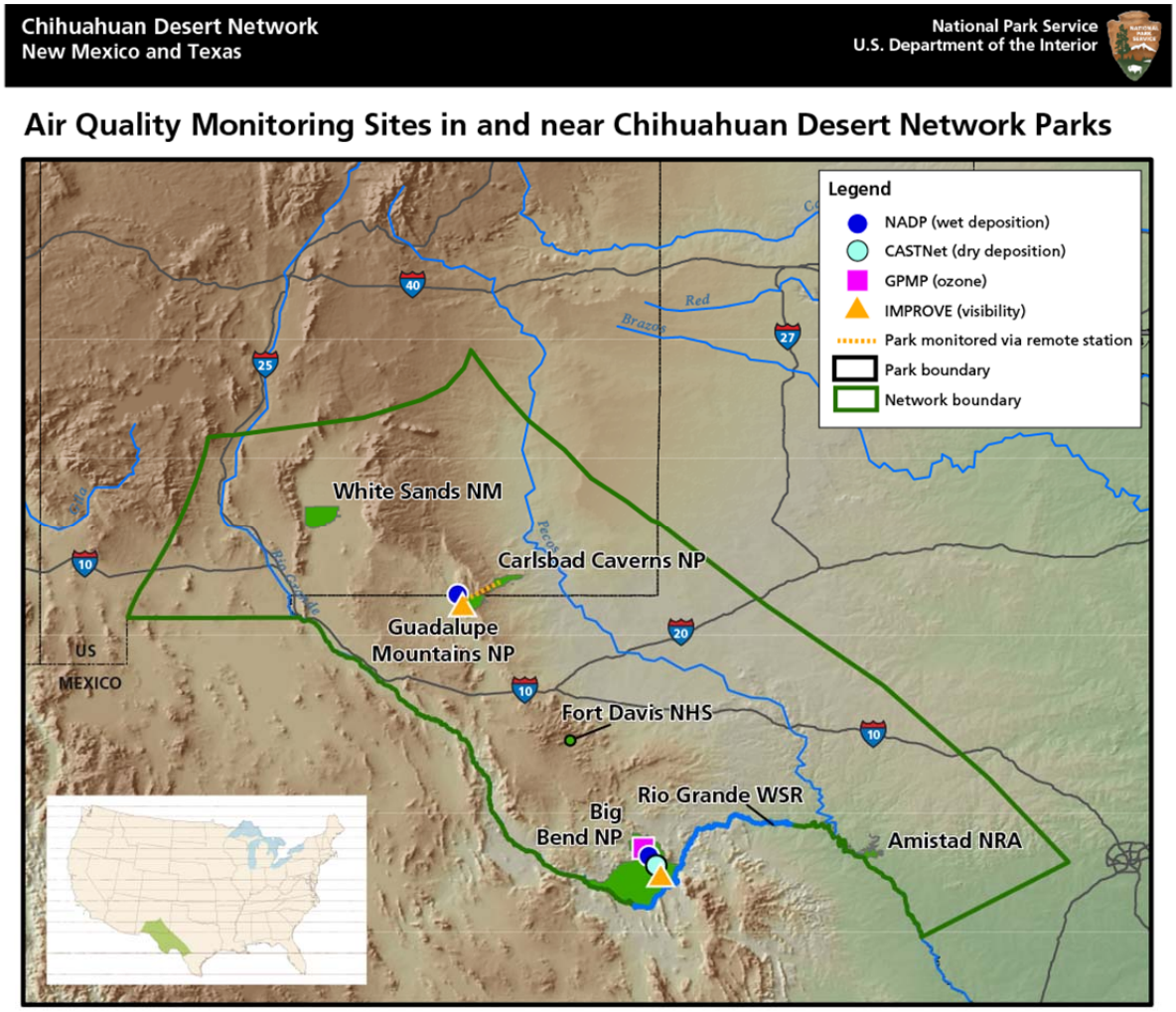

Figure 1-3. Air quality monitoring stations in the Chihuahuan Desert Network.

1.3 Monitoring types

1.3.1 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 gases 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. Research in BIBE has found a rapid, major decrease in soil pH in park grasslands (NPS-ARD 2010).

