National Park Service
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Natural Resource Program Center
Fort Collins, Colorado

Weather and Climate Inventory
National Park Service
National Capital Region Network

Natural Resource Technical Report NPS/NCRN/NRTR—2006/009

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Weather and Climate Inventory National Park Service National Capital Region Network

Natural Resource Technical Report NPS/NCRN/NRTR—2006/009
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Acronyms

AASC	American Association of State Climatologists
ACIS	Applied Climate Information System
ANTI	Antietam National Battlefield
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
BLM	Bureau of Land Management
CASTNet	Clean Air Status and Trends Network
CATO	Catoctin Mountain Park
CHOH	Chesapeake and Ohio Canal National Historical Park
COOP	Cooperative Observer Program
CWOP	Citizen’s Weather Observer Program
CRN	Climate Reference Network
DFIR	Double-Fence Intercomparison Reference
DST	daylight savings time
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FIPS	Federal Information Processing Standards
GMT	Greenwich Mean Time
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GPS-MET	NOAA ground-based GPS meteorology
GWMP	George Washington Memorial Parkway
HAFE	Harpers Ferry National Historical Park
I&M	NPS Inventory and Monitoring Program
LEO	Low Earth Orbit
LST	local standard time
MANA	Manassas National Battlefield Park
MONO	Monocacy National Battlefield
NACE	National Capital Parks East
NADP	National Atmospheric Deposition Program
NCDC	National Climatic Data Center
NCRN	National Capital Region Inventory and Monitoring Network
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
PRISM	Parameter Regression on Independent Slopes Model
PRWI	Prince William Forest Park
RAWS	Remote Automated Weather Station Network
RCC	regional climate center
ROCR	Rock Creek Park
SAO	Surface Airways Observation Program
SCAN	Soil Climate Analysis Network

Surfrad	Surface Radiation Budget Network
SNOTEL	Snowfall Telemetry Network
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UTC	Coordinated Universal Time
WBAN	Weather Bureau Army Navy
WMO	World Meteorological Organization
WOTR	Wolf Trap Farm Park
WRCC	Western Regional Climate Center
WX4U	Weather For You Network

Executive Summary

Climate is a dominant factor driving the physical and ecologic processes affecting the National Capital Region Inventory and Monitoring Network (NCRN). The NCRN originally included large tracts of forests along with riparian and wetland areas. Much of the NCRN lies within the Potomac River basin, which remains one of the most biologically diverse areas in the entire mid-Atlantic region. Human uses, however, have significantly altered the natural systems within NCRN over the past several centuries, so that today, most of the land area is either urban or agricultural. These human influences have introduced stresses on the natural systems in the NCRN, stresses that frequently have negative impacts on the region's biodiversity. There are concerns about the climate changes associated with urbanization and other human activities and how they might introduce further stresses to the NCRN, including changes in forest species composition and increases in disturbance frequency and intensity due to extreme precipitation events and heat waves. Because of its influence on the ecology of NCRN park units and the surrounding areas, climate was identified as a high-priority, vital sign for NCRN, and climate is one of the 12 basic inventories to be completed for all National Park Service (NPS) Inventory and Monitoring Program (I&M) networks.

This project was initiated to inventory past and present climate monitoring efforts in NCRN. In this report, we provide the following information:

- Overview of broad-scale climatic factors important to NCRN park units.
- Inventory of weather and climate station locations in and near NCRN park units relevant to the NPS I&M Program.
- Results of an inventory of metadata on each weather station, including affiliations for weather-monitoring networks, types of measurements recorded at these stations, and information about the actual measurements (length of record, etc.).
- Initial evaluation of the adequacy of coverage for existing weather stations and recommendations for improvements in monitoring weather and climate.

The climate of the NCRN is characterized by moderately cold winters and warm, humid summers. There are small gradients in temperature and precipitation along the Potomac River Basin. Mean annual temperatures range from 10°C in the upper portions of this basin to over 12°C in the Washington metropolitan area. Winter minimums are generally between -5°C and -10°C in the NCRN. Summers can see maximum daily temperatures well over 30°C, especially in the lower Potomac River basin. Heat waves during the summer are often accompanied by high humidity levels and corresponding ozone pollution. Mean annual precipitation ranges from slightly under 1000 mm in the northwest part of NCRN to slightly over 1000 mm around Washington. Precipitation is a common occurrence throughout the year but is generally more common in summer. Occasional extreme precipitation events can cause significant flooding, especially in the more rugged terrain in the north and west part of the NCRN. Nor'easter storms during the winter months can also occasionally bring large snowfalls to the NCRN. While precipitation trends in the NCRN appear to be neutral, temperature trends for the region seem to show slight warming over the past century.

Through an accompanying search of national databases and inquiries to NPS staff, we have identified eight weather/climate stations that are at or within NCRN park units. These include one station at Antietam National Battlefield (ANTI), two stations at Catoctin Mountain Park (CATO), two stations at Chesapeake and Ohio Canal National Historical Park (CHOH), two stations at George Washington Memorial Parkway (GWMP), and one station at Harpers Ferry National Historical Park (HAFE). Six of the eight aforementioned stations are COOP (National Weather Service Cooperative Observer Program) stations.

Many NCRN park units are historical sites such as battlefields or other memorials and therefore must rely heavily on stations outside of the park units for their weather and climate data. This is particularly common for the NCRN park units in the greater Washington metropolitan area. Fortunately, there are numerous manual and automated weather/climate stations around most of these NCRN park units, due to their urban setting. Stations at the major airports in the region provide reliable climate records going back to the early twentieth century and also provide real-time weather data for the region. The NCRN is surrounded by many valuable long-term COOP climate stations, including several stations with data records that go back to the 1800s. These stations provide valuable records for the NCRN.

Some NCRN park units, such as Rock Creek Park (ROCR) and Prince William Forest Reserve (PRWI) currently have no current weather/climate stations but encompass lands that will have either very limited or no further urban development for years to come. The placement of stations within these park units would allow for future climate trends to be monitored in relatively-protected locations. Due to their protected locations, stations at these sites would be less sensitive to local microclimate changes and more sensitive to climate changes affecting the Washington area in general. Installing an automated station at these park units would include the added benefit of providing near-real-time data for the park units.

Acknowledgements

This work was supported and completed under Task Agreement H8R07010001 with the Great Basin Cooperative Ecosystem Studies Unit. We would like to acknowledge very helpful assistance from various National Park Service personnel associated with the Eastern Rivers and Mountains Inventory and Monitoring Network. Particular thanks are extended to Shawn Carter, John Gross, Margaret Beer, Grant Kelly, Heather Angeloff, and Greg McCurdy. Seth Gutman with the National Oceanic and Atmospheric Administration Earth Systems Research Laboratory provided valuable input on the GPS-MET station network. Portions of the work also were supported by the Western Regional Climate Center under the auspices of the National Oceanic and Atmospheric Administration.

1.0. Introduction

Weather and climate are key drivers in ecosystem structure and function. Global- and regional-scale climate variations will have a tremendous impact on natural systems (Chapin et al. 1996; Schlesinger 1997; Jacobson et al. 2000; Bonan 2002). These variations influence the fundamental properties of ecologic systems, such as soil–water relationships, plant–soil processes, and nutrient cycling, as well as disturbance rates and intensity. These properties, in turn, influence the life-history strategies supported by a climatic regime (Neilson 1987).

Given the importance of climate, it is one of 12 basic inventories to be completed by the National Park Service (NPS) Inventory and Monitoring Program (I&M) network (I&M 2006). It is essential that park units within the National Capital Region Inventory and Monitoring Network (NCRN) have an effective climate-monitoring system in place to track climate changes and to aid in management decisions relating to these changes. Most park units observe weather and climate elements as part of their overall mission. The lands under NPS stewardship provide many excellent locations for monitoring climatic conditions. The primary objective for climate and weather monitoring in NCRN is to "track the change in weather patterns across NCRN parks" (NPS 2005). This includes (NPS 2005):

- Determining variability and long-term trends in climate for all NCRN parks through monthly and annual summaries of descriptive statistics for selected weather parameters, including air temperature and precipitation.
- Identifying and determining frequencies and patterns of extreme climatic conditions for common weather parameters.

The purpose of this report is to determine the current status of weather and climate monitoring within NCRN (Figure 1.1), which includes 11 park units (Table 1.1). In this report, we provide the following informational elements:

- Overview of broad-scale climatic factors important to NCRN park units.
- Inventory of locations for all weather stations in and near NCRN park units that are relevant to the NPS I&M networks.
- Results of metadata inventory for each station, including weather-monitoring network affiliations, types of recorded measurements, and information about actual measurements (length of record, etc.).
- Initial evaluation of the adequacy of coverage for existing weather stations and recommendations for improvements in monitoring weather and climate.

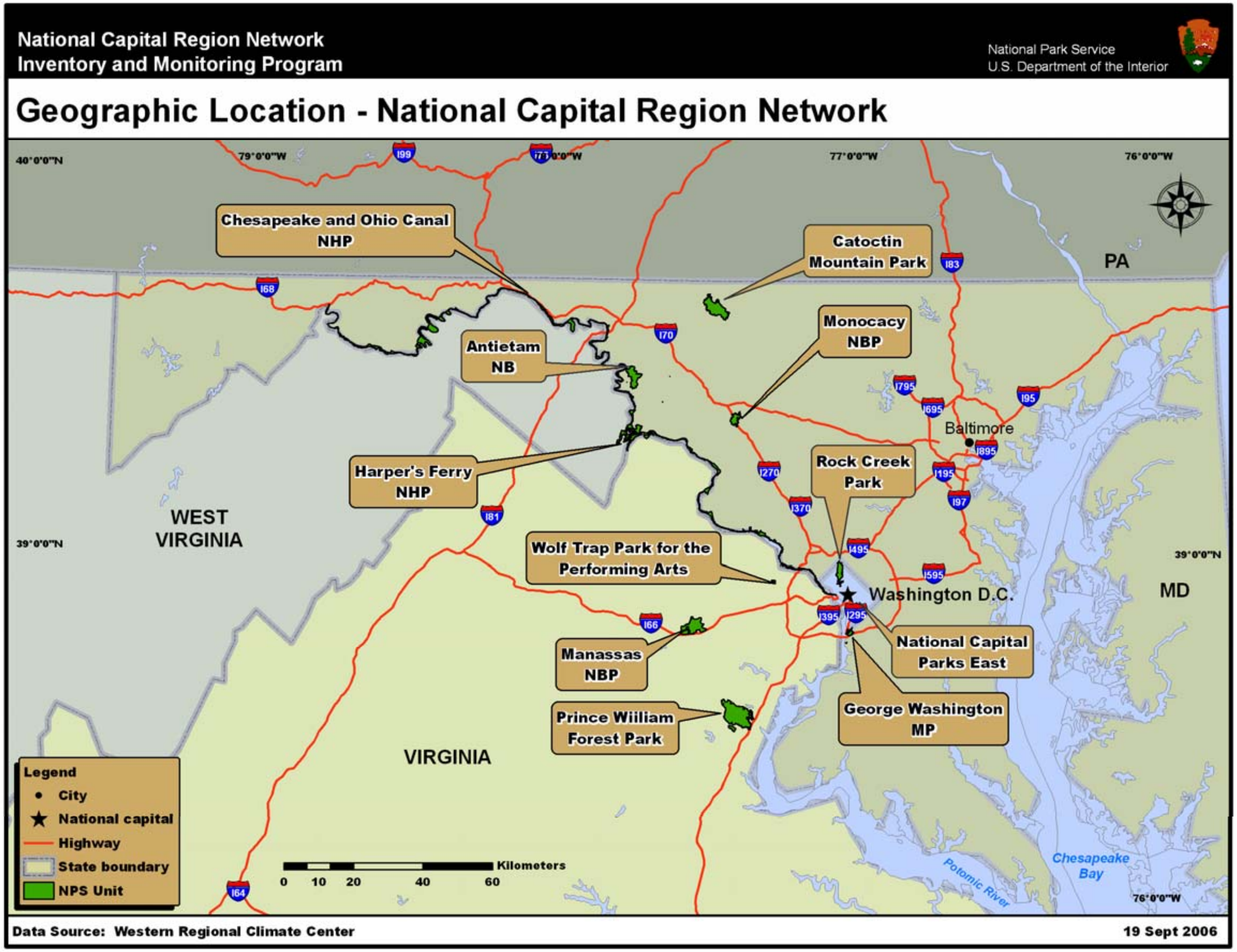

Figure 1.1. Map of the National Capital Region Inventory and Monitoring Network.

Table 1.1. Park units in NCRN.

Acronym	Name
ANTI	Antietam National Battlefield
CATO	Catoctin Mountain Park
CHOH	Chesapeake and Ohio Canal National Historical Park
GWMP	George Washington Memorial Parkway
HAFE	Harpers Ferry National Historical Park
MANA	Manassas National Battlefield Park
MONO	Monocacy National Battlefield
NACE	National Capital Parks East
PRWI	Prince William Forest Park
ROCR	Rock Creek Park
WOTR	Wolf Trap Farm Park

1.1. Network Terminology

Before proceeding, it is important to stress that this report discusses the idea of “networks” in two different ways. Modifiers are used to distinguish between NPS I&M networks and weather/climate station networks. See Appendix B for a full definition of these terms.

1.1.1. Weather/Climate Station Networks

Most weather and climate measurements are made not from isolated stations but from stations that are part of a network operated in support of a particular mission. The limiting case is a network of one station, where measurements are made by an interested observer or group. Larger networks usually have more and better inventory data and station-tracking procedures. Many national weather/climate networks are associated with the National Oceanic and Atmospheric Administration (NOAA), including the National Weather Service (NWS) Cooperative Observer Program (COOP) and the Surface Airways Observation Network (SAO). Usually a single agency, but sometimes a consortium of interested parties, will jointly support a particular weather/climate network.

1.1.2. NPS I&M Networks

Within the NPS, the system for monitoring various attributes in the participating park units (about 280–290 in total) is divided into 32 NPS I&M networks. These networks are collections of park units grouped together around a common theme, typically geographical.

1.2. Weather versus Climate Definitions

It is also important to distinguish whether the primary use of a given station is for weather purposes or for climate purposes. Weather station networks are intended for near-real-time usage, where the precise circumstances of a set of measurements are typically less important. In these cases, changes in exposure or other attributes over time are not as critical. Climate networks, however, are intended for long-term tracking of atmospheric conditions. Siting and exposure are critical factors for climate networks, and it is vitally important that the observational circumstances remain essentially unchanged over the duration of the station record. Some climate networks can be considered hybrids of weather/climate networks. These hybrid climate networks can supply information on a short-term "weather" time scale and a longer-term "climate" time scale.

In this report, "weather" generally refers to current (or near-real-time) atmospheric conditions, while "climate" is defined as the complete ensemble of statistical descriptors for temporal and spatial properties of atmospheric behavior (see Appendix B). Climate and weather phenomena shade gradually into each other and are ultimately inseparable.

1.3. Purpose of Measurements

Climate inventory and monitoring climate activities should be based on a set of guiding fundamental principles. Any evaluation of weather/climate monitoring programs begins with asking the following question:

- What is the purpose of weather and climate measurements?

Evaluation of past, present, or planned weather/climate monitoring activities must be based on the answer to this question.

Weather and climate data and information constitute a prominent and widely requested component of the NPS I&M networks (I&M 2006). As primary environmental drivers for the other "vital signs," weather and climate patterns present various practical and management consequences and implications for the NPS (Oakley et al. 2003). Within the context of the NPS, the following services constitute the main purposes for recording weather and climate observations:

- Provide measurements for real-time operational needs and early warnings of potential hazards (landslides, mudflows, washouts, fallen trees, plowing activities, fire conditions, aircraft and watercraft conditions, road conditions, rescue conditions, fog, restoration and remediation activities, etc.).
- Provide visitor education and aid interpretation of expected and actual conditions for visitors while they are in the park and for deciding if and when to visit the park.
- Establish engineering and design criteria for structures, roads, culverts, etc., for human comfort, safety, and economic needs.
- Consistently monitor climate over the long-term to detect changes in environmental drivers affecting ecosystems, including both gradual and sudden events.
- Provide retrospective data to understand *a posteriori* changes in flora and fauna.
- Document for posterity the physical conditions in and near the park units, including mean, extreme, and variable measurements (in time and space) for all applications.

The last three items in the preceding list are pertinent primarily to the NPS I&M networks; however, all items are important to NPS operations and management. Most of the needs in this list overlap heavily. It is often impractical to operate separate climate measuring systems that also cannot be used to meet ordinary weather needs, where there is greater emphasis on timeliness and reliability.

1.4. Design of Climate-Monitoring Programs

Determining the purposes for collecting measurements in a given weather/climate monitoring program will guide the process of identifying weather/climate stations suitable for the monitoring program. The context for making these decisions is provided in Chapter 2 where background on the NCRN climate is presented. However, this process is only one step in evaluating and designing a climate-monitoring program. This process includes the following additional steps:

- Define park and network-specific monitoring needs and objectives.
- Identify locations and data repositories of existing and historic stations.
- Acquire existing data when necessary or practical.
- Evaluate the quality of existing data.
- Evaluate the adequacy of coverage of existing stations.
- Develop a protocol for monitoring the weather and climate, including the following:
  - Standardized summaries and reports of weather/climate data.
  - Data management (quality assurance and quality control, archiving, data access, etc.).
- Develop and implement a plan for installing or modifying stations, as necessary.

Throughout the design process, there are various factors that require consideration in evaluating weather and climate measurements. Many of these factors have been summarized by Dr. Tom Karl, director of the NOAA National Climatic Data Center (NCDC), and widely distributed as the “Ten Principles for Climate Monitoring” (Karl et al. 1996a; NRC 2001). These principles are presented in Appendix A, and the guidelines are embodied in many of the comments made throughout this report. The most critical factors are presented here. In addition, an overview of requirements necessary to operate a climate network is provided in Appendix C, with further discussion in Appendix E.

1.4.1. Need for Consistency

A principal goal in climate monitoring is to detect and characterize slow and sudden changes in climate through time. This is of less concern for day-to-day weather changes, but it is of paramount importance for climate change. There are many ways whereby changes in techniques for making measurements, changes in instruments or their exposures, or seemingly innocuous changes in site characteristics can lead to apparent changes in climate. Safeguards must be in place to avoid these false sources of temporal “climate” variability if we are to draw correct inferences about climate behavior over time from archived measurements.

For climate monitoring, consistency through time is vital, counting at least as important as absolute accuracy. Sensors record only what is occurring at the sensor—this is all they can detect. It is the responsibility of station or station network managers to ensure that observations are representative of the spatial and temporal climate scales that we wish to record.

1.4.2. Metadata

Changes in instruments, site characteristics, and observing methodologies can lead to apparent changes in climate through time. It is therefore vital to document all factors that can bear on the interpretation of climate measurements and to update the information repeatedly through time. This information ("metadata," data about data) has its own history and set of quality-control issues that parallel those of the actual data. There is no single standard for the content of climate metadata, but a simple rule suffices:

- Observers should record all information that could be needed in the future to interpret observations correctly without benefit of the observers' personal recollections.

Such documentation includes notes, drawings, site forms, and photos, which can be of inestimable value if taken in the correct manner. That stated, it is not always clear to the metadata provider *what is important* for posterity and *what will be important* in the future. It is almost impossible to "over document" a station. Station documentation is underappreciated greatly and seldom thorough enough (especially for climate purposes). Insufficient attention to this issue often lowers the present and especially future value of otherwise useful data.

The convention followed throughout climatology is to refer to metadata as information about the measurement process, station circumstances, and data. The term "data" is reserved solely for the actual weather and climate records obtained from sensors.

1.4.3. Maintenance

Inattention to maintenance is the greatest source of failure in weather/climate stations and networks. Problems usually begin to occur soon after sites are deployed. A regular visit schedule must be implemented, where sites, settings (e.g., vegetation), sensors, communications, and data flow are checked routinely (once or twice a year at a minimum) and updated as necessary. Parts must be changed out for recalibration (annual) or replacement. With adequate maintenance, the entire instrument suite should be replaced or completely refurbished about once every five to seven years.

Simple preventative maintenance is effective but requires much planning and skilled technical staff. Changes in technology and products require retraining and continual re-education. Travel, logistics, scheduling, and seasonal access restrictions consume major amounts of time and budget but are absolutely necessary. Without such attention, data gradually become less credible and then often are misused or not used at all.

1.4.4. Automated versus Manual Stations

Historic stations often have depended on manual observations and many continue to operate in this mode. Manual observations frequently produce excellent data sets. Sensors and data are simple and intuitive, well tested, and relatively cheap. Manual stations have much to offer in certain circumstances and can be a source of both primary and backup data. However, methodical consistency for manual measurements is a constant challenge, especially with a mobile work force. Operating manual stations takes time and affects schedules, though sometimes the routine is welcome.

Nearly all newer stations are automated. Automated stations provide better time resolution, increased (though imperfect) reliability, greater capacity for data storage, and improved accessibility to large amounts of data. The purchase cost for automated stations is higher than for manual stations. A common expectation and serious misconception is that an automated station can be deployed and left to operate on its own. In reality, automation does not eliminate the need for people but rather changes the type of person that is needed. Skilled technical personnel are needed and must be readily available, especially if live communications exist and data gaps are not wanted. Site visits are needed at least annually and spare parts must be maintained. Typical annual costs for sensors and maintenance are $1.5–2.5K per station per year.

1.4.5. Communications

With manual stations, the observer is responsible for recording and transmitting station data. Data from automated stations, however, can be transmitted quickly for access by research and operations personnel, which is a highly preferable situation. A comparison of communication systems for automated and manual stations shows that automated stations generally require additional equipment, more power, higher transmission costs, attention to sources of disruption or garbling, and backup procedures (manual downloads from data loggers).

Automated stations are capable of functioning normally without communication and retaining many months of data. At such sites, however, alerts about station problems are not possible, large gaps can accrue when accessible stations quit, and the constituencies needed to support such stations are smaller and less vocal. Two-way communications permit full recovery from disruptions, ability to reprogram data loggers remotely, and better opportunities for diagnostics and troubleshooting. In virtually all cases, two-way communications are much preferred to all other communication methods. However, two-way communications require considerations of cost, signal access, transmission rates, interference, and methods for keeping sensor and communication power loops separate. Two-way communications are frequently impossible (no service) or impractical, expensive, or power consumptive. Two-way methods (cellular, land line, radio, Internet) require smaller up-front costs as compared to other methods of communication and have variable recurrent costs, starting at zero. Satellite links work everywhere (except when blocked by trees or cliffs) and are quite reliable but are one-way and relatively slow, allow no re-transmissions, and require high up-front costs ($3–4K) but no recurrent costs. Communications technology is changing constantly and requires vigilant attention by maintenance personnel.

1.4.6. Quality Assurance and Quality Control

Quality control and quality assurance are issues at every step through the entire sequence of sensing, communication, storage, retrieval, and display of environmental data. Quality assurance is an umbrella concept that covers all data collection and processing (start-to-finish) and ensures that credible information is available to the end user. Quality control has a more limited scope and is defined by the International Standards Organization as “the operational techniques and activities that are used to satisfy quality requirements." The central problem can be better appreciated if we approach quality control in the following way.

- Quality control is the evaluation, assessment, and rehabilitation of imperfect data by utilizing other imperfect data.

The quality of the observation only decreases with time once the observation is made. The best and most effective quality control, therefore, consists in making high-quality measurements from the start and then successfully transmitting the measurements to an ingest process and storage site. Once the data are received from a monitoring station, a series of checks with increasing complexity can be applied, ranging from single-element checks (self-consistency) to multiple-element checks (inter-sensor consistency) to multiple-station/single-element checks (inter-station consistency). Suitable ancillary data (battery voltages, data ranges for all measurements, etc.) can prove extremely useful in diagnosing problems.

With measurements, there is rarely a single technique that will work satisfactorily for all situations. Quality-control procedures must be tailored to individual station circumstances, data access and storage methods, and climate regimes.

The fundamental issue in quality control centers on the tradeoff between falsely rejecting good data (Type I error) and falsely accepting bad data (Type II error). We cannot reduce the incidence of one type of error without increasing the incidence of the other type. In weather and climate data assessments, Type I errors are deemed far less desirable than Type II errors.

Not all observations are equal. Quality-control procedures are likely to have great impact on the most important (extreme) observations, where independent information usually must be sought and incorporated. Any form of quality control usually involves a great deal of infrastructure with its own (imperfect) error-detection methods, which must be in place before a single value can be evaluated.

1.4.7. Standards

Although there is near-universal recognition of the value in systematic weather and climate measurements, these measurements will have little value unless they conform to accepted standards. There is not a single source for standards for collecting weather and climate data nor a single standard that meets all needs. Measurement standards have been developed by the American Association of State Climatologists (AASC 1985), U.S. Environmental Protection Agency (EPA 1987), World Meteorological Organization (WMO 1983; 2005), Finklin and Fischer (1990), National Wildfire Coordinating Group (2004), and the RAWS program (Bureau of Land Management [BLM] 1997). Variations to these measurement standards also have been offered by instrument makers (e.g., Tanner 1990).

1.4.8. Who Makes the Measurements?

The lands under NPS stewardship provide many excellent locations to host the monitoring of climate by the NPS or other collaborators. Most park units historically have observed weather/climate elements as part of their overall mission. Many of these measurements come from station networks managed by other agencies, with observations taken or overseen by NPS personnel, in some cases, or by collaborators from the other agencies. National Park Service units that are small, lack sufficient resources, or lack sites presenting adequate exposure may benefit by utilizing weather/climate measurements collected from nearly stations.

2.0. Climate Background

Ecosystem processes in NCRN are strongly governed by climate characteristics (NPS 2005). It is therefore essential to understand the climate characteristics of the NCRN. These characteristics are discussed in this chapter.

2.1. Climate and the NCRN Environment

Most of the NCRN lies within the Potomac River basin, with the only exceptions being some parks within the National Capital Parks-East (NACE) that lie within the Patuxent River drainage (NPS 2005). The original landscape in the NCRN included large tracts of forests along with riparian and wetland areas. The Potomac River corridor remains one of the most biologically diverse areas in the entire mid-Atlantic region (Cohn 2004; NPS 2005). Human uses, however, have significantly altered the natural systems within NCRN over the past several centuries (NPS 2005). Today, over 70% of the land area is either urban or agricultural, while the rest is either forest or wetland (Dail et al. 1998; NPS 2005). These human influences have introduced stresses on the natural systems in the NCRN, including various plant diseases (Ayres and Lombardero 2000), atmospheric pollutant deposition, and habitat fragmentation (NPS 2005), all of which have negative impacts on the region's biodiversity.

In addition to this, it is well known that global- and regional-scale climate variations will have a tremendous impact on natural systems (Schlesinger 1997; Jacobson et al. 2000; Bonan 2002). There are ongoing concerns about the climate changes that both accompany and result from urbanization and other human activities and how they might further stress the natural systems in the NCRN (NPS 2005). It is generally expected that forest species composition will change dramatically in the area, that extreme precipitation events will increase, and that heat waves will become more common (NAST 2001; NPS 2005). The possible changes in the temperature regimes of the NCRN could accelerate the formation of ozone and other air pollutants (Schlesinger 1997; NRC 2001).

2.2. Spatial Variability

The climate of the NCRN is characterized by moderately cold winters and warm, humid summers (Dail et al. 1998; NPS 2005). The mean annual temperature of the region ranges between about 10°C in the northwest, including much of the Chesapeake and Ohio Canal National Historical Park (CHOH), to over 12°C in the Washington metropolitan area. Summers can see maximum daily temperatures well over 30°C, especially in the lower Potomac River basin. Heat waves during the summer are often accompanied by high humidity levels and corresponding ozone pollution, especially in the southeastern parts of NCRN. These conditions can be oppressive for visitors to the parks and memorials in Washington. Such heat waves occurred in 2003 and most recently in the summer of 2006. Winter minimums are generally between -5°C and -10°C.

Mean annual precipitation is quite homogeneous throughout the NCRN, ranging from slightly under 1000 mm in the northwest part of NCRN to slightly over 1000 mm around the Washington metropolitan area. Seasonal precipitation patterns at various locations in the NCRN (Figure 2.1) show that precipitation is a common occurrence throughout the year but that there is generally more precipitation during the summer months. Mean annual snowfall in NCRN is over 600 mm (NPS 2005), with slightly heavier totals occurring in the upper Potomac River Basin. Occasional extreme precipitation events, such as tropical systems, can cause significant flooding, especially in the more rugged terrain in the north and west part of the NCRN. Nor'easter storms during the winter months can also occasionally bring large snowfalls to the NCRN. The Presidents' Day Storm of February 15-18, 2003 brought heavy snow to the area, with almost 50 cm of snow in Washington and even higher amounts in the regions west of the city. A similar storm on February 18-19, 1979 (the original "Presidents' Day Storm") brought similarly heavy snows to the Washington area.

2.3. Temporal Variability

Precipitation trends in the eastern U.S. have shown strong increases in precipitation over the last century (Karl et al. 1996b; Karl and Knight 1998; NAST 2001). This is not as apparent in the precipitation trends for the NCRN region (e.g. Maryland; see Figure 2.2).

Trends in temperature over NCRN are more evident than the corresponding precipitation trends for NCRN. Temperature trends in this region have shown a warming of about 0.5°C (2°F) over the last century (Figure 2.3).

Tropical storm and hurricanes are significant extreme storm events that occasionally impact the NCRN. Although some wind damage can accompany these storms, the heavy precipitation and flooding from these storms is by far a more important disturbance factor for NCRN ecosystems. About 3 tropical storms and/or hurricanes have made landfall in the U.S. each year over the past century (Lyons 2004). Most of these storms that make landfall in the U.S. originate either in the Gulf of Mexico or the Western Caribbean (Lyons 2004). Strong hurricanes have generally made landfall in the U.S. at a rate of just under one per year over the past century (Smith 1999; Lyons 2004). The number of these storms that reach middle and northern portions of the eastern U.S. has been very sporadic during this time period but the events, when they do occur, tend to do so in clusters. These clusters of storms occur on time scales of a couple decades (Smith 1999).

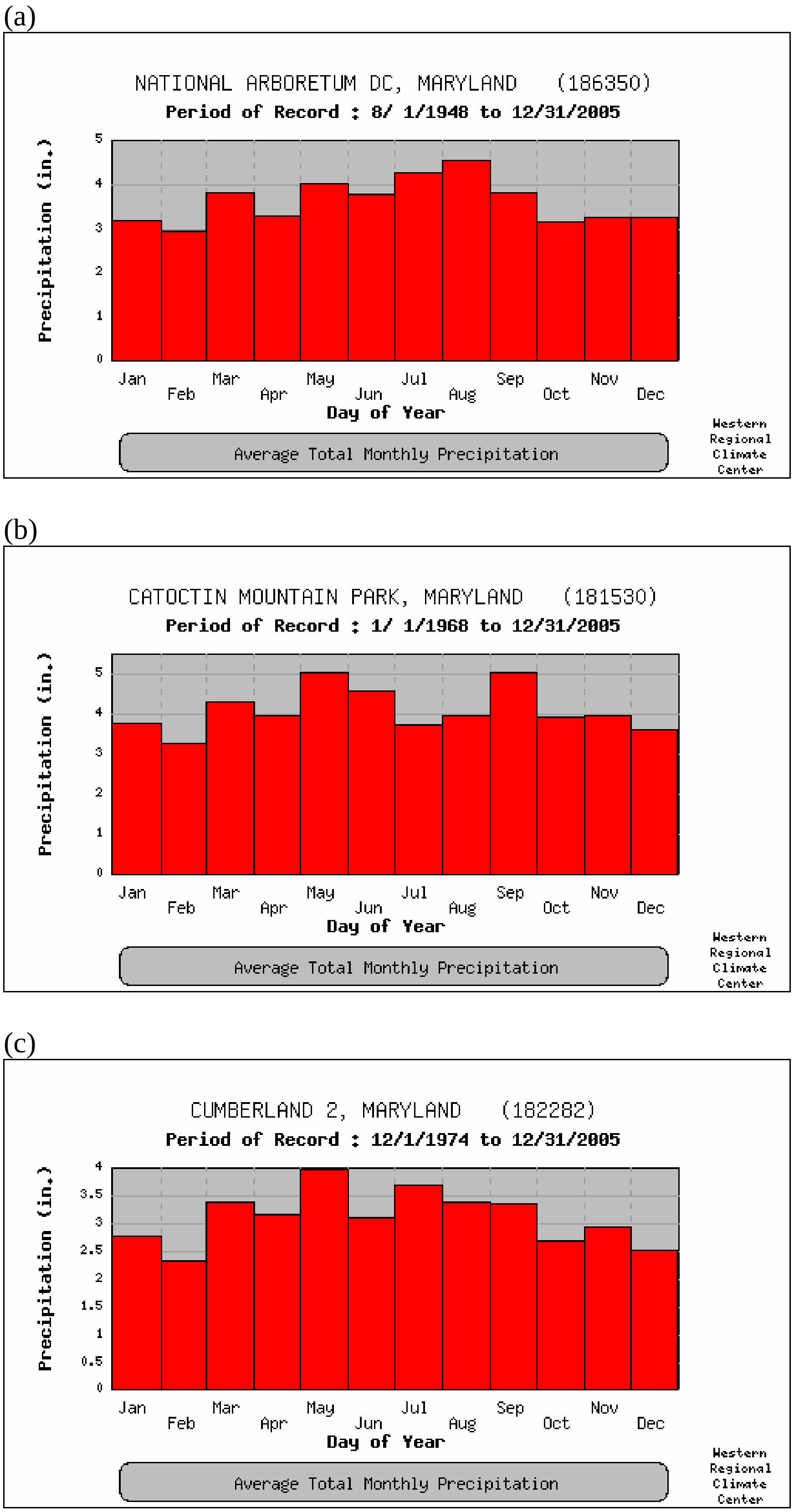

Figure 2.1. Mean monthly precipitation at selected locations in the NCRN region.

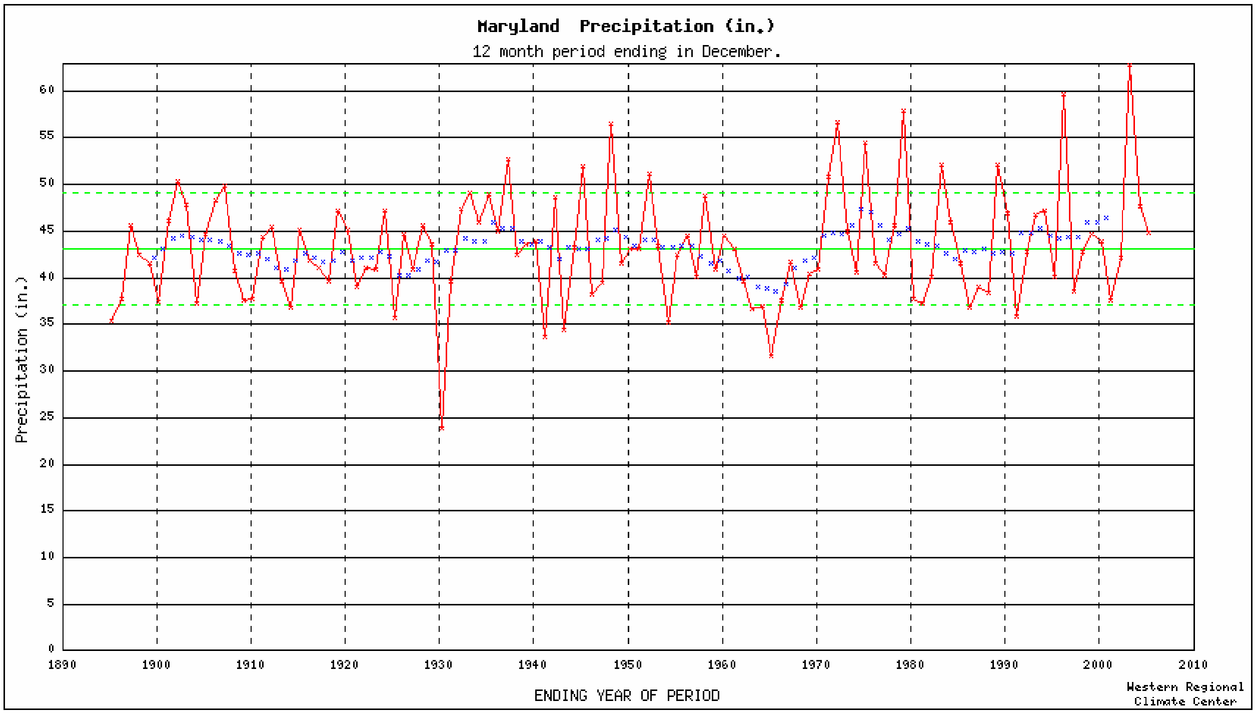

Figure 2.2. Maryland precipitation time series, 1895-2005. Twelve-month average precipitation ending in December (red), 10-year running mean (blue), mean (green), and plus/minus one standard deviation (green dotted line), 1895-2005.

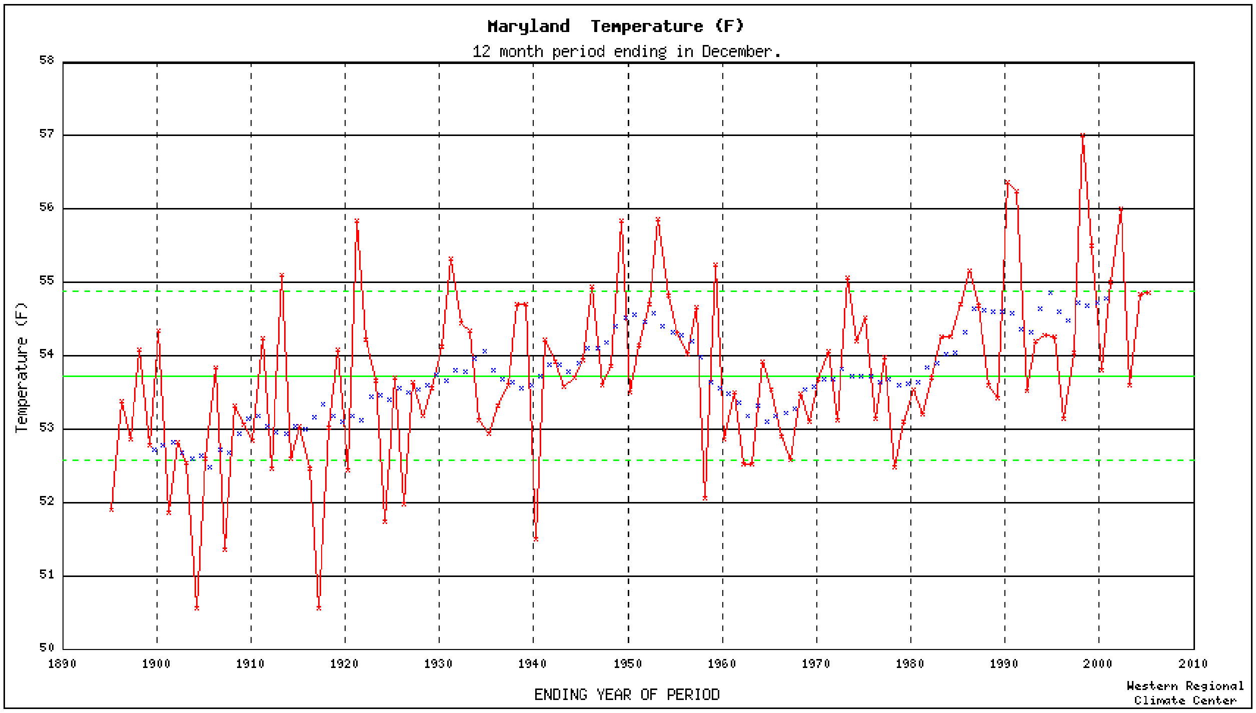

Figure 2.3. Maryland temperature time series, 1895-2005. Twelve-month average temperature ending in December (red), 10-year running mean (blue), mean (green), and plus/minus one standard deviation (green dotted line), 1895-2005.

3.0. Methods

Having discussed the climatic characteristics of NCRN, we now present the procedures that were used to obtain information for weather/climate stations within NCRN. This information was obtained from various sources, as mentioned in the following paragraphs. Retrieval of station metadata constituted a major component of this work.

3.1. Metadata Retrieval

A key component of station inventories is determining the kinds of observations that have been conducted over time, by whom, and in what manner; when each type of observation began and ended; and whether these observations are still being conducted. Metadata about the observational process (Table 3.1) generally consist of a series of vignettes that apply to time intervals and, therefore, constitute a *history* rather than a single snapshot. An expanded list of relevant metadata fields for this inventory is provided in Appendix D. This report has relied on metadata records from three sources: (a) Western Regional Climate Center (WRCC), (b) NPS personnel, and (c) other knowledgeable personnel, such as state climate office staff.

The initial metadata sources for this report were stored at WRCC. This regional climate center acts as a working repository of many western climate records, including the main networks outlined in this section. Live and periodic ingests from all major national and western weather/climate networks are maintained at WRCC. These networks include the COOP network, the Surface Airways Observation Network (SAO) jointly operated by NOAA and the Federal Aviation Administration (FAA), and various smaller networks. The WRCC is expanding its capability to ingest information from other networks as resources permit and usefulness dictates. This center has relied heavily on historic archives (in many cases supplemented with live ingests) to assess the quantity (not necessarily quality) of data available for NPS I&M network applications.

This report has relied primarily on metadata stored in the Applied Climate Information System (ACIS), a joint effort among regional climate centers (RCCs) and other NOAA entities. Metadata for NCRN weather/climate stations identified from the ACIS database are available in file "NCRN_from_ACIS.tar.gz" (see Appendix G). Historic metadata pertaining to major climate- and weather-observing systems in the United States are stored in ACIS where metadata are linked to the observed data. A distributed system, ACIS is synchronized among the RCCs. Mainstream software is utilized, including Postgress, Python™, and Java™ programming languages; CORBA®-compliant network software; and industry-standard, nonproprietary hardware and software. All major national climate and weather networks have been entered into the ACIS database. For this project, the available metadata from many smaller networks also have been entered. Data sets are in the NetCDF (Network Common Data Form) format, but the design allows for integration with legacy systems, including non-NetCDF files (used at WRCC) and additional metadata (added for this project). The ACIS also supports a suite of products to visualize or summarize data from these data sets. National climate-monitoring maps are updated daily using the ACIS data feed. The developmental phases of ACIS have utilized metadata supplied by the NCDC and NWS with many tens of thousands of entries, screened as well as possible for duplications, mistakes, and omissions.