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 (see http://nadp.sws.uiuc.edu/lib/) 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 Sonoran Desert Network, CHIR has participated in this program since 1999, GICL has participated since 1985, and ORPI has participated since 1980. In the Southern Plains Network, CAVO has participated in this program since 1984, and the Las Animas Fish Hatchery (PECO) since 1983. In the Chihuahuan Desert Network, BIBE has participated since 1980, and GUMO since 1984.

Dry deposition chemistry is monitored 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 sulfur dioxide, sulfate, nitrate, nitric acid, and ammonium. Chiricahua National Monument has the only CASTNet sampler in the SODN region; it has operated from 1989 to 1992, and 1995 to the present. Big Bend National Park has the only CASTNet sampler in the CHDN region. Dry deposition is not monitored in the SOPN.

1.3.2 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). To protect human health and the environment, the Environmental Protection Agency (EPA) has set a national standard for ozone of 75 parts per billion (ppb). Areas not meeting the standard are designated as non-attainment areas, and states are required to develop plans to bring such areas into attainment.

In the SODN region, two counties in Arizona (Maricopa and Pinal counties) are designated “non-attainment” for the ozone standard. There are no SODN parks in Maricopa County; Casa Grande Ruins NM is located in Pinal County, but the NPS does not monitor air quality at that park. The risk of ozone injury to plants in the Sonoran Desert Network has been determined to be low for all parks except MOCA, ORPI, and TONT (moderate risk) (NPS-ARD 2004a). The risk of ozone injury to plants in the Southern Plains Network has been determined to be low for all parks except LYJO (moderate risk) and CHIC (high risk) (NPS-ARD 2004b). Ozone is not monitored close enough to any SOPN parks for network reporting to occur. The risk of foliar injury in the Chihuahuan Desert Network has been determined to be low for all parks except Amistad NRA (moderate), where no ozone-sensitive plants have been identified (NPS-ARD 2004c). In the CHDN, ozone is only monitored at BIBE.

Ozone is monitored using continuous samplers at BIBE, SAGU, and CHIR; the latter location is sufficiently close to Fort Bowie National Historic Site for reasonable inference to that unit, as well. 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.

1.3.3 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. Two Sonoran Desert Network parks, CHIR and SAGU, are designated Class I areas. In the Chihuahuan Desert Network, BIBE, CAVE, and GUMO are Class I areas. No units of the Southern Plains Network are designated as Class I areas.

Visibility is monitored through the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. 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. In the Sonoran Desert Network, IMPROVE particulate samplers are deployed at CHIR, GICL, ORPI, SAGU, and TONT. IMPROVE monitors are close enough to FOBO and TUMA to allow reporting for those parks, as well (NPS-ARD 2010). In the Southern Plains Network, IMPROVE monitors are close enough to FOLS, PECO, and WABA to allow reporting for those parks (NPS-ARD 2010). In the Chihuahuan Desert Network, IMPROVE particulate samplers are deployed at BIBE and GUMO, and are close enough to CAVE to allow reporting for that park, as well (NPS-ARD 2010).

1.4 Monitoring questions

Air quality parameters are monitored in SWNC 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 the national air quality monitoring programs. Therefore, it is not the SWNC's objective to replicate these analyses. Instead, the objectives are to compile the data summaries performed by these groups and provide them in the form of resource briefs to be analyzed in conjunction with other SWNC vital signs. SWNC air quality monitoring questions are:

- What are the conditions and spatial and temporal trends in ozone, nitrogen deposition, sulfur deposition, and visibility-reducing pollutants in SWNC park units?
- How do ozone, nitrogen deposition, sulfur deposition, and visibility-reducing pollutants vary with associated vital signs (e.g., vegetation community composition, exotic plant status, climate)?

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

2 Methods

2.1 Atmospheric deposition

Field air quality instruments are generally automated to ensure data consistency and minimize the workload of park staff. Important exceptions are the routine replacement of sample collectors (e.g., filters, deposition buckets) and the completion of the Field Observer Reporting Form (see Dossett and Bowersox 1999). Field operations consist of weekly visits for inspection, routine maintenance, and sample collection by park staff, and semi-annual maintenance by program specialists (see Dossett and Bowersox 1999).