Table 3.1. Primary metadata fields for weather/climate stations within NCRN. Explanations of each field are provided as appropriate.

Metadata Field	Notes
Station name	Station name associated with network listed in "Climate Network."
Latitude	Numerical value (units: see coordinate units).
Longitude	Numerical value (units: see coordinate units).
Coordinate units	Latitude/longitude (units: decimal degrees, degree-minute-second, etc.).
Datum	Datum used as basis for coordinates: WGS 84, NAD 83, etc.
Elevation	Elevation of station above mean sea level (m).
Slope	Slope of ground surface below station (degrees).
Aspect	Azimuth that ground surface below station faces.
Climate division	NOAA climate division where station is located. Climate divisions are NOAA-specified zones sharing similar climate and hydrology characteristics.
Country	Country where station is located.
State	State where station is located.
County	County where station is located.
Weather/climate network	Primary weather/climate network the station belongs to (RAWS, Clean Air Status and Trends Network [CASTNet], etc.).
NPS unit code	Four-letter code identifying park unit where station resides.
NPS unit name	Full name of park unit.
NPS unit type	National park, national monument, etc.
UTM zone	If UTM is the only coordinate system available.
Location notes	Useful information not already included in "station narrative."
Climate variables	Temperature, precipitation, etc.
Installation date	Date of station installation.
Removal date	Date of station removal.
Station photograph	Digital image of station.
Photograph date	Date photograph was taken.
Photographer	Name of person who took the photograph.
Station narrative	Anything related to general site description; may include site exposure, characteristics of surrounding vegetation, driving directions, etc.
Contact name	Name of the person involved with station operation.
Organization	Group or agency affiliation of contact person.
Contact type	Designation that identifies contact person as the station owner, observer, maintenance person, data manager, etc.
Position/job title	Official position/job title of contact person.
Address	Address of contact person.
E-mail address	E-mail address of contact person.
Phone	Phone number of contact person (and extension if available).
Contact notes	Other information needed to reach contact person.

In addition to obtaining NCRN weather/climate station metadata from ACIS, metadata were obtained from staff at the NWS Headquarters in Silver Spring, Maryland. Our primary contact at this office was David Miskus (Phone: 202-720-7919; Email: david.miskus@noaa.gov).

Two types of information have been used to complete the climate station inventory for NCRN.

- Station inventories: Information about the observational procedures, latitude/longitude, elevation, measured elements, measurement frequency, sensor types, exposures, ground cover and vegetation, data-processing details, network, purpose, and managing individual or agency, etc.

- Data inventories: Information about measured data values including completeness, seasonality, data gaps, representation of missing data, flagging systems, how special circumstances in the data record are denoted, etc.

This is not a straightforward process. Extensive searches are typically required to develop historic station and data inventories. Both types of inventories frequently contain information gaps and often have built-in, unrealistic assumptions. Sources of information for these inventories frequently are difficult to recover or are undocumented and unreliable. In many cases, the actual weather/climate data available from different sources are not linked directly to metadata records. To the extent that actual data can be acquired (rather than just metadata), it is possible to cross-check these records and perform additional assessments based on the amount and completeness of the data.

Certain types of weather/climate networks that possess any of the following attributes have also not been considered for inclusion in the inventory:

- Private networks with proprietary access and/or inability to obtain or provide sufficient metadata.
- Private weather enthusiasts (often with high-quality data) whose metadata are not available and whose data are not readily accessible.
- Unofficial observers supplying data to the NWS (lack of access to current data and historic archives; lack of metadata).
- Networks having no available historic data.
- Networks having poor-quality metadata.
- Networks having poor access to metadata.
- Real-time networks having poor access to real-time data.

Previous inventory efforts at WRCC have shown that for the weather networks identified in the preceding list, in light of the need for quality data to track weather and climate, the resources required and difficulty encountered in obtaining metadata or data are prohibitively large.

3.2. Criteria for Locating Stations

To identify stations for each park unit in NCRN, we identified all weather and climate stations, past and present, that were within a certain distances from the park boundaries. There are many weather stations in the Washington metropolitan area. Therefore, we selected a 10-km buffer for the NCRN park units that were in or around the Washington metropolitan area. This was intended to limit our inventory to those stations that are nearest to the park units and thus likely to provide the most representative weather/climate data for these park units.

For all other NCRN park units, a 30-km buffer was selected. These park units are more rural relative to the Washington park units and thus a wider buffer is needed in order to ensure the inclusion of both manual and automated stations in the station inventories.

The station locator maps presented in Chapter 4 were designed to show clearly the spatial distributions of all major weather/climate station networks in NCRN. We recognize that other mapping formats may be more suitable for other specific needs.

4.0. Station Inventory

An objective of this report is to show the locations of weather/climate stations for the NCRN region in relation to the boundaries of the NPS park units within NCRN. A station does not have to be within park boundaries to provide useful data and information for a park unit.

4.1. Climate and Weather Networks

Most stations in the NCRN region are associated with at least one of nine major weather/climate networks (Table 4.1). Brief descriptions of each weather/climate network are provided below (see Appendix F for greater detail).

Table 4.1. Weather/climate networks represented within NCRN.

Acronym	Name
CASTNet	Clean Air Status and Trends Network
COOP	NWS Cooperative Observer Program
CWOP	Citizen Weather Observer Program
GPS-MET	NOAA ground-based GPS meteorology
RAWS	Remote Automated Weather Station network
SAO	NWS/FAA Surface Airways Observation Network
SCAN	Soil Climate Analysis Network
WBAN	Weather Bureau Army Navy
WX4U	Weather For You Network

4.1.1. Clean Air Status and Trends Network (CASTNet)

CASTNet is primarily an air-quality monitoring network managed by the EPA. Standard hourly weather and climate elements are measured and include temperature, wind, humidity, solar radiation, soil temperature, and sometimes moisture. These elements are intended to support interpretation of air-quality parameters that also are measured at CASTNet sites. Data records at CASTNet sites are generally one–two decades in length.

4.1.2. NWS Cooperative Observer Program (COOP)

The COOP network has been a foundation of the U.S. climate program for decades and continues to play an important role. Manual measurements are made by volunteers and consist of daily maximum and minimum temperatures, observation-time temperature, daily precipitation, daily snowfall, and snow depth. When blended with NWS measurements, the data set is known as SOD, or “Summary of the Day.” The quality of data from COOP sites ranges from excellent to modest.

4.1.3. Citizen Weather Observer Program (CWOP)

The CWOP network consists primarily of automated weather stations operated by private citizens who have either an Internet connection and/or a wireless Ham radio setup. Data from CWOP stations are specifically intended for use in research, education, and homeland security activities. Although standard meteorological elements such as temperature, precipitation, and wind are measured at all CWOP stations, station characteristics do vary, including sensor types and site exposure.

4.1.4. NOAA Ground-Based GPS Meteorology (GPS-MET)

The GPS-MET network is the first network of its kind dedicated to GPS meteorology (see Duan et al. 1996). GPS meteorology utilizes the radio signals broadcast by the satellite Global Positioning System for atmospheric remote sensing. GPS meteorology applications have evolved along two paths: ground-based (Bevis et al. 1992) and space-based (Yuan et al. 1993). For more information, please see Appendix G. The stations identified in this inventory are all ground-based. The GPS-MET network was developed in response to the need for improved moisture observations to support weather forecasting, climate monitoring, and other research activities. The primary goals of this network are to measure atmospheric water vapor using ground-based GPS receivers, facilitate the operational use of these data, and encourage usage of GPS meteorology for atmospheric research and other applications. GPS-MET is a collaboration between NOAA and several other governmental and university organizations and institutions. Ancillary meteorological observations at GPS-MET stations include temperature, relative humidity, and pressure.

4.1.5. Remote Automated Weather Station Network (RAWS)

The RAWS network is administered through many land management agencies, particularly the BLM and the Forest Service. Hourly meteorological elements are measured and include temperature, wind, humidity, solar radiation, barometric pressure, fuel temperature, and precipitation (when temperatures are above freezing). The fire community is the primary client for RAWS data. These sites are remote and data typically are transmitted via GOES (Geostationary Operational Environmental Satellite). Some sites operate all winter. Most data records for RAWS sites began during or after the mid-1980s.

4.1.6. NWS/FAA Surface Airways Observation Network (SAO)

These stations are located usually at major airports and military bases. Almost all SAO sites are automated. The hourly data measured at these sites include temperature, precipitation, humidity, wind, pressure, sky cover, ceiling, visibility, and current weather. Most data records begin during or after the 1940s, and these data are generally of high quality.

4.1.7. Soil Climate Analysis Network (SCAN)

This network is administered by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and is a cooperative nationwide soil moisture and climate information system with a primary goal of supporting natural resource assessment and conservation activities. The SCAN network is concentrated primarily in the agricultural areas of the U.S. Measured meteorological elements include temperature, precipitation, relative humidity, wind speed and direction, solar radiation, snow water content and depth, soil moisture, and soil temperature.

4.1.8. Weather Bureau Army Navy (WBAN)

This is a station identification system rather than a true weather/climate network. Stations identified with WBAN are largely historical stations that reported meteorological observations on the WBAN weather observation forms that were common during the early and middle parts of the 20th Century. The use of WBAN numbers to identify stations was one of the first attempts in the U.S. to use a coordinated station numbering scheme between several weather station networks, such as the SAO and COOP networks.

4.1.9. Weather For You Network (WX4U)

The WX4U network is a nationwide collection of weather stations run by local observers. Data quality varies with site. Standard meteorological elements are measured and usually include temperature, precipitation, wind, and humidity.

4.1.10. Other Networks

In addition to the major networks mentioned above, there are various networks that are operated for specific purposes by specific organizations or governmental agencies or scientific research projects. These networks could be present within NCRN but have not been identified in this report. Some of the commonly used networks include the following:

- NOAA upper-air stations
- National Atmospheric Deposition Program (NADP)
- U.S. Department of Energy Surface Radiation Budget Network (Surfrad)
- U.S. Geological Survey (USGS) hydrologic stations
- Park-specific monitoring networks and stations
- Other research or project networks having many possible owners

The metadatabase files for weather/climate stations in NCRN are constantly being updated. As new weather/climate networks are identified, these will be added to the final versions of the metadatabase files accompanying this report.

4.2. Station Locations

The major weather/climate networks in NCRN (discussed in Section 4.1) have at most a few stations that are at or inside each park unit (Table 4.2). The CHOH and GWMP park units have the most weather stations both in and near park boundaries.

Lists of stations have been compiled for the NCRN. A station does not have to be within the boundaries to provide useful data and information regarding the park unit in question. Some might be physically *within* the administrative or political boundaries, whereas others might be just outside, or even some distance away, but would be *nearby* in behavior and representativeness. What constitutes "useful" and "representative" are also significant questions, whose answers can vary according to application, type of element, period of record, procedural or methodological observation conventions, and the like.

Table 4.2. Number of stations near (in) NCRN park units. Numbers are listed by park unit and weather/climate network.

Network	**ANTI**	**CATO**	**CHOH**	**GWMP**	**HAFE**	**MANA**
CASTNet	**0**(0)	**1**(0)	**2**(0)	**1**(0)	**0**(0)	**0**(0)
COOP	**40**(1)	**36**(1)	**209**(2)	**126**(1)	**44**(1)	**36**(0)
CWOP	**18**(0)	**12**(0)	**97**(0)	**82**(0)	**21**(0)	**33**(0)
GPS-MET	**1**(0)	**1**(0)	**5**(0)	**4**(1)	**2**(0)	**2**(0)
RAWS	**0**(0)	**0**(0)	**2**(0)	**1**(0)	**0**(0)	**0**(0)
SAO	**4**(0)	**3**(1)	**17**(0)	**13**(0)	**3**(0)	**5**(0)
SCAN	**0**(0)	**0**(0)	**1**(0)	**1**(0)	**0**(0)	**0**(0)
WX4U	**2**(0)	**1**(0)	**7**(0)	**6**(0)	**1**(0)	**2**(0)
Other	**2**(0)	**3**(0)	**10**(0)	**3**(0)	**1**(0)	**0**(0)
Total	**67**(1)	**57**(2)	**350**(2)	**237**(2)	**72**(1)	**78**(0)

Network	**MONO**	**NACE**	**PRWI**	**ROCR**	**WOTR**
CASTNet	**0**(0)	**1**(0)	**0**(0)	**1**(0)	**1**(0)
COOP	**47**(0)	**94**(0)	**31**(0)	**92**(0)	**82**(0)
CWOP	**31**(0)	**59**(0)	**29**(0)	**56**(0)	**53**(0)
GPS-MET	**2**(0)	**4**(0)	**0**(0)	**4**(0)	**4**(0)
RAWS	**0**(0)	**1**(0)	**0**(0)	**1**(0)	**0**(0)
SAO	**4**(0)	**11**(0)	**6**(0)	**8**(0)	**9**(0)
SCAN	**0**(0)	**1**(0)	**0**(0)	**1**(0)	**1**(0)
WX4U	**0**(0)	**5**(0)	**3**(0)	**3**(0)	**2**(0)
Other	**1**(0)	**2**(0)	**0**(0)	**2**(0)	**2**(0)
Total	**85**(0)	**178**(0)	**69**(0)	**168**(0)	**154**(0)

4.2.1. Washington Metropolitan Area Park Units

We have identified no active weather/climate stations that directly measure surface meteorological elements at or within any of the NCRN park units located in the Washington metropolitan area. The only active site within these park units that we identified in this report is a GPS-MET site "Turner-Fairbank HRC", located in GWMP (Table 4.3). However, due to the urban setting of these park units, there are generally numerous nearby weather/climate stations providing data for the park units (Figure 4.1).

Two stations have been identified within the boundaries of GWMP. Besides the aforementioned GPS-MET site, a COOP station (Great Falls) operated between 1948 and 1950 inside this park unit (Table 4.3).

Despite the lack of weather and climate stations inside the boundaries of GWMP, there are numerous active stations located within 10 km of GWMP (Table 4.3). For instance, there are 43 COOP stations that are currently active within 10 km of GWMP. Several of these active COOP stations we have identified have records that begin in the 1920s or earlier. The COOP station “Harpers Ferry River” has the longest record of these stations, beginning in 1889. The data record at this site is of questionable quality, however. The COOP station “Laurel 3 W” has the next longest record, beginning in 1895. Occasional multi-month gaps have occurred in the data record at “Laurel 3 W”. A few other COOP stations also have records going back to the beginning of the twentieth century. The most reliable data records from these long-term COOP stations come from “Glenn Dale Bell Stn.”, which started in 1921, and the COOP station at Reagan National Airport (Washington Reagan National AP), which started in 1929.

In addition to these COOP stations, there are many automated weather/climate stations that are active within 10 km of GWMP, including one CASTNet station, four GPS-MET sites, one RAWS station, 13 SAO stations, one SCAN station, and several dozen stations associated with volunteer networks like CWOP and WX4U (Table 4.3). The SAO sites at Dulles International Airport, Reagan National Airport, and Andrews Air Force Base provide very reliable data records, some of which start as early as the 1920s.

No stations have been identified within MANA (Table 4.3). There are 14 active COOP stations within 10 km of MANA. The closest station to MANA is the current COOP station at Manassas, Virginia. This COOP site has only been operating since 2004. There was a separate COOP station at Manassas from 1895 until 1987 (Table 4.3). Several COOP stations within 10 km of MANA have data records going back to the 1920s or earlier. The COOP station “Vienna” is just under 10 km east of MANA and has a reliable data record that goes back to 1925. Lincoln (1900-present) and Mount Weather (1915-present) are two COOP stations that are located 10 km north and northwest of MANA, respectively. Both sites have reliable data records. The longest data record provided by the stations within 10 km of MANA is at the “Warrenton 3 SE” COOP station, about 10 km southwest of MANA. This site has operated since 1897 (Table 4.3). The data record is not as complete as the previous stations and data have been sporadic since 2000.

Five active SAO stations are located within 10 km of MANA. The SAO station with the longest period of record is “Davison AAF”, which goes back to 1957 (Table 4.3). Dulles International Airport, 5 km northeast of MANA, has a data record that is slightly shorter (1962-Present) than that of “Davison AAF”, but the data from this site are known to be quite reliable.

National Capital Parks East (NACE) has no weather/climate stations at any of its units. However, due to its urban setting within Washington, the park unit is surrounded by numerous active stations. We have identified 28 active COOP sites within 10 km of NACE (Table 4.3). The longest periods of record are found at the COOP sites “Laurel 3 W” (1895-present) and “Rockville 1 NE” (1907-present). The COOP station “Laurel 3 W” is about 10 km northeast of NACE while the COOP station “Rockville 1 NE” is about 10 km northwest of NACE. Both of these stations have occasional multi-month gaps that occur once every few years. The COOP station “Glenn Dale Bell Station” is only 5 km east of NACE units, has operated since 1921, and has a very complete data record. The National Arboretum has a COOP station that has data going back to 1948. There was a significant data gap in the record for this COOP station during much of 2001. However, it is centrally located in Washington among the NACE units and still provides valuable data for NACE.

There are also numerous near-real-time stations around NACE. There is a CASTNet site at Beltsville, under 10 km northeast of the NACE units. We have also identified one RAWS station (Cedarville), a SCAN station (Powder Mill), and 10 active SAO stations within 10 km of NACE (Table 4.3). In addition to these, there are numerous stations associated with volunteer weather/climate networks like CWOP and WX4U. Both Dulles International Airport and Reagan National Airport provide reliable near-real-time observations for the area, along with SAO stations at Andrews Air Force Base (Andrews AFB) and the Quantico military complex (Quantico MCAS). The SAO stations with the longest periods of record are “Quantico MCAS”, which started in 1922, and Reagan National Airport, which started in 1929 (Table 4.3).

We have identified no weather/climate stations at PRWI. There are 69 stations within 10 km of PRWI (Table 4.2), 44 of which we have identified as being active. Six of these are COOP stations. The COOP station “Warrenton 3 SE”, previously discussed, has the longest period of record available for the COOP stations near PRWI. The COOP station at Dulles International Airport provides another longer-term record for PRWI, going back to 1962. Six SAO stations are located within 10 km of PRWI, with the longest record coming from “Quantico MCAS”.

Like PRWI, no stations have been identified within ROCR. There are at least 28 COOP stations that are currently in operation within 10 km of ROCR (Table 4.3). The COOP station “Dalecarlia Reservoir” is only about 5 km west of ROCR and has a reliable data record going back to 1948 (Table 4.3). The longest data records are found at “Laurel 3 W” and “Rockville 1 NE”, both of which were discussed previously. Several SAO stations have been identified within 10 km of ROCR (Table 4.3), including the international airport and military sites discussed previously.

No stations have been identified at WOTR. We have noted 26 COOP stations that are currently in operation within 10 km of WOTR (Table 4.3). Several of these sites have long data records, including “Laurel 3 W”, “Rockville 1 NE”, and “Glenn Dale Bell Stn”, all discussed previously. There are nine SAO stations within 10 km of WOTR (Table 4.3). This park unit is centrally located between Dulles International Airport and Reagan National Airport (Figure 4.1), so real-time observations are readily available.

Table 4.3. Weather/climate stations for NCRN park units in the greater Washington metropolitan area. Stations inside park units and within 10 km of the park unit boundary are included. Each listing includes station name, location, and elevation; weather/climate network associated with station; operational start/end dates for station; and flag to indicate if station is located inside park unit boundaries. Missing entries are indicated by “M”.

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
George Washington Memorial Parkway (GWMP)							
Great Falls	39.000	-77.25	61	COOP	8/1/1948	10/31/1950	YES
Turner-Fairbank HRC	38.96	-77.15	84	GPS-MET	M	Present	YES
Beltsville	39.028	-76.817	46	CASTNet	11/1/1988	Present	NO
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Alexandria Potomac Y	38.817	-77.05	6	COOP	4/1/1893	10/31/1962	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Battery Park	39	-77.117	104	COOP	8/1/1948	7/31/1950	NO
Beltsville	39.03	-76.931	44	COOP	8/1/1948	Present	NO
Beltsville Plant Stn.	39.017	-76.95	30	COOP	1/1/1949	9/30/1978	NO
Beltsville SCS R1	39.05	-76.95	95	COOP	7/1/1950	1/31/1952	NO
Berryville	39.15	-77.983	183	COOP	6/1/1931	2/17/1988	NO
Bethesda	38.967	-77.117	101	COOP	8/1/1945	12/31/1966	NO
Bethesda NIH	39	-77.1	95	COOP	11/15/1943	9/30/1960	NO
Boonsboro	39.517	-77.65	226	COOP	5/1/1960	11/15/1972	NO
Boonsboro 1 NE	39.517	-77.65	192	COOP	11/1/1972	4/30/1977	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Brighton Dam	39.191	-77.01	101	COOP	8/1/1948	Present	NO
Brightwood DC	38.95	-77.017	79	COOP	11/1/1944	7/1/1961	NO
Brookdale	38.95	-77.1	79	COOP	1/1/1945	1/1/1974	NO
Brookside Manor	38.967	-76.967	15	COOP	8/1/1945	3/31/1953	NO
Brookville	39.183	-77.057	122	COOP	2/1/1995	Present	NO
Burnt Mills Res.	39.033	-77	67	COOP	11/1/1944	9/30/1961	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Charles Town 2 SE	39.298	-77.834	158	COOP	11/1/1992	10/1/2001	NO
Cheltenham 1 NW	38.733	-76.85	70	COOP	5/1/1901	10/31/1956	NO
Clarendon Lyon Park	38.9	-77.083	67	COOP	4/1/1925	12/31/1963	NO
College Park	38.983	-76.95	27	COOP	1/1/1894	4/1/1996	NO
College Park SCS R1	39.05	-76.95	95	COOP	7/1/1948	10/31/1948	NO
Dalecarlia Reservoir	38.94	-77.113	46	COOP	8/1/1948	Present	NO
Damascus 2	39.291	-77.203	122	COOP	9/1/1992	Present	NO
Damascus 2 SW	39.267	-77.233	220	COOP	8/1/1973	1/1/1992	NO
Damascus 3 SSW	39.265	-77.232	212	COOP	1/1/1993	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
District Heights	38.85	-76.9	83	COOP	8/4/1945	2/28/1957	NO
Dranesville	38.983	-77.35	116	COOP	10/1/1953	12/31/1956	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Fort George G Meade	39.1	-76.75	43	COOP	2/1/1942	8/31/1975	NO
Fort Washington Nat'l Park	38.717	-77.033	37	COOP	6/1/1968	8/31/1975	NO
Frederick	39.417	-77.417	92	COOP	8/1/1948	6/30/1949	NO
Frederick 2 NNE	39.434	-77.392	85	COOP	1/23/2003	Present	NO
Frederick 3 E	39.4	-77.367	117	COOP	12/20/1948	6/1/1990	NO
Frederick Gas Plant	39.45	-77.4	88	COOP	3/1/1994	4/1/1994	NO
Frederick Municipal AP	39.417	-77.383	94	COOP	10/1/1933	Present	NO
Frederick Police Brk.	39.416	-77.439	116	COOP	7/1/1894	7/1/2002	NO
Frederick Telemark	39.404	-77.366	71	COOP	8/1/1969	Present	NO
Frederick Wastewater	39.433	-77.383	79	COOP	7/1/1994	10/1/1997	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Frederick WFMD	39.417	-77.467	133	COOP	11/1/1963	12/31/1970	NO
Fredericksburg	38.315	-77.461	16	COOP	3/24/1988	11/17/2003	NO
Fredericksburg 2	38.3	-77.467	37	COOP	9/1/1978	11/10/1992	NO
Fredericksburg Embry	38.3	-77.467	6	COOP	7/13/1943	8/20/1969	NO
Fredericksburg N P	38.317	-77.45	27	COOP	4/17/1893	4/1/1997	NO
Fredericksburg Sewage	38.287	-77.451	5	COOP	2/15/1993	Present	NO
Gambrill State Park	39.467	-77.5	491	COOP	9/1/1964	1/31/1970	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Germantown 2 W	39.174	-77.294	122	COOP	11/13/1997	4/1/1998	NO
Glen Echo	38.967	-77.15	46	COOP	8/1/1948	12/31/1966	NO
Glenn Dale Bell Stn.	38.969	-76.804	46	COOP	1/1/1921	Present	NO
Greenbelt	39	-76.883	61	COOP	1/1/1949	1/31/1975	NO
Grosvenor Lane	39.017	-77.117	101	COOP	8/1/1948	Present	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Harpers Ferry Natl. Park	39.317	-77.733	88	COOP	6/1/1958	3/1/1975	NO
Harpers Ferry River	39.323	-77.729	75	COOP	7/1/1889	Present	NO
Herndon	38.967	-77.383	113	COOP	12/1/1956	6/30/1960	NO
Hipsley Mill Floren	39.277	-77.111	168	COOP	5/6/1993	Present	NO
Indianhead	38.592	-77.158	11	COOP	1/23/1998	3/31/1998	NO
Keedysville	39.483	-77.7	128	COOP	11/1/1904	5/31/1960	NO
La Plata 1 W	38.533	-77	43	COOP	12/1/1894	10/1/1998	NO
Lanham	38.967	-76.85	55	COOP	5/1/1958	1/1/1987	NO
Laurel 3 W	39.085	-76.9	122	COOP	4/1/1895	Present	NO
Leesburg	39.117	-77.567	98	COOP	11/1/1944	6/30/1949	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Lincoln	39.088	-77.693	152	COOP	9/26/1900	Present	NO
Lisbon 1 W	39.35	-77.1	223	COOP	8/1/1949	6/30/1954	NO
Little Falls Dam	38.95	-77.127	12	COOP	10/1/1966	Present	NO
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Marshall	38.867	-77.883	177	COOP	8/1/1948	4/30/1954	NO
Martinsburg Radio Re	39.167	-77.500	128	COOP	9/1/1963	10/31/1969	NO
Mason Springs	38.583	-77.1	9	COOP	10/1/1994	2/1/1998	NO
Millville	39.282	-77.79	89	COOP	3/13/1961	Present	NO
Mount Weather	39.063	-77.889	524	COOP	1/1/1915	Present	NO
National Arboretum DC	38.913	-76.97	15	COOP	8/1/1948	Present	NO
Oxon Hill	38.796	-76.995	37	COOP	5/1/1994	Present	NO
Point Of Rocks	39.274	-77.543	61	COOP	2/1/1965	Present	YES
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Quantico 1 S	38.5	-77.317	3	COOP	4/1/1896	3/31/1976	NO
Ranson 4 NW	39.325	-77.92	171	COOP	6/26/2003	Present	NO
Riverdale	38.967	-76.933	15	COOP	1/1/1946	3/31/1955	NO
Rock Creek Forest	39	-77.067	61	COOP	8/1/1945	11/30/1949	NO
Rockville 1 NE	39.101	-77.149	134	COOP	12/17/1907	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Sharpsburg	39.45	-77.731	95	COOP	2/17/1988	Present	NO
Sharpsburg 5 S	39.398	-77.722	152	COOP	2/1/1998	Present	NO
Shepherdstown	39.434	-77.802	86	COOP	8/1/1967	Present	NO
Silver Hill Obsv.	38.833	-76.95	85	COOP	10/1/1950	Present	NO
Silver Spring	39	-77.017	82	COOP	2/1/1939	4/30/1975	NO
Sterling	38.983	-77.467	85	COOP	10/1/1960	Present	NO
Sterling RCS	38.976	-77.477	85	COOP	7/1/1964	Present	NO
Suitland	38.85	-76.933	82	COOP	12/1/1962	4/30/1974	NO
Takoma Park Miss Ave.	38.983	-77	70	COOP	3/1/1945	7/31/1961	NO
Takoma Park Balt Ave.	38.983	-77.017	98	COOP	8/1/1948	2/28/1949	NO
The Plains 2 NNE	38.896	-77.755	162	COOP	4/1/1954	Present	NO
U S Soldiers Home DC	38.933	-77.017	70	COOP	8/1/1948	8/1/1990	NO
Unionville	39.450	-77.183	131	COOP	7/1/1940	12/1/1996	NO
Upper Marlboro 3 NNW	38.865	-76.777	30	COOP	5/1/1956	Present	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Viers Mill	39.05	-77.083	92	COOP	7/13/1950	3/31/1960	NO
Waldorf 4 W	38.642	-76.986	64	COOP	7/1/1994	10/26/2002	NO
Waldorf Police Brk.	38.652	-76.881	64	COOP	8/1/1948	1/4/2002	NO
Walkers Chapel	38.917	-77.133	73	COOP	8/6/1945	5/31/1951	NO
Warrenton 3 SE	38.682	-77.768	152	COOP	3/1/1897	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	COOP	7/1/1929	Present	NO
Washington DC American Univ.	38.933	-77.083	122	COOP	7/1/1952	8/31/1953	NO
Washington DC WB City	38.9	-77.05	22	COOP	1/1/1871	1/1/1966	NO
Washington DC Cornth YC	38.867	-77	0	COOP	11/1/1958	Present	NO
Waterford	39.183	-77.600	162	COOP	11/1/1944	12/31/1963	NO
Waterloo Police Brk.	39.167	-76.783	70	COOP	8/1/1948	Present	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
West Lanham Hills	38.95	-76.883	49	COOP	4/3/1947	7/31/1952	NO
Wheaton Reg. Park	39.067	-77.033	101	COOP	6/1/1961	10/1/2005	NO
Wisconsin Ave.	38.9	-77.061	43	COOP	2/1/1964	Present	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0146 Round Hill	39.134	-77.766	168	CWOP	M	Present	NO
CW0351 Brookeville	39.167	-77.068	147	CWOP	M	Present	NO
CW0415 Savage	39.154	-76.828	96	CWOP	M	Present	NO
CW0433 Montgomery Village	39.163	-77.2	106	CWOP	M	Present	NO
CW0497 Washington	38.957	-77.034	77	CWOP	M	Present	NO
CW0626 Germantown	39.173	-77.295	154	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0643 Goldvein	38.438	-77.661	109	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW0746 Manassas	38.788	-77.625	350	CWOP	M	Present	NO
CW0802 Fredericksburg	38.302	-77.465	9	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO
CW1180 Frederick	39.429	-77.433	120	CWOP	M	Present	NO
CW1236 Beltsville	39.045	-76.944	90	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO
CW1574 Camp Springs	38.823	-76.918	86	CWOP	M	Present	NO
CW1619 Falmouth	38.293	-77.417	59	CWOP	M	Present	NO
CW1676 Highland	39.178	-76.965	170	CWOP	M	Present	NO
CW1764 Germantown	39.214	-77.209	122	CWOP	M	Present	NO
CW1826 Silver Spring	39.043	-77.012	107	CWOP	M	Present	NO
CW2057 Rockville	39.094	-77.162	138	CWOP	M	Present	NO
CW2182 Silver Spring	39.015	-77.01	98	CWOP	M	Present	NO
CW2287 Laurel	39.103	-76.881	152	CWOP	M	Present	NO
CW2463 Laytonsville	39.205	-77.131	182	CWOP	M	Present	NO
CW2503 Columbia	39.2	-76.9	233	CWOP	M	Present	NO
CW2575 Arlington	38.904	-77.12	104	CWOP	M	Present	NO
CW2579 Accokeek	38.667	-77.037	81	CWOP	M	Present	NO
CW2950 Purcellville	39.172	-77.765	204	CWOP	M	Present	NO
CW3062 Silver Spring	39.042	-77.028	122	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3397 Ellicott	39.261	-76.91	124	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3438 Hollis Point	38.635	-77.11	10	CWOP	M	Present	NO
CW3647 Lanham	38.98	-76.881	50	CWOP	M	Present	NO
CW3648 Bethesda	39.018	-77.131	123	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3774 Leesburg	39.098	-77.587	112	CWOP	M	Present	NO
CW3791 Germantown	39.191	-77.277	147	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4047 Laytonsville	39.266	-77.188	200	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO
CW4264 Middletown	39.437	-77.549	162	CWOP	M	Present	NO
CW4293 Union Bridge	39.567	-77.18	155	CWOP	M	Present	NO
CW4384 Germantown	39.166	-77.273	137	CWOP	M	Present	NO
CW4571 Bluemont	39.095	-77.807	208	CWOP	M	Present	NO
CW4662 Crofton	38.998	-76.689	34	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4966 Halltown	39.337	-77.794	419	CWOP	M	Present	NO
CW4977 Warrenton	38.68	-77.752	127	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW4994 Bowie	38.99	-76.795	50	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5167 Nokesville	38.669	-77.586	80	CWOP	M	Present	NO
CW5204 Harpers Ferry	39.337	-77.79	142	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5307 Columbia	39.196	-76.796	101	CWOP	M	Present	NO
CW5368 Westminster	39.476	-77.032	222	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5406 Purcellville	39.158	-77.699	162	CWOP	M	Present	NO
CW5498 Lovettsville	39.264	-77.584	133	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5741 Berryville	39.161	-77.989	192	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K3CHZ Dayton	39.243	-76.998	163	CWOP	M	Present	NO
K3GJ-1 La Plata	38.58	-76.996	64	CWOP	M	Present	NO
K3WTF Potomac Hts.	38.605	-77.136	25	CWOP	M	Present	NO
K4AA-10 Great Falls	38.997	-77.276	90	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KA6AKH Alexandria	38.728	-77.046	16	CWOP	M	Present	NO
KF6ZPN Warrenton	38.756	-77.734	173	CWOP	M	Present	NO
KG4QXL-2 Fort Valley	38.813	-77.612	105	CWOP	M	Present	NO
KM6LJ Washington	38.928	-77.04	49	CWOP	M	Present	NO
N3OK Monrovia	39.344	-77.248	202	CWOP	M	Present	NO
N3SZW Bowie	39.003	-76.77	68	CWOP	M	Present	NO
N4NW Stafford County	38.461	-77.463	102	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
W0NQW Fort Meade	39.132	-76.728	72	CWOP	M	Present	NO
W3ALF Union Bridge	39.567	-77.167	123	CWOP	M	Present	NO
W4IFI Warrenton	38.756	-77.734	174	CWOP	M	Present	NO
Greenbelt	38.99	-76.84	87	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
US Naval Obs.	38.92	-77.07	81	GPS-MET	M	Present	NO
Cedarville	38.653	-76.821	61	RAWS	12/1/2004	Present	NO
Anacostia NAS	38.85	-77.033	16	SAO	7/1/1924	10/31/1961	NO
Andrews AFB	38.817	-76.867	86	SAO	6/1/1943	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Fort Meade Tptn. AAF	39.083	-76.767	43	SAO	11/1/1959	Present	NO
Frederick Municipal AP	39.417	-77.383	94	SAO	10/1/1933	Present	NO
Gaithersburg Montgomery County	39.167	-77.167	0	SAO	8/1/1975	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Manassas Regional Davis Field	38.721	-77.515	59	SAO	7/1/1991	Present	NO
Quantico MCAS	38.5	-77.3	4	SAO	9/1/1922	Present	NO
Stafford Regional Airport	38.398	-77.456	65	SAO	1/7/2004	Present	NO
Sterling	38.983	-77.483	83	SAO	11/12/1991	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	SAO	7/1/1929	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Powder Mill	39.02	-76.85	32	SCAN	M	Present	NO
Frederick AF	39.433	-77.45	100	WBAN	8/1/1946	4/30/1955	NO
Washington DC Bolling Field AF	38.833	-77.017	18	WBAN	10/1/1920	9/30/1969	NO
Washington DC Central	38.883	-77.05	12	WBAN	12/1/1922	12/31/1933	NO
BoltAssociates Beltsville	39.035	-76.908	57	WX4U	M	Present	NO
Locust Hill GC	39.292	-77.907	173	WX4U	M	Present	NO
N4NW Stafford	38.463	-77.463	102	WX4U	M	Present	NO
Oakton	38.882	-77.32	107	WX4U	M	Present	NO
Stafford	38.42	-77.4	52	WX4U	M	Present	NO
Upper Marlboro	38.751	-76.82	61	WX4U	M	Present	NO
Manassas National Battlefield Park (MANA)							
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Dalecarlia Reservoir	38.94	-77.113	46	COOP	8/1/1948	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
Dranesville	38.983	-77.35	116	COOP	10/1/1953	12/31/1956	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Glen Echo	38.967	-77.15	46	COOP	8/1/1948	12/31/1966	NO
Great Falls	39	-77.25	61	COOP	8/1/1948	10/31/1950	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Herndon	38.967	-77.383	113	COOP	12/1/1956	6/30/1960	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Leesburg	39.117	-77.567	98	COOP	11/1/1944	6/30/1949	NO
Lincoln	39.088	-77.693	152	COOP	9/26/1900	Present	NO
Little Falls Dam	38.95	-77.127	12	COOP	10/1/1966	Present	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Marshall	38.867	-77.883	177	COOP	8/1/1948	4/30/1954	NO
Martinsburg Radio Re	39.167	-77.500	128	COOP	9/1/1963	10/31/1969	NO
Mount Weather	39.063	-77.889	524	COOP	1/1/1915	Present	NO
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Sterling	38.983	-77.467	85	COOP	10/1/1960	Present	NO
Sterling RCS	38.976	-77.477	85	COOP	7/1/1964	Present	NO
The Plains 2 NNE	38.896	-77.755	162	COOP	4/1/1954	Present	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Walkers Chapel	38.917	-77.133	73	COOP	8/6/1945	5/31/1951	NO
Warrenton 3 SE	38.682	-77.768	152	COOP	3/1/1897	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0146 Round Hill	39.134	-77.766	168	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO
CW0746 Manassas	38.788	-77.625	350	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO
CW2575 Arlington	38.904	-77.12	104	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3774 Leesburg	39.098	-77.587	112	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO
CW4571 Bluemont	39.095	-77.807	208	CWOP	M	Present	NO
CW4977 Warrenton	38.68	-77.752	127	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5167 Nokesville	38.669	-77.586	80	CWOP	M	Present	NO
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5406 Purcellville	39.158	-77.699	162	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K4AA-10 Great Falls	38.997	-77.276	90	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KF6ZPN Warrenton	38.756	-77.734	173	CWOP	M	Present	NO
KG4QXL-2 Fort Valley	38.813	-77.612	105	CWOP	M	Present	NO
N4NW Stafford County	38.461	-77.463	102	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
W4IFI Warrenton	38.756	-77.734	174	CWOP	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Turner-Fairbank HRC	38.96	-77.15	84	GPS-MET	M	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Manassas Regional Davis Field	38.721	-77.515	59	SAO	7/1/1991	Present	NO
Sterling	38.983	-77.483	83	SAO	11/12/1991	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
N4NW Stafford	38.463	-77.463	102	WX4U	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Oakton	38.882	-77.32	107	WX4U	M	Present	NO
National Capital Parks East (NACE)							
Beltsville	39.028	-76.817	46	CASTNet	11/1/1988	Present	NO
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Alexandria Potomac Y	38.817	-77.05	6	COOP	4/1/1893	10/31/1962	NO
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Battery Park	39	-77.117	104	COOP	8/1/1948	7/31/1950	NO
Beltsville	39.03	-76.931	44	COOP	8/1/1948	Present	NO
Beltsville Plant Stn.	39.017	-76.95	30	COOP	1/1/1949	9/30/1978	NO
Beltsville SCS R1	39.05	-76.95	95	COOP	7/1/1950	1/31/1952	NO
Bethesda	38.967	-77.117	101	COOP	8/1/1945	12/31/1966	NO
Bethesda NIH	39	-77.1	95	COOP	11/15/1943	9/30/1960	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Brighton Dam	39.191	-77.01	101	COOP	8/1/1948	Present	NO
Brightwood Dc	38.95	-77.017	79	COOP	11/1/1944	7/1/1961	NO
Brookdale	38.95	-77.1	79	COOP	1/1/1945	1/1/1974	NO
Brookside Manor	38.967	-76.967	15	COOP	8/1/1945	3/31/1953	NO
Brookville	39.183	-77.057	122	COOP	2/1/1995	Present	NO
Burnt Mills Res.	39.033	-77	67	COOP	11/1/1944	9/30/1961	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Cheltenham 1 NW	38.733	-76.85	70	COOP	5/1/1901	10/31/1956	NO
Clarendon Lyon Park	38.9	-77.083	67	COOP	4/1/1925	12/31/1963	NO
Clarksville 3 NNE	39.255	-76.929	113	COOP	12/1/1958	12/2/2004	NO
College Park	38.983	-76.95	27	COOP	1/1/1894	4/1/1996	NO
College Park SCS R1	39.05	-76.95	95	COOP	7/1/1948	10/31/1948	NO
Cooksville	39.318	-77.008	177	COOP	11/25/1995	4/1/2003	NO
Dalecarlia Reservoir	38.94	-77.113	46	COOP	8/1/1948	Present	NO
Damascus 2	39.291	-77.203	122	COOP	9/1/1992	Present	NO
Damascus 2 SW	39.267	-77.233	220	COOP	8/1/1973	1/1/1992	NO
Damascus 3 SSW	39.265	-77.232	212	COOP	1/1/1993	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
District Heights	38.85	-76.9	83	COOP	8/4/1945	2/28/1957	NO
Dranesville	38.983	-77.35	116	COOP	10/1/1953	12/31/1956	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Fort George G Meade	39.1	-76.75	43	COOP	2/1/1942	8/31/1975	NO
Ft. Washington Natl. Park	38.717	-77.033	37	COOP	6/1/1968	8/31/1975	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Germantown 2 W	39.174	-77.294	122	COOP	11/13/1997	4/1/1998	NO
Glen Echo	38.967	-77.15	46	COOP	8/1/1948	12/31/1966	NO
Glenelg	39.267	-76.983	192	COOP	1/1/1948	9/30/1948	NO
Glenn Dale Bell Stn.	38.969	-76.804	46	COOP	1/1/1921	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Great Falls	39	-77.25	61	COOP	8/1/1948	10/31/1950	NO
Greenbelt	39	-76.883	61	COOP	1/1/1949	1/31/1975	NO
Grosvenor Lane	39.017	-77.117	101	COOP	8/1/1948	Present	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Herndon	38.967	-77.383	113	COOP	12/1/1956	6/30/1960	NO
Hipsley Mill Floren	39.277	-77.111	168	COOP	5/6/1993	Present	NO
Indianhead	38.592	-77.158	11	COOP	1/23/1998	3/31/1998	NO
La Plata 1 W	38.533	-77	43	COOP	12/1/1894	10/1/1998	NO
Lanham	38.967	-76.85	55	COOP	5/1/1958	1/1/1987	NO
Laurel 3 W	39.085	-76.9	122	COOP	4/1/1895	Present	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Lisbon 1 W	39.35	-77.1	223	COOP	8/1/1949	6/30/1954	NO
Little Falls Dam	38.95	-77.127	12	COOP	10/1/1966	Present	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Martinsburg Radio Re	39.167	-77.500	128	COOP	9/1/1963	10/31/1969	NO
Mason Springs	38.583	-77.1	9	COOP	10/1/1994	2/1/1998	NO
National Arboretum DC	38.913	-76.97	15	COOP	8/1/1948	Present	NO
Owings Ferry Landing	38.683	-76.667	49	COOP	8/1/1948	2/28/1998	NO
Oxon Hill	38.796	-76.995	37	COOP	5/1/1994	Present	NO
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Quantico 1 S	38.5	-77.317	3	COOP	4/1/1896	3/31/1976	NO
Riverdale	38.967	-76.933	15	COOP	1/1/1946	3/31/1955	NO
Rock Creek Forest	39	-77.067	61	COOP	8/1/1945	11/30/1949	NO
Rockville 1 NE	39.101	-77.149	134	COOP	12/17/1907	Present	NO
Silver Hill Obsv.	38.833	-76.95	85	COOP	10/1/1950	Present	NO
Silver Spring	39	-77.017	82	COOP	2/1/1939	4/30/1975	NO
Sterling	38.983	-77.467	85	COOP	10/1/1960	Present	NO
Sterling RCS	38.976	-77.477	85	COOP	7/1/1964	Present	NO
Suitland	38.85	-76.933	82	COOP	12/1/1962	4/30/1974	NO
Takoma Park Miss Ave.	38.983	-77	70	COOP	3/1/1945	7/31/1961	NO
Takoma Park Balt Ave.	38.983	-77.017	98	COOP	8/1/1948	2/28/1949	NO
U S Soldiers Home DC	38.933	-77.017	70	COOP	8/1/1948	8/1/1990	NO
Unionville	39.450	-77.183	131	COOP	7/1/1940	12/1/1996	NO
Upper Marlboro 3 NNW	38.865	-76.777	30	COOP	5/1/1956	Present	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Viers Mill	39.05	-77.083	92	COOP	7/13/1950	3/31/1960	NO
Waldorf 4 W	38.642	-76.986	64	COOP	7/1/1994	10/26/2002	NO
Waldorf Police Brk.	38.652	-76.881	64	COOP	8/1/1948	1/4/2002	NO
Walkers Chapel	38.917	-77.133	73	COOP	8/6/1945	5/31/1951	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	COOP	7/1/1929	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Washington DC American Univ.	38.933	-77.083	122	COOP	7/1/1952	8/31/1953	NO
Washington DC WB City	38.9	-77.05	22	COOP	1/1/1871	1/1/1966	NO
Washington DC Cornth YC	38.867	-77	0	COOP	11/1/1958	Present	NO
Waterloo Police Brk.	39.167	-76.783	70	COOP	8/1/1948	Present	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
West Lanham Hills	38.95	-76.883	49	COOP	4/3/1947	7/31/1952	NO
Wheaton Reg. Park	39.067	-77.033	101	COOP	6/1/1961	10/1/2005	NO
Wisconsin Ave.	38.9	-77.061	43	COOP	2/1/1964	Present	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0351 Brookeville	39.167	-77.068	147	CWOP	M	Present	NO
CW0415 Savage	39.154	-76.828	96	CWOP	M	Present	NO
CW0433 Montgomery Village	39.163	-77.2	106	CWOP	M	Present	NO
CW0497 Washington	38.957	-77.034	77	CWOP	M	Present	NO
CW0626 Germantown	39.173	-77.295	154	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO
CW1236 Beltsville	39.045	-76.944	90	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO
CW1574 Camp Springs	38.823	-76.918	86	CWOP	M	Present	NO
CW1676 Highland	39.178	-76.965	170	CWOP	M	Present	NO
CW1764 Germantown	39.214	-77.209	122	CWOP	M	Present	NO
CW1826 Silver Spring	39.043	-77.012	107	CWOP	M	Present	NO
CW2057 Rockville	39.094	-77.162	138	CWOP	M	Present	NO
CW2182 Silver Spring	39.015	-77.01	98	CWOP	M	Present	NO
CW2287 Laurel	39.103	-76.881	152	CWOP	M	Present	NO
CW2463 Laytonsville	39.205	-77.131	182	CWOP	M	Present	NO
CW2503 Columbia	39.2	-76.9	233	CWOP	M	Present	NO
CW2575 Arlington	38.904	-77.12	104	CWOP	M	Present	NO