2.1.1 Wet deposition

Each NADP/NTN 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 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 (i.e., wet + dry 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. 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.[1]

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 has responsibility 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 to troubleshoot and repair malfunctioning equipment. Weekly sample collection procedures and routine maintenance and testing are described in the *National Trends Network Site Operation Manual* (Dossett and Bowersox 1999). Biennial site visit procedures are outlined in Dossett and Bowersox (1999). These SOPs are available at http://nadp.sws.uiuc.edu/lib/qaPlans.aspx.

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 to a central analytical laboratory in Gainesville, Florida, for analysis. CASTNet uses NADP data in conjunction with dry deposition data to report total deposition. The CASTNet SOPs are available at http://java.epa.gov/castnet/documents.do.

2.2 Ozone

The NPS Gaseous Pollutant Monitoring Program (GPMP) 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 available at http://www.nature.nps.gov/air/Monitoring/docs/FinalOzoneProtocol.pdf.

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

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[1] 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 below. 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.

($PM_{2.5}$) and the mass of coarse particulate matter (PM_{10}) in the atmosphere, are located at all IMPROVE sampling sites.

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 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. Sample laboratory 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 *IMPROVE Standard Operating Procedure 201, version 3 (SOP 201-3): Sampler Maintenance by Site Operators* (CNL no date) and *Version II IMPROVE Sampler Operating Procedures Manual for use in the IMPROVE Monitoring Network* (CNL 2001). These SOPs are available at http://vista.cira.colostate.edu/improve/Publications/SOPs/ucdsop.asp.

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 field observer report 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 *NADP Network Quality Assurance Plan 2009-09* (NADP 2009), available at http://nadp.sws.uiuc.edu/lib/qaPlans.aspx.

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 Air Resources Specialists, Inc., 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.

3.1.3 Visibility

Particulate data processing and validation are performed in parallel, principally in the Crocker Nuclear Laboratory, University of California–Davis, 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 available at http://vista.cira.colostate.edu/improve/Publications/SOPs/ucdsop.asp.

3.2 Data acquisition

Data collected by the various air quality monitoring programs are available from web-based program archives. Dry deposition data are archived by the EPA CASTNet program. Wet deposition data are archived by the NADP/NTN. Ozone data are archived by the NPS Air Resources Division (only the data from in-park monitors are archived by the NPS-ARD; ozone data collected outside the parks are archived by the EPA AirData website at http://www.epa.gov/air/data/). Visibility data are archived by the IMPROVE program. All national databases are accompanied by extensive metadata documentation that provides details on procedures, equipment, and measurements taken.

3.3 Metadata procedures

All national databases are accompanied by extensive metadata documents that provide details on procedures, equipment, and measurements taken. In addition to this documentation, this protocol requires that a README file be created when data are downloaded from a site. These README files, saved in the same location as the data files, document the name of the person performing the download, the date the file was created, a description of the data format and source, and any additional information that is required for a user to understand the data provenance.

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.

3.4 Data archival procedures

Because data are archived by the NPS Air Resources Division and only derived information products are used in SWNC reporting, data will not be archived locally. The data products downloaded from the agencies that conduct air quality monitoring and used in SWNC reporting will be stored and archived by the individual networks in accordance with SOP #1 and individual network procedures.

3.5 Data analysis and reporting

3.5.1 Form

To maximize efficiency and the usefulness of information provided to network parks, SWNC air quality reporting will take the form of annual briefs, rather than an annual report. Network staff will produce a 1–4-page brief for each park where air quality is monitored, for a total of 7 SODN briefs, 5 SOPN briefs, and 3 CHDN briefs. Specific instructions for preparing resource briefs are provided in SOP #1. The briefs will be distributed via the Learning Center of the American Southwest (LCAS; http://southwestlearning.org). Examples of completed briefs can be found at http://www.southwestlearning.org/subproducts/45/1. Appendix A provides a list of additional resources.

3.5.2 Timing

Because the air quality monitoring programs used to assess NPS air quality do not operate on a coordinated reporting schedule, and because status and trend information reported in SWNC air quality

resource briefs will be derived from information provided by the NPS-ARD's annual performance and progress reports, SWNC air quality reporting will coincide with the NPS-ARD's release of those reports, which typically occurs annually.

4 Personnel Requirements and Training

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

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. For SODN, data-product downloading is the responsibility of the science writer-editor, who will also write the resource briefs. For SOPN and CHDN, data-product downloading is the responsibility of the data manager; the program manager will write and design the resource briefs. Briefs will be submitted to NPS-ARD staff for review prior to publication.