CW2579 Accokeek	38.667	-77.037	81	CWOP	M	Present	NO
CW3062 Silver Spring	39.042	-77.028	122	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3397 Ellicott	39.261	-76.91	124	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3438 Hollis Point	38.635	-77.11	10	CWOP	M	Present	NO
CW3647 Lanham	38.98	-76.881	50	CWOP	M	Present	NO
CW3648 Bethesda	39.018	-77.131	123	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3791 Germantown	39.191	-77.277	147	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4047 Laytonsville	39.266	-77.188	200	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW4384 Germantown	39.166	-77.273	137	CWOP	M	Present	NO
CW4662 Crofton	38.998	-76.689	34	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW4994 Bowie	38.99	-76.795	50	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5307 Columbia	39.196	-76.796	101	CWOP	M	Present	NO
CW5368 Westminster	39.476	-77.032	222	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K3CHZ Dayton	39.243	-76.998	163	CWOP	M	Present	NO
K3GJ-1 La Plata	38.58	-76.996	64	CWOP	M	Present	NO
K3WTF Potomac Hts.	38.605	-77.136	25	CWOP	M	Present	NO
K4AA-10 Great Falls	38.997	-77.276	90	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KA6AKH Alexandria	38.728	-77.046	16	CWOP	M	Present	NO
KM6LJ Washington	38.928	-77.04	49	CWOP	M	Present	NO
N3OK Monrovia	39.344	-77.248	202	CWOP	M	Present	NO
N3SZW Bowie	39.003	-76.77	68	CWOP	M	Present	NO
N4NW Stafford County	38.461	-77.463	102	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
W0NQW Fort Meade	39.132	-76.728	72	CWOP	M	Present	NO
Greenbelt	38.99	-76.84	87	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Turner-Fairbank HRC	38.96	-77.15	84	GPS-MET	M	Present	NO
US Naval Obs.	38.92	-77.07	81	GPS-MET	M	Present	NO
Cedarville	38.653	-76.821	61	RAWS	12/1/2004	Present	NO
Anacostia NAS	38.85	-77.033	16	SAO	7/1/1924	10/31/1961	NO
Andrews AFB	38.817	-76.867	86	SAO	6/1/1943	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Fort Meade Tptn, AAF	39.083	-76.767	43	SAO	11/1/1959	Present	NO
Gaithersburg Montgomery County	39.167	-77.167	0	SAO	8/1/1975	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Manassas Regional Davis Field	38.721	-77.515	59	SAO	7/1/1991	Present	NO
Quantico MCAS	38.5	-77.3	4	SAO	9/1/1922	Present	NO
Sterling	38.983	-77.483	83	SAO	11/12/1991	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	SAO	7/1/1929	Present	NO
Powder Mill	39.02	-76.85	32	SCAN	M	Present	NO
Washington DC Bolling Field AF	38.833	-77.017	18	WBAN	10/1/1920	9/30/1969	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Washington DC Central	38.883	-77.05	12	WBAN	12/1/1922	12/31/1933	NO
BoltAssociates Beltsville	39.035	-76.908	57	WX4U	M	Present	NO
N4NW Stafford	38.463	-77.463	102	WX4U	M	Present	NO
Oakton	38.882	-77.32	107	WX4U	M	Present	NO
Stafford	38.42	-77.4	52	WX4U	M	Present	NO
Upper Marlboro	38.751	-76.82	61	WX4U	M	Present	NO
Prince William Forest Park (PRWI)							
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Alexandria Potomac Y	38.817	-77.05	6	COOP	4/1/1893	10/31/1962	NO
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Fredericksburg	38.315	-77.461	16	COOP	3/24/1988	11/17/2003	NO
Fredericksburg 2	38.3	-77.467	37	COOP	9/1/1978	11/10/1992	NO
Fredericksburg Embry	38.3	-77.467	6	COOP	7/13/1943	8/20/1969	NO
Fredericksburg N P	38.317	-77.45	27	COOP	4/17/1893	4/1/1997	NO
Fredericksburg Sewage	38.287	-77.451	5	COOP	2/15/1993	Present	NO
Ft. Washington Natl. Park	38.717	-77.033	37	COOP	6/1/1968	8/31/1975	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Indianhead	38.592	-77.158	11	COOP	1/23/1998	3/31/1998	NO
La Plata 1 W	38.533	-77	43	COOP	12/1/1894	10/1/1998	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Mason Springs	38.583	-77.1	9	COOP	10/1/1994	2/1/1998	NO
Oxon Hill	38.796	-76.995	37	COOP	5/1/1994	Present	NO
Quantico 1 S	38.5	-77.317	3	COOP	4/1/1896	3/31/1976	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Waldorf 4 W	38.642	-76.986	64	COOP	7/1/1994	10/26/2002	NO
Warrenton 3 SE	38.682	-77.768	152	COOP	3/1/1897	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0643 Goldvein	38.438	-77.661	109	CWOP	M	Present	NO
CW0746 Manassas	38.788	-77.625	350	CWOP	M	Present	NO
CW0802 Fredericksburg	38.302	-77.465	9	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW1619 Falmouth	38.293	-77.417	59	CWOP	M	Present	NO
CW2579 Accokeek	38.667	-77.037	81	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3438 Hollis Point	38.635	-77.11	10	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO
CW4977 Warrenton	38.68	-77.752	127	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5167 Nokesville	38.669	-77.586	80	CWOP	M	Present	NO
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K3GJ-1 La Plata	38.58	-76.996	64	CWOP	M	Present	NO
K3WTF Potomac Hts.	38.605	-77.136	25	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KA6AKH Alexandria	38.728	-77.046	16	CWOP	M	Present	NO
KF6ZPN Warrenton	38.756	-77.734	173	CWOP	M	Present	NO
KG4QXL-2 Fort Valley	38.813	-77.612	105	CWOP	M	Present	NO
N4NW Stafford County	38.461	-77.463	102	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
W4IFI Warrenton	38.756	-77.734	174	CWOP	M	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Fredericksburg Shannon Airport	38.267	-77.449	26	SAO	7/1/1991	Present	NO
Manassas Regional Davis Field	38.721	-77.515	59	SAO	7/1/1991	Present	NO
Quantico MCAS	38.5	-77.3	4	SAO	9/1/1922	Present	NO
Stafford Regional Airport	38.398	-77.456	65	SAO	1/7/2004	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
N4NW Stafford	38.463	-77.463	102	WX4U	M	Present	NO
Oakton	38.882	-77.32	107	WX4U	M	Present	NO
Stafford	38.42	-77.4	52	WX4U	M	Present	NO
Rock Creek Park (ROCR)							
Beltsville	39.028	-76.817	46	CASTNet	11/1/1988	Present	NO
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Alexandria Potomac Y	38.817	-77.05	6	COOP	4/1/1893	10/31/1962	NO
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Battery Park	39	-77.117	104	COOP	8/1/1948	7/31/1950	NO
Beltsville	39.03	-76.931	44	COOP	8/1/1948	Present	NO
Beltsville Plant Stn.	39.017	-76.95	30	COOP	1/1/1949	9/30/1978	NO
Beltsville SCS R1	39.05	-76.95	95	COOP	7/1/1950	1/31/1952	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Bethesda	38.967	-77.117	101	COOP	8/1/1945	12/31/1966	NO
Bethesda NIH	39	-77.1	95	COOP	11/15/1943	9/30/1960	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Brighton Dam	39.191	-77.01	101	COOP	8/1/1948	Present	NO
Brightwood DC	38.95	-77.017	79	COOP	11/1/1944	7/1/1961	NO
Brookdale	38.95	-77.1	79	COOP	1/1/1945	1/1/1974	NO
Brookside Manor	38.967	-76.967	15	COOP	8/1/1945	3/31/1953	NO
Brookville	39.183	-77.057	122	COOP	2/1/1995	Present	NO
Burnt Mills Res.	39.033	-77	67	COOP	11/1/1944	9/30/1961	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Cheltenham 1 NW	38.733	-76.85	70	COOP	5/1/1901	10/31/1956	NO
Clarendon Lyon Park	38.9	-77.083	67	COOP	4/1/1925	12/31/1963	NO
Clarksville 3 NNE	39.255	-76.929	113	COOP	12/1/1958	12/2/2004	NO
College Park	38.983	-76.95	27	COOP	1/1/1894	4/1/1996	NO
College Park SCS R1	39.05	-76.95	95	COOP	7/1/1948	10/31/1948	NO
Cooksville	39.318	-77.008	177	COOP	11/25/1995	4/1/2003	NO
Dalecarlia Reservoir	38.94	-77.113	46	COOP	8/1/1948	Present	NO
Damascus 2	39.291	-77.203	122	COOP	9/1/1992	Present	NO
Damascus 2 SW	39.267	-77.233	220	COOP	8/1/1973	1/1/1992	NO
Damascus 3 SSW	39.265	-77.232	212	COOP	1/1/1993	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
District Heights	38.85	-76.9	83	COOP	8/4/1945	2/28/1957	NO
Dranesville	38.983	-77.35	116	COOP	10/1/1953	12/31/1956	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Fort George G Meade	39.1	-76.75	43	COOP	2/1/1942	8/31/1975	NO
Ft. Washington Natl. Park	38.717	-77.033	37	COOP	6/1/1968	8/31/1975	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Germantown 2 W	39.174	-77.294	122	COOP	11/13/1997	4/1/1998	NO
Glen Echo	38.967	-77.15	46	COOP	8/1/1948	12/31/1966	NO
Glenelg	39.267	-76.983	192	COOP	1/1/1948	9/30/1948	NO
Glenn Dale Bell Stn.	38.969	-76.804	46	COOP	1/1/1921	Present	NO
Great Falls	39	-77.25	61	COOP	8/1/1948	10/31/1950	NO
Greenbelt	39	-76.883	61	COOP	1/1/1949	1/31/1975	NO
Grosvenor Lane	39.017	-77.117	101	COOP	8/1/1948	Present	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Herndon	38.967	-77.383	113	COOP	12/1/1956	6/30/1960	NO
Hipsley Mill Floren	39.277	-77.111	168	COOP	5/6/1993	Present	NO
Indianhead	38.592	-77.158	11	COOP	1/23/1998	3/31/1998	NO
La Plata 1 W	38.533	-77	43	COOP	12/1/1894	10/1/1998	NO
Lanham	38.967	-76.85	55	COOP	5/1/1958	1/1/1987	NO
Laurel 3 W	39.085	-76.9	122	COOP	4/1/1895	Present	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Lisbon 1 W	39.35	-77.1	223	COOP	8/1/1949	6/30/1954	NO
Little Falls Dam	38.95	-77.127	12	COOP	10/1/1966	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Mason Springs	38.583	-77.1	9	COOP	10/1/1994	2/1/1998	NO
National Arboretum DC	38.913	-76.97	15	COOP	8/1/1948	Present	NO
Owings Ferry Landing	38.683	-76.667	49	COOP	8/1/1948	2/28/1998	NO
Oxon Hill	38.796	-76.995	37	COOP	5/1/1994	Present	NO
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Riverdale	38.967	-76.933	15	COOP	1/1/1946	3/31/1955	NO
Rock Creek Forest	39	-77.067	61	COOP	8/1/1945	11/30/1949	NO
Rockville 1 NE	39.101	-77.149	134	COOP	12/17/1907	Present	NO
Silver Hill Obsv.	38.833	-76.95	85	COOP	10/1/1950	Present	NO
Silver Spring	39	-77.017	82	COOP	2/1/1939	4/30/1975	NO
Sterling	38.983	-77.467	85	COOP	10/1/1960	Present	NO
Sterling RCS	38.976	-77.477	85	COOP	7/1/1964	Present	NO
Suitland	38.85	-76.933	82	COOP	12/1/1962	4/30/1974	NO
Takoma Park Miss Ave.	38.983	-77	70	COOP	3/1/1945	7/31/1961	NO
Takoma Park Balt Ave.	38.983	-77.017	98	COOP	8/1/1948	2/28/1949	NO
U S Soldiers Home DC	38.933	-77.017	70	COOP	8/1/1948	8/1/1990	NO
Upper Marlboro 3 NNW	38.865	-76.777	30	COOP	5/1/1956	Present	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Viers Mill	39.05	-77.083	92	COOP	7/13/1950	3/31/1960	NO
Waldorf 4 W	38.642	-76.986	64	COOP	7/1/1994	10/26/2002	NO
Waldorf Police Brk.	38.652	-76.881	64	COOP	8/1/1948	1/4/2002	NO
Walkers Chapel	38.917	-77.133	73	COOP	8/6/1945	5/31/1951	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	COOP	7/1/1929	Present	NO
Washington DC American Univ.	38.933	-77.083	122	COOP	7/1/1952	8/31/1953	NO
Washington DC WB City	38.9	-77.05	22	COOP	1/1/1871	1/1/1966	NO
Washington DC Cornth YC	38.867	-77	0	COOP	11/1/1958	Present	NO
Waterloo Police Brk.	39.167	-76.783	70	COOP	8/1/1948	Present	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
West Lanham Hills	38.95	-76.883	49	COOP	4/3/1947	7/31/1952	NO
Wheaton Reg. Park	39.067	-77.033	101	COOP	6/1/1961	10/1/2005	NO
Wisconsin Ave.	38.9	-77.061	43	COOP	2/1/1964	Present	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0351 Brookeville	39.167	-77.068	147	CWOP	M	Present	NO
CW0415 Savage	39.154	-76.828	96	CWOP	M	Present	NO
CW0433 Montgomery Village	39.163	-77.2	106	CWOP	M	Present	NO
CW0497 Washington	38.957	-77.034	77	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW0626 Germantown	39.173	-77.295	154	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO
CW1236 Beltsville	39.045	-76.944	90	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO
CW1574 Camp Springs	38.823	-76.918	86	CWOP	M	Present	NO
CW1676 Highland	39.178	-76.965	170	CWOP	M	Present	NO
CW1764 Germantown	39.214	-77.209	122	CWOP	M	Present	NO
CW1826 Silver Spring	39.043	-77.012	107	CWOP	M	Present	NO
CW2057 Rockville	39.094	-77.162	138	CWOP	M	Present	NO
CW2182 Silver Spring	39.015	-77.01	98	CWOP	M	Present	NO
CW2287 Laurel	39.103	-76.881	152	CWOP	M	Present	NO
CW2463 Laytonsville	39.205	-77.131	182	CWOP	M	Present	NO
CW2503 Columbia	39.2	-76.9	233	CWOP	M	Present	NO
CW2575 Arlington	38.904	-77.12	104	CWOP	M	Present	NO
CW2579 Accokeek	38.667	-77.037	81	CWOP	M	Present	NO
CW3062 Silver Spring	39.042	-77.028	122	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3397 Ellicott	39.261	-76.91	124	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3438 Hollis Point	38.635	-77.11	10	CWOP	M	Present	NO
CW3647 Lanham	38.98	-76.881	50	CWOP	M	Present	NO
CW3648 Bethesda	39.018	-77.131	123	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3791 Germantown	39.191	-77.277	147	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4047 Laytonsville	39.266	-77.188	200	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO
CW4384 Germantown	39.166	-77.273	137	CWOP	M	Present	NO
CW4662 Crofton	38.998	-76.689	34	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW4994 Bowie	38.99	-76.795	50	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5307 Columbia	39.196	-76.796	101	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K3CHZ Dayton	39.243	-76.998	163	CWOP	M	Present	NO
K3GJ-1 La Plata	38.58	-76.996	64	CWOP	M	Present	NO
K3WTF Potomac Hts.	38.605	-77.136	25	CWOP	M	Present	NO
K4AA-10 Great Falls	38.997	-77.276	90	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KA6AKH Alexandria	38.728	-77.046	16	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
KM6LJ Washington	38.928	-77.04	49	CWOP	M	Present	NO
N3SZW Bowie	39.003	-76.77	68	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
W0NQW Fort Meade	39.132	-76.728	72	CWOP	M	Present	NO
Greenbelt	38.99	-76.84	87	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Turner-Fairbank HRC	38.96	-77.15	84	GPS-MET	M	Present	NO
US Naval Obs.	38.92	-77.07	81	GPS-MET	M	Present	NO
Cedarville	38.653	-76.821	61	RAWS	12/1/2004	Present	NO
Anacostia NAS	38.85	-77.033	16	SAO	7/1/1924	10/31/1961	NO
Andrews AFB	38.817	-76.867	86	SAO	6/1/1943	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Fort Meade Tptn. AAF	39.083	-76.767	43	SAO	11/1/1959	Present	NO
Gaithersburg Montgomery County	39.167	-77.167	0	SAO	8/1/1975	Present	NO
Sterling	38.983	-77.483	83	SAO	11/12/1991	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	SAO	7/1/1929	Present	NO
Powder Mill	39.02	-76.85	32	SCAN	M	Present	NO
Washington DC Bolling Field AF	38.833	-77.017	18	WBAN	10/1/1920	9/30/1969	NO
Washington DC Central	38.883	-77.05	12	WBAN	12/1/1922	12/31/1933	NO
BoltAssociates Beltsville	39.035	-76.908	57	WX4U	M	Present	NO
Oakton	38.882	-77.32	107	WX4U	M	Present	NO
Upper Marlboro	38.751	-76.82	61	WX4U	M	Present	NO
Wolf Trap Farm Park (WOTR)							
Beltsville	39.028	-76.817	46	CASTNet	11/1/1988	Present	NO
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Alexandria Potomac Y	38.817	-77.05	6	COOP	4/1/1893	10/31/1962	NO
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Battery Park	39	-77.117	104	COOP	8/1/1948	7/31/1950	NO
Beltsville	39.03	-76.931	44	COOP	8/1/1948	Present	NO
Beltsville Plant Stn.	39.017	-76.95	30	COOP	1/1/1949	9/30/1978	NO
Beltsville SCS R1	39.05	-76.95	95	COOP	7/1/1950	1/31/1952	NO
Bethesda	38.967	-77.117	101	COOP	8/1/1945	12/31/1966	NO
Bethesda NIH	39	-77.1	95	COOP	11/15/1943	9/30/1960	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Brighton Dam	39.191	-77.01	101	COOP	8/1/1948	Present	NO
Brightwood DC	38.95	-77.017	79	COOP	11/1/1944	7/1/1961	NO
Brookdale	38.95	-77.1	79	COOP	1/1/1945	1/1/1974	NO
Brookside Manor	38.967	-76.967	15	COOP	8/1/1945	3/31/1953	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Brookville	39.183	-77.057	122	COOP	2/1/1995	Present	NO
Burnt Mills Res.	39.033	-77	67	COOP	11/1/1944	9/30/1961	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Clarendon Lyon Park	38.9	-77.083	67	COOP	4/1/1925	12/31/1963	NO
College Park	38.983	-76.95	27	COOP	1/1/1894	4/1/1996	NO
College Park SCS R1	39.05	-76.95	95	COOP	7/1/1948	10/31/1948	NO
Dalecarlia Reservoir	38.94	-77.113	46	COOP	8/1/1948	Present	NO
Damascus 2	39.291	-77.203	122	COOP	9/1/1992	Present	NO
Damascus 2 SW	39.267	-77.233	220	COOP	8/1/1973	1/1/1992	NO
Damascus 3 SSW	39.265	-77.232	212	COOP	1/1/1993	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
District Heights	38.85	-76.9	83	COOP	8/4/1945	2/28/1957	NO
Dranesville	38.983	-77.35	116	COOP	10/1/1953	12/31/1956	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Ft. Washington Natl. Park	38.717	-77.033	37	COOP	6/1/1968	8/31/1975	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Germantown 2 W	39.174	-77.294	122	COOP	11/13/1997	4/1/1998	NO
Glen Echo	38.967	-77.15	46	COOP	8/1/1948	12/31/1966	NO
Glenn Dale Bell Stn.	38.969	-76.804	46	COOP	1/1/1921	Present	NO
Great Falls	39	-77.25	61	COOP	8/1/1948	10/31/1950	NO
Greenbelt	39	-76.883	61	COOP	1/1/1949	1/31/1975	NO
Grosvenor Lane	39.017	-77.117	101	COOP	8/1/1948	Present	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Herndon	38.967	-77.383	113	COOP	12/1/1956	6/30/1960	NO
Hipsley Mill Floren	39.277	-77.111	168	COOP	5/6/1993	Present	NO
Indianhead	38.592	-77.158	11	COOP	1/23/1998	3/31/1998	NO
Lanham	38.967	-76.85	55	COOP	5/1/1958	1/1/1987	NO
Laurel 3 W	39.085	-76.9	122	COOP	4/1/1895	Present	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Leesburg	39.117	-77.567	98	COOP	11/1/1944	6/30/1949	NO
Little Falls Dam	38.95	-77.127	12	COOP	10/1/1966	Present	NO
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Martinsburg Radio Re	39.167	-77.500	128	COOP	9/1/1963	10/31/1969	NO
National Arboretum DC	38.913	-76.97	15	COOP	8/1/1948	Present	NO
Oxon Hill	38.796	-76.995	37	COOP	5/1/1994	Present	NO
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Riverdale	38.967	-76.933	15	COOP	1/1/1946	3/31/1955	NO
Rock Creek Forest	39	-77.067	61	COOP	8/1/1945	11/30/1949	NO
Rockville 1 NE	39.101	-77.149	134	COOP	12/17/1907	Present	NO
Silver Hill Obsv.	38.833	-76.95	85	COOP	10/1/1950	Present	NO
Silver Spring	39	-77.017	82	COOP	2/1/1939	4/30/1975	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Sterling	38.983	-77.467	85	COOP	10/1/1960	Present	NO
Sterling RCS	38.976	-77.477	85	COOP	7/1/1964	Present	NO
Suitland	38.85	-76.933	82	COOP	12/1/1962	4/30/1974	NO
Takoma Park Miss Ave.	38.983	-77	70	COOP	3/1/1945	7/31/1961	NO
Takoma Park Balt Ave.	38.983	-77.017	98	COOP	8/1/1948	2/28/1949	NO
U S Soldiers Home DC	38.933	-77.017	70	COOP	8/1/1948	8/1/1990	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Viers Mill	39.05	-77.083	92	COOP	7/13/1950	3/31/1960	NO
Walkers Chapel	38.917	-77.133	73	COOP	8/6/1945	5/31/1951	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	COOP	7/1/1929	Present	NO
Washington DC American Univ.	38.933	-77.083	122	COOP	7/1/1952	8/31/1953	NO
Washington DC WB City	38.9	-77.05	22	COOP	1/1/1871	1/1/1966	NO
Washington DC Cornth YC	38.867	-77	0	COOP	11/1/1958	Present	NO
Waterford	39.183	-77.600	162	COOP	11/1/1944	12/31/1963	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
West Lanham Hills	38.95	-76.883	49	COOP	4/3/1947	7/31/1952	NO
Wheaton Reg. Park	39.067	-77.033	101	COOP	6/1/1961	10/1/2005	NO
Wisconsin Ave.	38.9	-77.061	43	COOP	2/1/1964	Present	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0351 Brookeville	39.167	-77.068	147	CWOP	M	Present	NO
CW0433 Montgomery Village	39.163	-77.2	106	CWOP	M	Present	NO
CW0497 Washington	38.957	-77.034	77	CWOP	M	Present	NO
CW0626 Germantown	39.173	-77.295	154	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO
CW0746 Manassas	38.788	-77.625	350	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO
CW1236 Beltsville	39.045	-76.944	90	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO
CW1574 Camp Springs	38.823	-76.918	86	CWOP	M	Present	NO
CW1676 Highland	39.178	-76.965	170	CWOP	M	Present	NO
CW1764 Germantown	39.214	-77.209	122	CWOP	M	Present	NO
CW1826 Silver Spring	39.043	-77.012	107	CWOP	M	Present	NO
CW2057 Rockville	39.094	-77.162	138	CWOP	M	Present	NO
CW2182 Silver Spring	39.015	-77.01	98	CWOP	M	Present	NO
CW2287 Laurel	39.103	-76.881	152	CWOP	M	Present	NO
CW2463 Laytonsville	39.205	-77.131	182	CWOP	M	Present	NO
CW2575 Arlington	38.904	-77.12	104	CWOP	M	Present	NO
CW2579 Accokeek	38.667	-77.037	81	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW3062 Silver Spring	39.042	-77.028	122	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3438 Hollis Point	38.635	-77.11	10	CWOP	M	Present	NO
CW3647 Lanham	38.98	-76.881	50	CWOP	M	Present	NO
CW3648 Bethesda	39.018	-77.131	123	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3774 Leesburg	39.098	-77.587	112	CWOP	M	Present	NO
CW3791 Germantown	39.191	-77.277	147	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4047 Laytonsville	39.266	-77.188	200	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO
CW4384 Germantown	39.166	-77.273	137	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW4994 Bowie	38.99	-76.795	50	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5167 Nokesville	38.669	-77.586	80	CWOP	M	Present	NO
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K3CHZ Dayton	39.243	-76.998	163	CWOP	M	Present	NO
K3WTF Potomac Hts.	38.605	-77.136	25	CWOP	M	Present	NO
K4AA-10 Great Falls	38.997	-77.276	90	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KA6AKH Alexandria	38.728	-77.046	16	CWOP	M	Present	NO
KG4QXL-2 Fort Valley	38.813	-77.612	105	CWOP	M	Present	NO
KM6LJ Washington	38.928	-77.04	49	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
Greenbelt	38.99	-76.84	87	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Turner-Fairbank HRC	38.96	-77.15	84	GPS-MET	M	Present	NO
US Naval Obs.	38.92	-77.07	81	GPS-MET	M	Present	NO
Anacostia NAS	38.85	-77.033	16	SAO	7/1/1924	10/31/1961	NO
Andrews AFB	38.817	-76.867	86	SAO	6/1/1943	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Gaithersburg Montgomery County	39.167	-77.167	0	SAO	8/1/1975	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Manassas Regional Davis Field	38.721	-77.515	59	SAO	7/1/1991	Present	NO
Sterling	38.983	-77.483	83	SAO	11/12/1991	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
Washington Reagan National	38.848	-77.034	3	SAO	7/1/1929	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
AP							
Powder Mill	39.02	-76.85	32	SCAN	M	Present	NO
Washington DC Bolling Field AF	38.833	-77.017	18	WBAN	10/1/1920	9/30/1969	NO
Washington DC Central	38.883	-77.05	12	WBAN	12/1/1922	12/31/1933	NO
BoltAssociates Beltsville	39.035	-76.908	57	WX4U	M	Present	NO
Oakton	38.882	-77.32	107	WX4U	M	Present	NO

4.2.2. Upper Potomac Basin Park Units

One active weather/climate station is located within ANTI (Table 4.4). This is a COOP station (Sharpsburg) which has a data record beginning in 1988. Within 30 km of ANTI, there are 18 active COOP stations. Besides Sharpsburg, the closest COOP stations are “Sharpsburg 5 S”, just under 10 km south of ANTI, and “Shepherdstown”, about 10 km west of ANTI. The data record at “Shepherdstown” goes back to 1967 (Table 4.4). The longest period of record for these stations is found at “Harpers Ferry River”, a COOP station that has been operating since 1889 (Table 4.4); however, the reliability of the data from this site is questionable. The COOP station “Lincoln” has been operating since 1900 (Table 4.4) and, despite sporadic gaps of a month or longer, has a reliable data record. Other long-term records are obtained from the COOP station “Martinsburg E WV Reg”, which has operated since 1926. This site also has a SAO station. Besides this SAO station there are three other active SAO sites within 30 km of ANTI (Table 4.4). At least two of these stations have records going back to the 1930s. Most of these SAO stations are between 20-30 km away from ANTI (Figure 4.1).

Two stations, both of which are active, are located within CATO. A COOP station is located at the headquarters of CATO, and has been operating since 1965 (Table 4.4). Besides a couple of 1-3 month gaps in the early- and mid-1990s, the station has a reliable data record. A SAO site (Camp David Thurmont) is also operational within CATO. We have identified 13 other active COOP stations within 30 km of CATO. The longest data record is at “Chambersburg 1 ESE”, a station that has been active since 1894 (Table 4.4) and is about 30 km north of CATO. The data from this station is generally reliable but there are occasional gaps of one to a few months in length.

The active stations within CHOH are all COOP stations (Table 4.4). There are two such stations in CHOH. Both stations have data records that are about 40 years in length. Both of these stations are located in the eastern portion of CHOH, so there are no weather/climate stations within the western parts of CHOH. Due to the elongated shape of CHOH (east-west; Figure 4.1), there are many active stations within 30 km of CHOH (Table 4.4). There are two CASTNet sites operating within 30 km of CHOH, along with numerous active COOP stations. The longest data record among these COOP stations is “Romney 1 SW”, which has operated since 1870 (Table 4.4). This station has some substantial data gaps in the early 1950s, the early 1970s, and around 1986. Besides these gaps, the data record for “Romney 1 SW” has generally been reliable. Other long-term records going back to the 1800s are provided from previously-discussed COOP stations like “Chambersburg 1 ESE”, “Harpers Ferry River”, “Laurel 3 W”, and “Warrenton 3

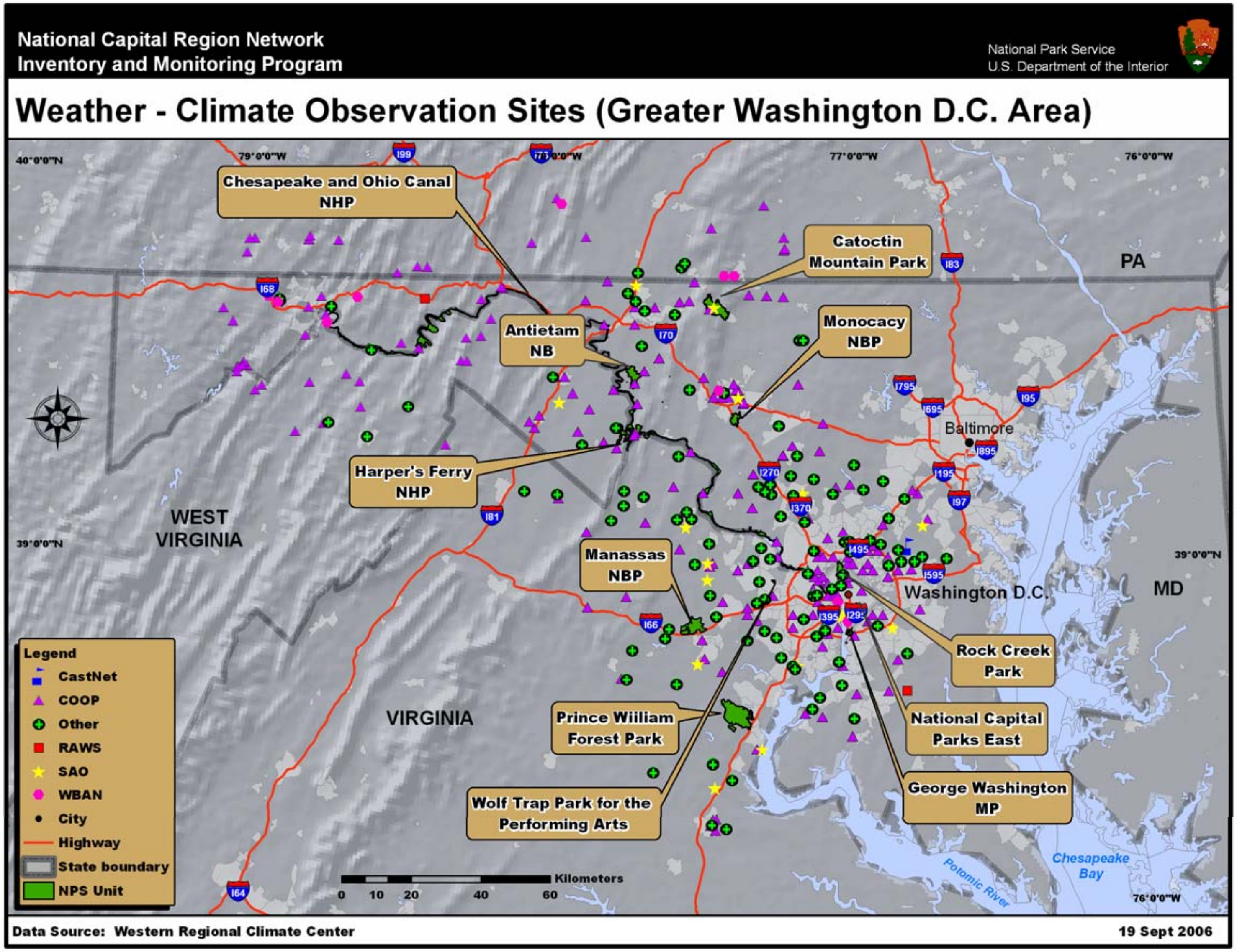

Figure 4.1. Station locations for NCRN park units.

SE”. There are 16 active SAO stations within 30 km of CHOH; most of these are located along the eastern portions of SAO. The SAO site “Martinsburg E WV Reg” provides a lengthy data record, going back to the 1920s, for the western portions of CHOH.

Harper’s Ferry National Historical Park (HAFE) has one station located within it. This is a COOP station (Harpers Ferry Natl. Park) that is no longer active. We have identified five active COOP stations within 30 km of HAFE (Table 4.4). The longest data record is found at “Harpers Ferry River”, previously discussed. Besides this COOP station, “Frederick Municipal AP” has a data record going back to 1933 (Table 4.4) This site also hosts a SAO station, with a similar data record. Besides this SAO station, there are two other active SAO sites within 30 km of HAFE (Table 4.4), one at Leesburg Executive Airport in Virginia and the other at Martinsburg, West Virginia (Martinsburg E WV Reg.).

We have identified no real-time weather stations in MONO. There are 21 active COOP stations within 30 km of MONO, with the longest records coming from “Harpers Ferry River”, about 25 km west of MONO. The previously-discussed COOP station “Frederick Municipal AP” is much closer to MONO as it is only about 5 km north of the park unit. Four SAO stations are located within 30 km of MONO, including the SAO station “Frederick Municipal AP”.

Table 4.4. Weather/climate stations for NCRN park units in the upper Potomac Basin. Stations inside park units and within 30 km of the park unit boundary are included. Each listing includes station name, location, and elevation; weather/climate network associated with station; operational start/end dates for station; and flag to indicate if station is located inside park unit boundaries. Missing entries are indicated by “M”.