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. No training is necessary for network personnel involved in data harvesting and reporting.

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. The workload for SWNC staff consists of data retrieval and report preparation.

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. The SWNC does not plan to fund additional air quality monitoring in network park units.

5.3 Startup costs and budget constraints

There are no startup costs associated with this program at the network level. It is anticipated that this protocol will require approximately one pay period per year of staff time at each network for data collection, writing, and design.

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

Because the SWNC has determined that SODN will be responsible for the group's air quality monitoring protocol, SODN will be the official "document owner" of all protocol documents, meaning that all changes will be submitted to the SODN program manager and then passed on to the SODN science writer for incorporation.

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 master version table database. Previous versions of the protocol narrative and SOPs will be archived in the SODN Air Quality Protocol Library (S:\Air_Quality\Protocol\Narrative_and_SOPs).

5.5 Updating the protocol and SOPs

Due to the impermanent nature of both air quality monitoring stations and urls, this protocol narrative, as well as SOP #1, will need to be checked for accuracy on an annual basis. In September of each year, the SODN writer-editor will follow the processes outlined in SOP #1 to ensure that all links and described procedures are still valid and update the SOP as appropriate, in accordance with Section 5.5 and SOP #2 of this document.

Upon the release of the NPS-ARD's annual air quality performance and progress report, the SODN writer-editor will check to see if any SWNC parks have been added to or dropped from NPS-ARD reporting and update the protocol narrative as appropriate, in accordance with Section 5.4 and SOP #2 of this document.

6 References

Crocker Nuclear Laboratory (CNL). no date. IMPROVE standard operating procedure 201, version 3 (SOP 301-3): Sampler maintenance by site operators. Davis, Calif.

——. 2008. IMPROVE standard operating procedure 351, version 2 (SOP 351-2): Data processing and validation, July. Davis, Calif.

——. 2001. Version II IMPROVE sampler operating procedures manual for use in the IMPROVE monitoring network v2.01.01. Technical Information Document TI 201A. January. Davis, Calif.

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MACTEC Engineering & Consulting, Inc. 2003. Clean Air Status and Trends Network (CASTNet) quality assurance project plan (QAPP), Revision 2.0. Gainesville, Fla.: MACTEC Engineering and Consulting, Inc. October, 317 pp.

National Atmospheric Deposition Program (NADP). 2009. NADP network quality assurance plan, version 1.3, NADP CAL QA plan 2009-09, August. Champaign, Ill.: Central Analytical Laboratory, Illinois State Water Survey.

National Park Service-Air Resources Division (NPS-ARD). 2010. Nitrogen and sulfur depositions studies: Overview. http://www.nature.nps.gov/air/studies/nsdeposition.cfm.

——. 2010. Air quality in national parks: 2009 annual performance and progress report. Natural Resource Report NPS/NRPC/ARD/NRR—2010/266. National Park Service, Denver, Colorado.

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——. 2004c. Assessing the risk of foliar injury from ozone on vegetation in parks in the Chihuahuan Desert Network. http://www.nature.nps.gov/air/Pubs/pdf/03Risk/chdnO3RiskOct042.pdf.

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Porter, E. 2003. Ozone-sensitive plant species on National Park Service and U.S. Fish and Wildlife Service lands: Results of a June 24–25, 2003, workshop. Baltimore, Md.: U.S. Department of the Interior. Natural Resource Report NPS/NRARD/NRR-2003/01.

Standard Operating Procedures

SOP #1: Preparing Air Quality Briefs

Version 2.00
(April 5, 2011)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Reason for change	New Version #
1.00	11/10/09	A. Wondrak Biel (SODN)	Name changed from SOP #5 due to deletion of SOPs 1–4. Formatting changes to all pages.	Formatting changed to bring document into compliance with NRTR styles and format. Content not affected.	2.00
1.00	11/10/09	A. Wondrak Biel	Minor changes to introductory paragraphs	Minor procedural changes	2.00
1.00	11/10/09	A. Wondrak Biel	Changes to data-harvesting procedures	Agencies have changed their web sites	2.00
1.00	11/10/09	A. Wondrak Biel	Moved document into Word from InDesign	To facilitate future changes and make hyperlinks operational for report writing	2.00
1.00	11/10/09	A. Wondrak Biel	Added instructions on preparing a resource brief	Product added to reporting scheme	2.00
1.00	2/8/11	A. Wondrak Biel	Removed all references to full-length reports	We will produce resource briefs instead to maximize efficiency and avoid duplication of effort	2.00
1.00	3/9/2011	A. Wondrak Biel	Removed all references to Coronado NMem	Park is further from IMPROVE station than the distance determined allowable by ARD	2.00
1.00	3/9/2011	A. Wondrak Biel	Incorporated information relevant to all three networks	Initiation of SWNC	2.00

Purpose and Scope

This SOP gives step-by-step instructions for producing air quality resource briefs for the three networks of the Southwest Network Collaboration. Efficient reporting of monitoring results is critical in assisting park resource managers with management decisions.

It is not necessary for individuals preparing air quality resource briefs 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 Air Resources Division personnel for more information (http://www.nature.nps.gov/contact/; Ellen_Porter@nps.gov; or John_D_Ray@nps.gov).

Preparing a Brief

To create a resource brief, collect the relevant data products according to the instructions below and use them to summarize the results for the parameter of interest for each monitored park. Examples are provided at http://www.southwestlearning.org/subproducts/45/1. It is not necessary to refer to all of the documents or use all of the graphics described below to complete the resource briefs. The preparer will decide which information and graphics to include, depending on which are most instructive for the time period covered by the briefs.

Internet Explorer is the preferred web browser for collection and download of the files described below. Some functions will not work in alternative browsers.

Air quality resource briefs should be created using the NPS-based air quality brief template posted at http://inpchdnms03/SWNCCP/Air/Reports/Forms/AllItems.aspx. If difficulties related to proprietary fonts, software compatibility, or other issues arise, the briefs should be created using the LCAS template for Resource Briefs, available at ftp://72.32.122.185/Product_Guidance_and_Templates/LCAS_Product_Templates/. This site is password-protected; login information can be obtained from the network program manager or data manager. Briefs will be posted to the LCAS as Resource Briefs at http://www.southwestlearning.org/subproducts/45/1.

Harvesting Data for Brief Population

File location

All downloaded or created files referred to in this SOP will be saved to the following folders:

SODN: V:\Air\Products\Monitoring_Briefs
SOPN: Drive TBD:\Monitoring\ Air\Products\Monitoring_Briefs
CHDN: In accordance with the CHDN directory structure SOP.

1. In the folder appropriate to your network, create a folder and give it the name of the year for which information is being collected.
2. Within that "Year" folder, create a folder for each air quality monitoring program (wet_dep, dry_dep, ozone, and visibility), as appropriate.
3. Download and store files described below in the program folders as appropriate.

NPS-ARD summary

The NPS-Air Resources Division reports trends in air quality parameters every year, with associated statistical significance, in compliance with the Government Performance and Results Act (GPRA) for NPS sites with long-term monitoring. A data record of 10 years is required for trend determination. A nonparametric regression technique (the Theil test) is used to determine statistically significant trends. Probabilities of ≤5% are considered to be statistically significant. Increasing or decreasing concentration trends with probabilities of ≤15% are also considered to allow for early detection of deteriorating or improving conditions.

To download the latest "Air Quality in National Parks: Performance & Progress Report,"

1. Direct the web browser to http://www2.nature.nps.gov/air/who/npsPerfMeasures.htm.

2. Download and save the most recent report using the existing file name.

3. Collect information from the report for the parks and parameters of interest, paying particular attention to the Table of Trend Results, typically included as an appendix.

Wet deposition (NADP)

Regional data

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

To download regional 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: NO3, 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., 2006_NO3conc.pdf).
6. Repeat steps 2–5 for both SO4 and NH4.

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 regional 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., 2006_SO4dep.pdf).

Park-specific data

Wet deposition data products are collected for the parks/at the sites shown in the table below.

Park unit	State	SiteID
Sonoran Desert Network		
Chiricahua NM	AZ	AZ98
Organ Pipe Cactus NM	AZ	AZ06
Gila Cliff Dwellings NM	NM	NM01
Southern Plains Network		
Bent's Old Fort NHS (Las Animas Fish Hatchery)	CO	CO01
Capulin Volcano NM	NM	NM12
Chihuahuan Desert Network		
Big Bend NP	TX	TX04
Guadalupe Mountains NP	TX	TX22

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 the state of interest.
4. Select the first park of interest.
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., CHIR_2010_NADP_Summary.pdf).
6. Repeat steps for all other parks/sites of interest to your network.