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Antietam National Battlefield Park (ANTI)							
Sharpsburg	39.45	-77.731	95	COOP	2/17/1988	Present	YES
Catoctin Mountain Park	39.645	-77.483	491	COOP	9/1/1965	Present	NO
Charles Town 2 SE	39.298	-77.834	158	COOP	11/1/1992	10/1/2001	NO
Chewsville-Bridgeport	39.65	-77.667	174	COOP	1/1/1899	8/1/1973	NO
Clear Spring 1 ENE	39.667	-77.9	177	COOP	1/1/1899	2/28/1975	NO
Edgemont	39.667	-77.55	276	COOP	1/1/1893	12/1/1995	NO
Fairview	39.716	-77.825	119	COOP	2/3/1988	Present	NO
Frederick	39.417	-77.417	92	COOP	8/1/1948	6/30/1949	NO
Frederick 2 NNE	39.434	-77.392	85	COOP	1/23/2003	Present	NO
Frederick 3 E	39.4	-77.367	117	COOP	12/20/1948	6/1/1990	NO
Frederick Gas Plant	39.45	-77.4	88	COOP	3/1/1994	4/1/1994	NO
Frederick Municipal AP	39.417	-77.383	94	COOP	10/1/1933	Present	NO
Frederick Police Brk.	39.416	-77.439	116	COOP	7/1/1894	7/1/2002	NO
Frederick Telemark	39.404	-77.366	71	COOP	8/1/1969	Present	NO
Frederick Wastewater	39.433	-77.383	79	COOP	7/1/1994	10/1/1997	NO
Frederick WFMD	39.417	-77.467	133	COOP	11/1/1963	12/31/1970	NO
Gambrill State Park	39.467	-77.5	491	COOP	9/1/1964	1/31/1970	NO
Gerrardstown 1 SE	39.35	-78.083	201	COOP	8/1/1967	12/31/1972	NO
Hagerstown	39.65	-77.733	201	COOP	5/1/1895	11/1/1993	NO
Hagerstown Police Brk.	39.604	-77.733	171	COOP	7/1/1958	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Harpers Ferry Natl. Park	39.317	-77.733	88	COOP	6/1/1958	3/1/1975	NO
Harpers Ferry River	39.323	-77.729	75	COOP	7/1/1889	Present	NO
Inwood	39.367	-78.05	174	COOP	1/1/1923	9/30/1948	NO
Kearneysville	39.383	-77.883	168	COOP	5/1/1930	6/1/1995	NO
Keedysville	39.483	-77.7	128	COOP	11/1/1904	5/31/1960	NO
Lincoln	39.088	-77.693	152	COOP	9/26/1900	Present	NO
Martinsburg	39.424	-77.939	108	COOP	9/21/1987	Present	NO
Martinsburg 2	39.466	-77.967	165	COOP	11/1/1996	Present	NO
Martinsburg 2 W	39.467	-78	165	COOP	M	3/31/1972	NO
Martinsburg E WV Reg.	39.402	-77.984	163	COOP	1/1/1926	Present	NO
Martinsburg Radio Re	39.167	-77.5	128	COOP	9/1/1963	10/31/1969	NO
Millville	39.282	-77.79	89	COOP	3/13/1961	Present	NO
Point Of Rocks	39.274	-77.543	61	COOP	2/1/1965	Present	NO
Ranson 4 NW	39.325	-77.92	171	COOP	6/26/2003	Present	NO
Ringgold 3 NE	39.717	-77.533	268	COOP	7/9/1962	8/12/1985	NO
Sharpsburg 5 S	39.398	-77.722	152	COOP	2/1/1998	Present	NO
Shepherdstown	39.434	-77.802	86	COOP	8/1/1967	Present	NO
Smithsburg 2 NW	39.664	-77.583	204	COOP	4/1/1994	Present	NO
Waterford	39.183	-77.6	162	COOP	11/1/1944	12/31/1963	NO
Williamsport	39.604	-77.836	110	COOP	11/1/1938	Present	NO
AB3BE Hagerstown	39.667	-77.732	189	CWOP	M	Present	NO
CW0146 Round Hill	39.134	-77.766	168	CWOP	M	Present	NO
CW1180 Frederick	39.429	-77.433	120	CWOP	M	Present	NO
CW1323 Hagerstown	39.642	-77.702	158	CWOP	M	Present	NO
CW1459 Smithsburg	39.633	-77.6	213	CWOP	M	Present	NO
CW1545 Waynesboro	39.767	-77.567	100	CWOP	M	Present	NO
CW1662 Hagerstown	39.687	-77.758	177	CWOP	M	Present	NO
CW1672 Martinsburg	39.467	-78.007	165	CWOP	M	Present	NO
CW2950 Purcellville	39.172	-77.765	204	CWOP	M	Present	NO
CW4264 Middletown	39.437	-77.549	162	CWOP	M	Present	NO
CW4362 Greencastle	39.741	-77.724	201	CWOP	M	Present	NO
CW4571 Bluemont	39.095	-77.807	208	CWOP	M	Present	NO
CW4966 Halltown	39.337	-77.794	419	CWOP	M	Present	NO
CW5204 Harpers Ferry	39.337	-77.79	142	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5406 Purcellville	39.158	-77.699	162	CWOP	M	Present	NO
CW5498 Lovettsville	39.264	-77.584	133	CWOP	M	Present	NO
CW5741 Berryville	39.161	-77.989	192	CWOP	M	Present	NO
Hagerstown	39.55	-77.71	155	GPS-MET	M	Present	NO
Camp David Thurmont	39.65	-77.467	569	SAO	M	Present	NO
Frederick Municipal AP	39.417	-77.383	94	SAO	10/1/1933	Present	NO
Hagerstown Washington Co Regl. AP	39.708	-77.73	213	SAO	1/1/1931	Present	NO
Martinsburg E WV Reg.	39.402	-77.984	163	SAO	1/1/1926	Present	NO
Frederick AF	39.433	-77.45	100	WBAN	8/1/1946	4/30/1955	NO
Fountain Dale Site R	39.733	-77.433	275	WBAN	1/1/1984	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Locust Hill GC	39.292	-77.907	173	WX4U	M	Present	NO
Waynesboro	39.756	-77.578	220	WX4U	M	Present	NO
Catoctin Mountain Park (CATO)							
Catoctin Mountain Park	39.645	-77.483	491	COOP	9/1/1965	Present	YES
Camp David Thurmont	39.65	-77.467	569	SAO	M	Present	YES
Arendtsville	39.923	-77.308	269	CASTNet	6/1/1988	Present	NO
Arendtsville	39.917	-77.3	217	COOP	9/1/1918	8/17/1971	NO
Boonsboro	39.517	-77.65	226	COOP	5/1/1960	11/15/1972	NO
Boonsboro 1 NE	39.517	-77.65	192	COOP	11/1/1972	4/30/1977	NO
Bridgeport	39.679	-77.234	104	COOP	7/1/1996	1/9/2003	NO
Chambersburg 1 ESE	39.935	-77.639	195	COOP	1/1/1894	Present	NO
Chewsville-Bridgeport	39.65	-77.667	174	COOP	1/1/1899	8/1/1973	NO
Clear Spring 1 ENE	39.667	-77.9	177	COOP	1/1/1899	2/28/1975	NO
Edgemont	39.667	-77.55	276	COOP	1/1/1893	12/1/1995	NO
Eisenhower NHS	39.805	-77.229	165	COOP	2/1/1982	Present	NO
Emmitsburg	39.683	-77.35	220	COOP	1/1/1893	5/31/1956	NO
Emmitsburg 2 SE	39.681	-77.29	127	COOP	5/1/1956	10/1/2005	NO
Fairview	39.716	-77.825	119	COOP	2/3/1988	Present	NO
Frederick	39.417	-77.417	92	COOP	8/1/1948	6/30/1949	NO
Frederick 2 NNE	39.434	-77.392	85	COOP	1/23/2003	Present	NO
Frederick 3 E	39.4	-77.367	117	COOP	12/20/1948	6/1/1990	NO
Frederick Gas Plant	39.45	-77.4	88	COOP	3/1/1994	4/1/1994	NO
Frederick Municipal AP	39.417	-77.383	94	COOP	10/1/1933	Present	NO
Frederick Police Brk.	39.416	-77.439	116	COOP	7/1/1894	7/1/2002	NO
Frederick Telemark	39.404	-77.366	71	COOP	8/1/1969	Present	NO
Frederick Wastewater	39.433	-77.383	79	COOP	7/1/1994	10/1/1997	NO
Frederick WFMD	39.417	-77.467	133	COOP	11/1/1963	12/31/1970	NO
Gambrill State Park	39.467	-77.5	491	COOP	9/1/1964	1/31/1970	NO
Gettysburg	39.833	-77.233	165	COOP	11/1/1892	2/1/1982	NO
Gettysburg 1 S	39.8	-77.233	162	COOP	5/1/1948	6/30/1980	NO
Hagerstown	39.65	-77.733	201	COOP	5/1/1895	11/1/1993	NO
Hagerstown Police Brk.	39.604	-77.733	171	COOP	7/1/1958	Present	NO
Keedysville	39.483	-77.7	128	COOP	11/1/1904	5/31/1960	NO
Ringgold 3 NE	39.717	-77.533	268	COOP	7/9/1962	8/12/1985	NO
Sharpsburg	39.45	-77.731	95	COOP	2/17/1988	Present	NO
Sharpsburg 5 S	39.398	-77.722	152	COOP	2/1/1998	Present	NO
Shepherdstown	39.434	-77.802	86	COOP	8/1/1967	Present	NO
Smithsburg 2 NW	39.664	-77.583	204	COOP	4/1/1994	Present	NO
South Mountain	39.858	-77.477	463	COOP	5/23/1940	Present	NO
Unionville	39.45	-77.183	131	COOP	7/1/1940	12/1/1996	NO
Williamsport	39.604	-77.836	110	COOP	11/1/1938	Present	NO
AB3BE Hagerstown	39.667	-77.732	189	CWOP	M	Present	NO
CW1180 Frederick	39.429	-77.433	120	CWOP	M	Present	NO
CW1323 Hagerstown	39.642	-77.702	158	CWOP	M	Present	NO
CW1459 Smithsburg	39.633	-77.6	213	CWOP	M	Present	NO
CW1545 Waynesboro	39.767	-77.567	100	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW1662 Hagerstown	39.687	-77.758	177	CWOP	M	Present	NO
CW4264 Middletown	39.437	-77.549	162	CWOP	M	Present	NO
CW4293 Union Bridge	39.567	-77.18	155	CWOP	M	Present	NO
CW4362 Greencastle	39.741	-77.724	201	CWOP	M	Present	NO
CW5368 Westminster	39.476	-77.032	222	CWOP	M	Present	NO
N3OK Monrovia	39.344	-77.248	202	CWOP	M	Present	NO
W3ALF Union Bridge	39.567	-77.167	123	CWOP	M	Present	NO
Hagerstown	39.55	-77.71	155	GPS-MET	M	Present	NO
Frederick Municipal AP	39.417	-77.383	94	SAO	10/1/1933	Present	NO
Hagerstown Washington Co Regl. AP	39.708	-77.73	213	SAO	1/1/1931	Present	NO
Fort Ritchie	39.733	-77.4	278	WBAN	1/1/1962	Present	NO
Fountain Dale Site R	39.733	-77.433	275	WBAN	1/1/1984	Present	NO
Frederick AF	39.433	-77.45	100	WBAN	8/1/1946	4/30/1955	NO
Waynesboro	39.756	-77.578	220	WX4U	M	Present	NO
Chesapeake and Ohio Canal National Historical Park (CHOH)							
Little Falls Dam	38.95	-77.127	12	COOP	10/1/1966	Present	YES
Point Of Rocks	39.274	-77.543	61	COOP	2/1/1965	Present	YES
Arendtsville	39.923	-77.308	269	CASTNet	6/1/1988	Present	NO
Beltsville	39.028	-76.817	46	CASTNet	11/1/1988	Present	NO
Alexandria City Garage	38.8	-77.083	21	COOP	2/1/1958	10/1/1975	NO
Alexandria Potomac Y	38.817	-77.05	6	COOP	4/1/1893	10/31/1962	NO
Annandale	38.817	-77.2	95	COOP	1/1/1947	4/30/1952	NO
Arendtsville	39.917	-77.3	217	COOP	9/1/1918	8/17/1971	NO
Artemas	39.75	-78.433	281	COOP	5/1/1950	9/30/1953	NO
Artemas 1 WNW	39.75	-78.467	381	COOP	9/1/1953	7/31/1957	NO
Bacon NR Fairfax	38.867	-77.35	116	COOP	8/1/1948	3/31/1949	NO
Baileys Crossroads	38.85	-77.133	79	COOP	8/1/1950	12/31/1951	NO
Barcroft	38.867	-77.1	58	COOP	8/5/1945	8/31/1950	NO
Battery Park	39	-77.117	104	COOP	8/1/1948	7/31/1950	NO
Beltsville	39.03	-76.931	44	COOP	8/1/1948	Present	NO
Beltsville Plant Stn.	39.017	-76.95	30	COOP	1/1/1949	9/30/1978	NO
Beltsville SCS R1	39.05	-76.95	95	COOP	7/1/1950	1/31/1952	NO
Berkeley Springs	39.617	-78.217	223	COOP	4/1/1904	8/31/1975	NO
Berkeley Springs 3 S	39.572	-78.25	285	COOP	5/1/1996	Present	NO
Berryville	39.15	-77.983	183	COOP	6/1/1931	2/17/1988	NO
Bethesda	38.967	-77.117	101	COOP	8/1/1945	12/31/1966	NO
Bethesda NIH	39	-77.1	95	COOP	11/15/1943	9/30/1960	NO
Big Cove Tannery	39.817	-78.083	278	COOP	5/1/1948	7/10/1973	NO
Boonsboro	39.517	-77.65	226	COOP	5/1/1960	11/15/1972	NO
Boonsboro 1 NE	39.517	-77.65	192	COOP	11/1/1972	4/30/1977	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Bridgeport	39.679	-77.234	104	COOP	7/1/1996	1/9/2003	NO
Brighton Dam	39.191	-77.01	101	COOP	8/1/1948	Present	NO
Brightwood DC	38.95	-77.017	79	COOP	11/1/1944	7/1/1961	NO
Brookdale	38.95	-77.1	79	COOP	1/1/1945	1/1/1974	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Brookside Manor	38.967	-76.967	15	COOP	8/1/1945	3/31/1953	NO
Brookville	39.183	-77.057	122	COOP	2/1/1995	Present	NO
Bunker Hill 1 W	39.333	-78.067	201	COOP	10/1/1967	8/31/1975	NO
Burnt Mills Res.	39.033	-77	67	COOP	11/1/1944	9/30/1961	NO
Cacapon State Park	39.506	-78.294	290	COOP	M	Present	NO
Cacapon State Park 2	39.506	-78.316	290	COOP	8/1/1945	Present	NO
Catoctin Mountain Park	39.645	-77.483	491	COOP	9/1/1965	Present	NO
Chambersburg 1 ESE	39.935	-77.639	195	COOP	1/1/1894	Present	NO
Chantilly	38.883	-77.433	98	COOP	8/1/1948	8/31/1954	NO
Charles Town 2 SE	39.298	-77.834	158	COOP	11/1/1992	10/1/2001	NO
Cheltenham 1 NW	38.733	-76.85	70	COOP	5/1/1901	10/31/1956	NO
Chewsville-Bridgeport	39.65	-77.667	174	COOP	1/1/1899	8/1/1973	NO
Clarendon Lyon Park	38.9	-77.083	67	COOP	4/1/1925	12/31/1963	NO
Clarksville 3 NNE	39.255	-76.929	113	COOP	12/1/1958	12/2/2004	NO
Clear Spring 1 ENE	39.667	-77.9	177	COOP	1/1/1899	2/28/1975	NO
College Park	38.983	-76.95	27	COOP	1/1/1894	4/1/1996	NO
College Park SCS R1	39.05	-76.95	95	COOP	7/1/1948	10/31/1948	NO
Cooksville	39.318	-77.008	177	COOP	11/25/1995	4/1/2003	NO
Cumberland	39.621	-78.773	179	COOP	4/7/1987	Present	NO
Cumberland	39.65	-78.75	274	COOP	7/1/1891	10/23/1973	NO
Cumberland 2	39.642	-78.756	223	COOP	10/1/1973	Present	NO
Cumberland Police Brk.	39.639	-78.831	296	COOP	8/1/1948	Present	NO
Dalecarlia Reservoir	38.94	-77.113	46	COOP	8/1/1948	Present	NO
Damascus 2	39.291	-77.203	122	COOP	9/1/1992	Present	NO
Damascus 2 SW	39.267	-77.233	220	COOP	8/1/1973	1/1/1992	NO
Damascus 3 SSW	39.265	-77.232	212	COOP	1/1/1993	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
District Heights	38.85	-76.9	83	COOP	8/4/1945	2/28/1957	NO
Dranesville	38.983	-77.35	116	COOP	10/1/1953	12/31/1956	NO
Edgemont	39.667	-77.55	276	COOP	1/1/1893	12/1/1995	NO
Eisenhower NHS	39.805	-77.229	165	COOP	2/1/1982	Present	NO
Emmitsburg	39.683	-77.35	220	COOP	1/1/1893	5/31/1956	NO
Emmitsburg 2 SE	39.681	-77.29	127	COOP	5/1/1956	10/1/2005	NO
Episcopal High School	38.817	-77.1	76	COOP	10/1/1945	2/28/1958	NO
Fairfax	38.833	-77.317	137	COOP	4/1/1949	3/3/1964	NO
Fairview	39.716	-77.825	119	COOP	2/3/1988	Present	NO
Falls Church 2 SW	38.85	-77.2	98	COOP	10/1/1945	11/1/1970	NO
Fort George G Meade	39.1	-76.75	43	COOP	2/1/1942	8/31/1975	NO
Frederick	39.417	-77.417	92	COOP	8/1/1948	6/30/1949	NO
Frederick 2 NNE	39.434	-77.392	85	COOP	1/23/2003	Present	NO
Frederick 3 E	39.4	-77.367	117	COOP	12/20/1948	6/1/1990	NO
Frederick Gas Plant	39.45	-77.4	88	COOP	3/1/1994	4/1/1994	NO
Frederick Municipal AP	39.417	-77.383	94	COOP	10/1/1933	Present	NO
Frederick Police Brk.	39.416	-77.439	116	COOP	7/1/1894	7/1/2002	NO
Frederick Telemark	39.404	-77.366	71	COOP	8/1/1969	Present	NO
Frederick Wastewater	39.433	-77.383	79	COOP	7/1/1994	10/1/1997	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Frederick WFMD	39.417	-77.467	133	COOP	11/1/1963	12/31/1970	NO
Fredericksburg	38.315	-77.461	16	COOP	3/24/1988	11/17/2003	NO
Fredericksburg 2	38.3	-77.467	37	COOP	9/1/1978	11/10/1992	NO
Fredericksburg Embry	38.3	-77.467	6	COOP	7/13/1943	8/20/1969	NO
Fredericksburg N P	38.317	-77.45	27	COOP	4/17/1893	4/1/1997	NO
Fredericksburg Sewage	38.287	-77.451	5	COOP	2/15/1993	Present	NO
Frostburg	39.65	-78.933	653	COOP	6/1/1898	4/20/1972	NO
Frostburg 2	39.667	-78.933	661	COOP	M	Present	NO
Ft Washington National Park	38.717	-77.033	37	COOP	6/1/1968	8/31/1975	NO
Gambrill State Park	39.467	-77.5	491	COOP	9/1/1964	1/31/1970	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Germantown 2 W	39.174	-77.294	122	COOP	11/13/1997	4/1/1998	NO
Gerrardstown 1 SE	39.35	-78.083	201	COOP	8/1/1967	12/31/1972	NO
Gettysburg	39.833	-77.233	165	COOP	11/1/1892	2/1/1982	NO
Gettysburg 1 S	39.8	-77.233	162	COOP	5/1/1948	6/30/1980	NO
Glen Echo	38.967	-77.15	46	COOP	8/1/1948	12/31/1966	NO
Glencoe	39.826	-78.83	486	COOP	6/30/2001	Present	NO
Glencoe 1 E	39.817	-78.833	576	COOP	1/1/1979	12/1/2000	NO
Glencoe 1 ENE	39.817	-78.833	491	COOP	10/1/1940	12/31/1978	NO
Glenelg	39.267	-76.983	192	COOP	1/1/1948	9/30/1948	NO
Glenn Dale Bell Stn.	38.969	-76.804	46	COOP	1/1/1921	Present	NO
Gore 3 E	39.288	-78.363	347	COOP	7/1/1962	4/29/2002	NO
Great Cacapon	39.567	-78.3	139	COOP	10/1/1987	1/10/1996	NO
Great Falls	39	-77.25	61	COOP	8/1/1948	10/31/1950	NO
Greenbelt	39	-76.883	61	COOP	1/1/1949	1/31/1975	NO
Grosvenor Lane	39.017	-77.117	101	COOP	8/1/1948	Present	NO
Groveton	38.767	-77.1	76	COOP	11/1/1951	1/1/1973	NO
Hagerstown	39.65	-77.733	201	COOP	5/1/1895	11/1/1993	NO
Hagerstown Police Brk.	39.604	-77.733	171	COOP	7/1/1958	Present	NO
Hancock	39.697	-78.178	117	COOP	6/1/1946	Present	NO
Hancock	39.7	-78.183	116	COOP	1/1/1895	8/1/1988	NO
Harpers Ferry Natl. Park	39.317	-77.733	88	COOP	6/1/1958	3/1/1975	NO
Harpers Ferry River	39.323	-77.729	75	COOP	7/1/1889	Present	NO
Headsville 4 NE	39.443	-78.822	190	COOP	8/1/1994	Present	NO
Herndon	38.967	-77.383	113	COOP	12/1/1956	6/30/1960	NO
Hewitt 2 S	39.733	-78.533	256	COOP	5/20/1944	5/31/1950	NO
Hipsley Mill Floren	39.277	-77.111	168	COOP	5/6/1993	Present	NO
Hyndman	39.817	-78.733	293	COOP	1/1/1906	1/1/1994	NO
Indianhead	38.592	-77.158	11	COOP	1/23/1998	3/31/1998	NO
Inwood	39.367	-78.05	174	COOP	1/1/1923	9/30/1948	NO
Junction	39.317	-78.867	244	COOP	4/1/1951	5/31/1954	NO
Kearneysville	39.383	-77.883	168	COOP	5/1/1930	6/1/1995	NO
Keedysville	39.483	-77.7	128	COOP	11/1/1904	5/31/1960	NO
Keyser	39.433	-78.983	284	COOP	11/1/1954	2/5/1965	NO
Keyser 2 SSW	39.421	-79.005	274	COOP	10/1/1993	Present	NO
Knobly Mountain	39.367	-79	409	COOP	1/1/1938	1/31/1961	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
La Plata 1 W	38.533	-77	43	COOP	12/1/1894	10/1/1998	NO
Lanham	38.967	-76.85	55	COOP	5/1/1958	1/1/1987	NO
Laurel 3 W	39.085	-76.9	122	COOP	4/1/1895	Present	NO
Leesburg	39.117	-77.567	98	COOP	11/1/1944	6/30/1949	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Lincoln	39.088	-77.693	152	COOP	9/26/1900	Present	NO
Lisbon 1 W	39.35	-77.1	223	COOP	8/1/1949	6/30/1954	NO