To download site trend data:

1. Repeat steps 1–4 above.
2. Select "Trend Plots."
3. Select NO3, "Mg/L" for units, Graph Size: Large, and click "Create Plot."
4. Right-click on the graph, select "Copy" and paste into a Word file (CHIR_2010_NO3_trends.doc).
5. Repeat steps for NH4 and SO4 , "Mg/L" for units. Name the files appropriately (e.g., CHIR_2010_nh4_trends.pdf, CHIR_2010_so4_trends.pdf).
6. Repeat steps for other parks/sites of interest.

A link to "Trends notes" describes how the trend lines were created and discusses data completeness criteria.

Dry deposition (CASTNet)

Dry deposition data products are collected for the parks/at the sites shown in the table below.

Park unit	State	SiteID
Sonoran Desert Network		
Chiricahua NM	AZ	CHA267
Chihuahuan Desert Network		
Big Bend NP	TX	BBE401

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" tab, then select the site of interest from the map.

2. Click on the bar chart labeled "Trends in total nitrogen deposition."

3. Right-click on the bar chart, select Save Picture As, and choose bmp. **Do not save as a .gif file.** Save as ParkName _Year_totalN_castnet.bmp.

4. Select Back, repeat steps 2–3 for the bar chart labeled, "Trends in total sulfur deposition." Save this image as ParkName _Year_totalS_castnet.bmp.

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., CHIR _2006_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., CHIR _2006_sdep_castnet.bmp).

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., CHIR _2006_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., CHIR _2006_swetdry_ castnet.bmp).

Ozone

Ozone data products are collected for the parks/at the sites shown in the table below.

Network	Parks
Sonoran Desert Network	Chiricahua NM Saguaro NP
Chihuahuan Desert Network	Big Bend NP

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 BIBE, CHIR, and SAGU.

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 with the file name ARD_Annual_Data_Summary_year.pdf.

In a table like the one below, 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).

Ozone concentrations (parts per billion-ppb) and exposure indices summaries for Chiricahua National Monument, 2008.

Site code	Number of days with 8-hr average O_3 values at >75 ppb	1st-highest 8-hr concentrations	2nd-highest 1-hr concentrations	4th-highest 8-hr concentrations	SUM06 (ppm-hr)b	W126 (ppm-hr)c
CHIR	0	73	70	67	20.8	18.4

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 the park(s) of interest, 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 the appropriate folder with the file name ParkName_Year_8hr_ard.bmp (e.g., CHIR_2009_8hr_ard.bmp).
6. Repeat steps 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)."

IMPROVE (visibility)

Visibility data products are collected for the parks/at the sites shown in the table below.

Park unit	SiteID
Sonoran Desert Network	
Chiricahua NM (+ Fort Bowie NHS)	Chiricahua NM
Gila Cliff Dwellings NM	Gila Wilderness
Organ Pipe Cactus NM	Organ Pipe
Saguaro NP–east	Saguaro NM
Saguaro NP–west (+ Tumacácori NHP)	Saguaro West
Tonto NM	Tonto NM
Southern Plains Network	
Fort Larned NHS	Cedar Bluff
Pecos NHP	Bandelier NM
Washita Battlefield NHS	Ellis
Chihuahuan Desert Network	
Big Bend NP	Big Bend NP
Guadalupe Mountains NP (+ Carlsbad Caverns NP)	Guadalupe Mountains NP

Spatial and seasonal trends data

1. Direct the web browser to the VIEWS website, http://views.cira.colostate.edu/web/DataWizard/. At the top, under Tools, click "Trends Tool."
2. Under the Site Selection Panel, select "show", then select the sites of interest.
3. On the Chart panel, under Years, select all years available.
4. At left, under "Parameters," click Show, then select "dv."
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 as Parkname_year_bext_bestworst20map.bmp.
9. On the Spreadsheet panel under the graphs, click Show. Download as an .xls file, then note value of deciviews 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 deciviews for the 20% best days.

Composition of visibility-reducing fine particles

1. Direct the web browser to the VIEWS website, http://views.cira.colostate.edu/web/DataWizard/. At the top, under Tools, select "Composition Tool."
2. Under "Site Selection/Site Selection Panel," select "Show," then select the sites of interest.
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 as Parkname_Year_hazecomp.bmp.

6. Repeat Step 5 for the pie charts. Save as ParkName_hazecomp_pie_Date.bmp.

Status and trends

Briefly describe the status and trends of each of the air quality parameters. 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 2.00
(April 5, 2011)

Revision History Log

Previous Version #	Revision date	Author	Changes made	Reason for change	New Version #
1.00	3/31/11	K. Beaupre	Extracted revision detail to another DM document. Left overarching rules and guidance	More efficient method of maintaining these documents and information	2.00

Purpose and Scope

This SOP explains that all protocol documents (the protocol narrative, appendices, SOPs, and datasheets) are highly controlled and managed. This is done (1) to ensure that only authorized and approved modifications are made to these documents and (2) to maintain a complete version history of this protocol and ensure that all associated data can be synthesized, analyzed, and reported.

Any revisions to protocol documents must be made in accordance with the SWNC global operating procedure, *Control and Versioning for SWNC Documents*, which can be found at http://inpchdnms03/SWNCCP/GOP/Forms/AllItems.aspx, Category: Data Management. The person responsible for making changes to the documents should also understand protocol versioning methods to ensure that the active version of a protocol document is revised. Revisions should be completed in a timely manner in order to minimize disruptions to project operations.

All modifications to protocol documents will be discussed with all interested stakeholders; however, the final decision on any modifications lies with the protocol lead/author.

Master Version Table

Version Key #	Date of Change	Narrative	SOP #1	SOP #2	SOP #3	SOP #4	SOP #5	SOP #6
1	April 2007	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	April 2011	2.00	2.00*	1.00	-	-	-	-

*On 11/18/2009, SOPs 1–4 from VK1 were deleted because it was deemed unnecessary for the SODN to archive raw data already archived by the agencies that collected it. At that time, SOP#5 (Creating a Report) from VK1 became SOP #1, and SOP #6 (Revising the Protocol) became SOP #2.

Appendix A: Additional Resources

The following resources may be of use or interest to readers of this protocol and/or preparers of SWNC resource briefs.

General Information on SWNC Air Quality

A variety of informational resources about air quality in the national parks are available at the NPS-ARD's website, http://www.nature.nps.gov/air/index.cfm.

For information on Air Quality Related Values in SWNC parks, visit http://www.nature.nps.gov/air/Permits/aris/chir/aqrv.cfm and substitute the acronym for the park of interest for "chir" in the url.

For general overviews of air quality in SWNC parks, visit http://www.nature.nps.gov/air/Permits/aris/chir/ and substitute the acronym for the park of interest for "chir" in the url.

Air Quality Monitoring Program Manuals and Quality Assurance Plans

National Trends Network Site Operation Manual
National Atmospheric Deposition Program. 1999-01c (revised). Champaign, Ill.
Web location: http://nadp.sws.uiuc.edu/lib/

NADP Network Quality Assurance Plan
National Atmospheric Deposition Program. 2009-09.: Central Analytical Laboratory. Champaign, Ill.
Web location: http://nadp.sws.uiuc.edu/lib/

CASTNet Quality Assurance Project Plan
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

Portable Ozone Monitoring Station (POMS) Operator's Guide.
National Park Service–Air Resources Division. 2008. Prepared by Air Resource Specialists, Inc., Ft. Collins, Colo.
Web location: http://www.nature.nps.gov/air/studies/portO3.cfm

Ozone Monitoring Protocol: Guidance on Selecting and Conducting Ozone Monitoring
National Park Service–Air Resources Division. 2004. Lakewood, Colorado. June.
Web location: http://www.nature.nps.gov/air/Monitoring/docs/FinalOzoneProtocol.pdf

Calibration and Routine Maintenance of 2B Technologies, Inc. Model 202 Ozone Analyzers
Air Resource Specialists, Inc. 2003.. Technical instruction manual 3100-2005. May.
Web location: http://www.nature.nps.gov/air/studies/portO3.cfm

IMPROVE SOP 201-3: Sampler Maintenance By Site Operators
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

IMPROVE Sampler Operating Procedures Manual
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

IMPROVE SOP 351-2: Data Processing and Validation
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

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 960/107672, May 2011

National Park Service
U.S. Department of the Interior

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