Luke	39.467	-79.067	311	COOP	1/1/1938	9/30/1965	NO
Luke 2	39.479	-79.065	288	COOP	6/24/1996	1/9/2003	NO
Manassas	38.734	-77.493	75	COOP	1/22/2004	Present	NO
Manassas	38.783	-77.5	101	COOP	6/1/1895	4/1/1987	NO
Manassas 4 S	38.7	-77.433	52	COOP	12/1/1930	6/30/1950	NO
Manion NR Fairfax	38.85	-77.35	137	COOP	8/1/1948	3/31/1949	NO
Marshall	38.867	-77.883	177	COOP	8/1/1948	4/30/1954	NO
Martinsburg	39.424	-77.939	108	COOP	9/21/1987	Present	NO
Martinsburg 2	39.466	-77.967	165	COOP	11/1/1996	Present	NO
Martinsburg 2 W	39.467	-78	165	COOP	M	3/31/1972	NO
Martinsburg E WV Reg.	39.402	-77.984	163	COOP	1/1/1926	Present	NO
Martinsburg Radio Re	39.167	-77.5	128	COOP	9/1/1963	10/31/1969	NO
Mason Springs	38.583	-77.1	9	COOP	10/1/1994	2/1/1998	NO
McConnellsburg 1 SW	39.933	-78	262	COOP	10/1/1938	Present	NO
Mercersburg 1 E	39.833	-77.9	165	COOP	8/16/1928	8/1/1992	NO
Merrill	39.6	-79.083	546	COOP	5/1/1951	1/1/1996	NO
Meyersdale	39.817	-79.017	641	COOP	4/1/1939	11/30/1962	NO
Meyersdale 1 ENE	39.817	-79.017	698	COOP	3/1/1956	7/31/1957	NO
Meyersdale 2 SSW	39.781	-79.041	610	COOP	11/1/1962	Present	NO
Meyersdale River	39.817	-79.033	588	COOP	6/1/1990	Present	NO
Millville	39.282	-77.79	89	COOP	3/13/1961	Present	NO
Mount Weather	39.063	-77.889	524	COOP	1/1/1915	Present	NO
National Arboretum DC	38.913	-76.97	15	COOP	8/1/1948	Present	NO
New Germany	39.633	-79.117	790	COOP	8/1/1949	8/31/1974	NO
New Germany 2	39.617	-79.133	756	COOP	9/1/1974	4/1/1992	NO
Owings Ferry Landing	38.683	-76.667	49	COOP	8/1/1948	2/28/1998	NO
Oxon Hill	38.796	-76.995	37	COOP	5/1/1994	Present	NO
Paw Paw	39.537	-78.458	149	COOP	2/18/1988	Present	NO
Picardy	39.55	-78.517	314	COOP	4/1/1927	1/1/1974	NO
Piedmont	39.483	-79.033	320	COOP	4/1/1914	6/30/1966	NO
Pinto	39.566	-78.84	198	COOP	6/24/1996	1/26/2005	NO
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Quantico 1 S	38.5	-77.317	3	COOP	4/1/1896	3/31/1976	NO
Ranson 4 NW	39.325	-77.92	171	COOP	6/26/2003	Present	NO
Ringgold 3 NE	39.717	-77.533	268	COOP	7/9/1962	8/12/1985	NO
Riverdale	38.967	-76.933	15	COOP	1/1/1946	3/31/1955	NO
Rock Creek Forest	39	-77.067	61	COOP	8/1/1945	11/30/1949	NO
Rockville 1 NE	39.101	-77.149	134	COOP	12/17/1907	Present	NO
Romney 1 SW	39.339	-78.773	219	COOP	8/13/1870	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Sharpsburg	39.45	-77.731	95	COOP	2/17/1988	Present	NO
Sharpsburg 5 S	39.398	-77.722	152	COOP	2/1/1998	Present	NO
Shepherdstown	39.434	-77.802	86	COOP	8/1/1967	Present	NO
Silver Hill Obsv	38.833	-76.95	85	COOP	10/1/1950	Present	NO
Silver Spring	39	-77.017	82	COOP	2/1/1939	4/30/1975	NO
Smithsburg 2 NW	39.664	-77.583	204	COOP	4/1/1994	Present	NO
South Mountain	39.858	-77.477	463	COOP	5/23/1940	Present	NO
Springfield	39.447	-78.654	172	COOP	4/15/1987	Present	NO
Springfield 1 N	39.467	-78.7	244	COOP	3/1/1908	10/31/1963	NO
Sterling	38.983	-77.467	85	COOP	10/1/1960	Present	NO
Sterling RCS	38.976	-77.477	85	COOP	7/1/1964	Present	NO
Suitland	38.85	-76.933	82	COOP	12/1/1962	4/30/1974	NO
Takoma Park Miss Ave.	38.983	-77	70	COOP	3/1/1945	7/31/1961	NO
Takoma Park Balt Ave.	38.983	-77.017	98	COOP	8/1/1948	2/28/1949	NO
The Plains 2 NNE	38.896	-77.755	162	COOP	4/1/1954	Present	NO
Three Churches 1 SSE	39.383	-78.65	381	COOP	7/1/1962	1/31/1973	NO
Tonoloway	39.667	-78.25	168	COOP	5/1/1924	5/31/1957	NO
U S Soldiers Home DC	38.933	-77.017	70	COOP	8/1/1948	8/1/1990	NO
Unionville	39.45	-77.183	131	COOP	7/1/1940	12/1/1996	NO
Upper Marlboro 3 NNW	38.865	-76.777	30	COOP	5/1/1956	Present	NO
Vienna	38.9	-77.266	127	COOP	4/1/1925	Present	NO
Viers Mill	39.05	-77.083	92	COOP	7/13/1950	3/31/1960	NO
Waldorf 4 W	38.642	-76.986	64	COOP	7/1/1994	10/26/2002	NO
Waldorf Police Brk.	38.652	-76.881	64	COOP	8/1/1948	1/4/2002	NO
Walkers Chapel	38.917	-77.133	73	COOP	8/6/1945	5/31/1951	NO
Warrenton 3 SE	38.682	-77.768	152	COOP	3/1/1897	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	COOP	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	COOP	7/1/1929	Present	NO
Washington DC American Univ.	38.933	-77.083	122	COOP	7/1/1952	8/31/1953	NO
Washington DC WB City	38.9	-77.05	22	COOP	1/1/1871	1/1/1966	NO
Washington DC Cornth YC	38.867	-77	0	COOP	11/1/1958	Present	NO
Waterford	39.183	-77.6	162	COOP	11/1/1944	12/31/1963	NO
Waterloo Police Brk.	39.167	-76.783	70	COOP	8/1/1948	Present	NO
Waverly Hills	38.883	-77.117	104	COOP	3/1/1945	5/31/1970	NO
West Lanham Hills	38.95	-76.883	49	COOP	4/3/1947	7/31/1952	NO
Westernport	39.483	-79.05	305	COOP	11/1/1894	1/1/1969	NO
Westernport 2	39.494	-79.045	293	COOP	6/17/1996	Present	NO
Westernport UPRC	39.483	-79.05	290	COOP	12/12/1967	10/1/1979	NO
Wheaton Reg. Park	39.067	-77.033	101	COOP	6/1/1961	10/1/2005	NO
Williamsport	39.604	-77.836	110	COOP	11/1/1938	Present	NO
Wills Creek	39.669	-78.788	195	COOP	6/24/1996	1/24/2003	NO
Winchester 7 SE	39.183	-78.117	207	COOP	4/1/1912	Present	NO
Wisconsin Ave.	38.9	-77.061	43	COOP	2/1/1964	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
AB3BE Hagerstown	39.667	-77.732	189	CWOP	M	Present	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0046 Vienna	38.892	-77.294	119	CWOP	M	Present	NO
CW0146 Round Hill	39.134	-77.766	168	CWOP	M	Present	NO
CW0351 Brookeville	39.167	-77.068	147	CWOP	M	Present	NO
CW0415 Savage	39.154	-76.828	96	CWOP	M	Present	NO
CW0433 Montgomery Village	39.163	-77.2	106	CWOP	M	Present	NO
CW0497 Washington	38.957	-77.034	77	CWOP	M	Present	NO
CW0626 Germantown	39.173	-77.295	154	CWOP	M	Present	NO
CW0630 Annandale	38.84	-77.165	110	CWOP	M	Present	NO
CW0643 Goldvein	38.438	-77.661	109	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO
CW0746 Manassas	38.788	-77.625	350	CWOP	M	Present	NO
CW0802 Fredericksburg	38.302	-77.465	9	CWOP	M	Present	NO
CW0980 Springfield	38.739	-77.238	211	CWOP	M	Present	NO
CW1167 Fort Belvoir	38.71	-77.192	120	CWOP	M	Present	NO
CW1180 Frederick	39.429	-77.433	120	CWOP	M	Present	NO
CW1236 Beltsville	39.045	-76.944	90	CWOP	M	Present	NO
CW1323 Hagerstown	39.642	-77.702	158	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO
CW1459 Smithsburg	39.633	-77.6	213	CWOP	M	Present	NO
CW1545 Waynesboro	39.767	-77.567	100	CWOP	M	Present	NO
CW1574 Camp Springs	38.823	-76.918	86	CWOP	M	Present	NO
CW1619 Falmouth	38.293	-77.417	59	CWOP	M	Present	NO
CW1653 Frostburg	39.655	-78.928	671	CWOP	M	Present	NO
CW1662 Hagerstown	39.687	-77.758	177	CWOP	M	Present	NO
CW1672 Martinsburg	39.467	-78.007	165	CWOP	M	Present	NO
CW1676 Highland	39.178	-76.965	170	CWOP	M	Present	NO
CW1764 Germantown	39.214	-77.209	122	CWOP	M	Present	NO
CW1826 Silver Spring	39.043	-77.012	107	CWOP	M	Present	NO
CW2057 Rockville	39.094	-77.162	138	CWOP	M	Present	NO
CW2182 Silver Spring	39.015	-77.01	98	CWOP	M	Present	NO
CW2287 Laurel	39.103	-76.881	152	CWOP	M	Present	NO
CW2463 Laytonsville	39.205	-77.131	182	CWOP	M	Present	NO
CW2503 Columbia	39.2	-76.9	233	CWOP	M	Present	NO
CW2575 Arlington	38.904	-77.12	104	CWOP	M	Present	NO
CW2579 Accokeek	38.667	-77.037	81	CWOP	M	Present	NO
CW2950 Purcellville	39.172	-77.765	204	CWOP	M	Present	NO
CW3062 Silver Spring	39.042	-77.028	122	CWOP	M	Present	NO
CW3128 Frostburg	39.661	-78.93	615	CWOP	M	Present	NO
CW3167 Fairfax Station	38.784	-77.352	73	CWOP	M	Present	NO
CW3397 Ellicott	39.261	-76.91	124	CWOP	M	Present	NO
CW3401 Greenspring	39.531	-78.618	198	CWOP	M	Present	NO
CW3406 Arlington	38.901	-77.132	92	CWOP	M	Present	NO
CW3416 Romney	39.342	-78.757	250	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW3438 Hollis Point	38.635	-77.11	10	CWOP	M	Present	NO
CW3503 Slanesville	39.386	-78.492	348	CWOP	M	Present	NO
CW3504 Augusta	39.306	-78.627	392	CWOP	M	Present	NO
CW3647 Lanham	38.98	-76.881	50	CWOP	M	Present	NO
CW3648 Bethesda	39.018	-77.131	123	CWOP	M	Present	NO
CW3766 Centreville	38.845	-77.455	81	CWOP	M	Present	NO
CW3774 Leesburg	39.098	-77.587	112	CWOP	M	Present	NO
CW3791 Germantown	39.191	-77.277	147	CWOP	M	Present	NO
CW3816 Reston	38.938	-77.312	91	CWOP	M	Present	NO
CW4047 Laytonsville	39.266	-77.188	200	CWOP	M	Present	NO
CW4120 Fairfax	38.809	-77.295	104	CWOP	M	Present	NO
CW4264 Middletown	39.437	-77.549	162	CWOP	M	Present	NO
CW4293 Union Bridge	39.567	-77.18	155	CWOP	M	Present	NO
CW4362 Greencastle	39.741	-77.724	201	CWOP	M	Present	NO
CW4384 Germantown	39.166	-77.273	137	CWOP	M	Present	NO
CW4571 Bluemont	39.095	-77.807	208	CWOP	M	Present	NO
CW4662 Crofton	38.998	-76.689	34	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4966 Halltown	39.337	-77.794	419	CWOP	M	Present	NO
CW4977 Warrenton	38.68	-77.752	127	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW4994 Bowie	38.99	-76.795	50	CWOP	M	Present	NO
CW5048 Winchester	39.169	-78.099	195	CWOP	M	Present	NO
CW5127 Alexandria	38.796	-77.121	55	CWOP	M	Present	NO
CW5167 Nokesville	38.669	-77.586	80	CWOP	M	Present	NO
CW5204 Harpers Ferry	39.337	-77.79	142	CWOP	M	Present	NO
CW5223 Lorton	38.717	-77.201	28	CWOP	M	Present	NO
CW5307 Columbia	39.196	-76.796	101	CWOP	M	Present	NO
CW5368 Westminster	39.476	-77.032	222	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5406 Purcellville	39.158	-77.699	162	CWOP	M	Present	NO
CW5498 Lovettsville	39.264	-77.584	133	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5741 Berryville	39.161	-77.989	192	CWOP	M	Present	NO
CW5871 Chantilly	38.901	-77.476	85	CWOP	M	Present	NO
K3CHZ Dayton	39.243	-76.998	163	CWOP	M	Present	NO
K3GJ-1 La Plata	38.58	-76.996	64	CWOP	M	Present	NO
K3WTF Potomac Hts.	38.605	-77.136	25	CWOP	M	Present	NO
K4AA-10 Great Falls	38.997	-77.276	90	CWOP	M	Present	NO
KA5TUU Alexandria	38.81	-77.093	77	CWOP	M	Present	NO
KA6AKH Alexandria	38.728	-77.046	16	CWOP	M	Present	NO
KB3FN-1 Cumberland	39.643	-78.756	250	CWOP	M	Present	NO
KF6ZPN Warrenton	38.756	-77.734	173	CWOP	M	Present	NO
KG4QXL-2 Fort Valley	38.813	-77.612	105	CWOP	M	Present	NO
KM6LJ Washington	38.928	-77.04	49	CWOP	M	Present	NO
N3OK Monrovia	39.344	-77.248	202	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
N3SZW Bowie	39.003	-76.77	68	CWOP	M	Present	NO
N4NW Stafford County	38.461	-77.463	102	CWOP	M	Present	NO
N4TVC Burke	38.791	-77.255	94	CWOP	M	Present	NO
W0NQW Fort Meade	39.132	-76.728	72	CWOP	M	Present	NO
W3ALF Union Bridge	39.567	-77.167	123	CWOP	M	Present	NO
W4IFI Warrenton	38.756	-77.734	174	CWOP	M	Present	NO
Greenbelt	38.99	-76.84	87	GPS-MET	M	Present	NO
Hagerstown	39.55	-77.71	155	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Turner-Fairbank HRC	38.96	-77.15	84	GPS-MET	M	Present	NO
US Naval Obs.	38.92	-77.07	81	GPS-MET	M	Present	NO
Cedarville	38.653	-76.821	61	RAWS	12/1/2004	Present	NO
Green Ridge	39.667	-78.441	240	RAWS	3/1/2004	Present	NO
Anacostia NAS	38.85	-77.033	16	SAO	7/1/1924	10/31/1961	NO
Andrews AFB	38.817	-76.867	86	SAO	6/1/1943	Present	NO
Camp David Thurmont	39.65	-77.467	569	SAO	M	Present	NO
Davison AAF	38.717	-77.183	27	SAO	2/1/1957	Present	NO
Fort Meade Tptn. AAF	39.083	-76.767	43	SAO	11/1/1959	Present	NO
Frederick Municipal AP	39.417	-77.383	94	SAO	10/1/1933	Present	NO
Fredericksburg Shannon Airport	38.267	-77.449	26	SAO	7/1/1991	Present	NO
Gaithersburg Montgomery County	39.167	-77.167	0	SAO	8/1/1975	Present	NO
Hagerstown Washington Co Reg. AP	39.708	-77.73	213	SAO	1/1/1931	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Manassas Regional Davis Field	38.721	-77.515	59	SAO	7/1/1991	Present	NO
Martinsburg E WV Reg.	39.402	-77.984	163	SAO	1/1/1926	Present	NO
Quantico MCAS	38.5	-77.3	4	SAO	9/1/1922	Present	NO
Stafford Regional Airport	38.398	-77.456	65	SAO	1/7/2004	Present	NO
Sterling	38.983	-77.483	83	SAO	11/12/1991	Present	NO
Washington DC Dulles Intl. AP	38.941	-77.484	88	SAO	11/17/1962	Present	NO
Washington Reagan National AP	38.848	-77.034	3	SAO	7/1/1929	Present	NO
Powder Mill	39.02	-76.85	32	SCAN	M	Present	NO
Cumberland	39.6	-78.767	238	WBAN	3/1/1949	Present	NO
Cumberland AAF	39.667	-78.667	184	WBAN	9/1/1926	12/31/1931	NO
Fort Ritchie	39.733	-77.4	278	WBAN	1/1/1962	Present	NO
Fountain Dale Site R	39.733	-77.433	275	WBAN	1/1/1984	Present	NO
Frederick AF	39.433	-77.45	100	WBAN	8/1/1946	4/30/1955	NO
Frostburg	39.65	-78.933	870	WBAN	12/1/1929	10/31/1945	NO
McConnellsburg	39.917	-77.983	293	WBAN	4/1/1931	4/30/1939	NO
Mount Savage	39.667	-78.967	868	WBAN	M	Present	NO
Washington DC Bolling Field AF	38.833	-77.017	18	WBAN	10/1/1920	9/30/1969	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Washington DC Central	38.883	-77.05	12	WBAN	12/1/1922	12/31/1933	NO
BoltAssociates Beltsville	39.035	-76.908	57	WX4U	M	Present	NO
Locust Hill GC	39.292	-77.907	173	WX4U	M	Present	NO
N4NW Stafford	38.463	-77.463	102	WX4U	M	Present	NO
Oakton	38.882	-77.32	107	WX4U	M	Present	NO
Stafford	38.42	-77.4	52	WX4U	M	Present	NO
Upper Marlboro	38.751	-76.82	61	WX4U	M	Present	NO
Waynesboro	39.756	-77.578	220	WX4U	M	Present	NO
Harper’s Ferry National Historical Park (HAFE)							
Harpers Ferry Natl. Park	39.317	-77.733	88	COOP	6/1/1958	3/1/1975	YES
Berryville	39.15	-77.983	183	COOP	6/1/1931	2/17/1988	NO
Boonsboro	39.517	-77.65	226	COOP	5/1/1960	11/15/1972	NO
Boonsboro 1 NE	39.517	-77.65	192	COOP	11/1/1972	4/30/1977	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Bunker Hill 1 W	39.333	-78.067	201	COOP	10/1/1967	8/31/1975	NO
Charles Town 2 SE	39.298	-77.834	158	COOP	11/1/1992	10/1/2001	NO
Chewsville-Bridgeport	39.65	-77.667	174	COOP	1/1/1899	8/1/1973	NO
Frederick	39.417	-77.417	92	COOP	8/1/1948	6/30/1949	NO
Frederick 2 NNE	39.434	-77.392	85	COOP	1/23/2003	Present	NO
Frederick 3 E	39.4	-77.367	117	COOP	12/20/1948	6/1/1990	NO
Frederick Gas Plant	39.45	-77.4	88	COOP	3/1/1994	4/1/1994	NO
Frederick Municipal AP	39.417	-77.383	94	COOP	10/1/1933	Present	NO
Frederick Police Brk.	39.416	-77.439	116	COOP	7/1/1894	7/1/2002	NO
Frederick Telemark	39.404	-77.366	71	COOP	8/1/1969	Present	NO
Frederick Wastewater	39.433	-77.383	79	COOP	7/1/1994	10/1/1997	NO
Frederick WFMD	39.417	-77.467	133	COOP	11/1/1963	12/31/1970	NO
Gambrill State Park	39.467	-77.5	491	COOP	9/1/1964	1/31/1970	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Gerrardstown 1 SE	39.35	-78.083	201	COOP	8/1/1967	12/31/1972	NO
Hagerstown	39.65	-77.733	201	COOP	5/1/1895	11/1/1993	NO
Hagerstown Police Brk.	39.604	-77.733	171	COOP	7/1/1958	Present	NO
Harpers Ferry River	39.323	-77.729	75	COOP	7/1/1889	Present	NO
Inwood	39.367	-78.05	174	COOP	1/1/1923	9/30/1948	NO
Kearneysville	39.383	-77.883	168	COOP	5/1/1930	6/1/1995	NO
Keedysville	39.483	-77.7	128	COOP	11/1/1904	5/31/1960	NO
Leesburg	39.117	-77.567	98	COOP	11/1/1944	6/30/1949	NO
Leesburg	39.019	-77.578	76	COOP	3/14/1987	Present	NO
Lincoln	39.088	-77.693	152	COOP	9/26/1900	Present	NO
Martinsburg	39.424	-77.939	108	COOP	9/21/1987	Present	NO
Martinsburg 2	39.466	-77.967	165	COOP	11/1/1996	Present	NO
Martinsburg 2 W	39.467	-78	165	COOP	M	3/31/1972	NO
Martinsburg E WV Reg.	39.402	-77.984	163	COOP	1/1/1926	Present	NO
Martinsburg Radio Re	39.167	-77.5	128	COOP	9/1/1963	10/31/1969	NO
Millville	39.282	-77.79	89	COOP	3/13/1961	Present	NO
Mount Weather	39.063	-77.889	524	COOP	1/1/1915	Present	NO
Point Of Rocks	39.274	-77.543	61	COOP	2/1/1965	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Ranson 4 NW	39.325	-77.92	171	COOP	6/26/2003	Present	NO
Sharpsburg	39.45	-77.731	95	COOP	2/17/1988	Present	NO
Sharpsburg 5 S	39.398	-77.722	152	COOP	2/1/1998	Present	NO
Shepherdstown	39.434	-77.802	86	COOP	8/1/1967	Present	NO
Smithsburg 2 NW	39.664	-77.583	204	COOP	4/1/1994	Present	NO
Waterford	39.183	-77.6	162	COOP	11/1/1944	12/31/1963	NO
Williamsport	39.604	-77.836	110	COOP	11/1/1938	Present	NO
AB3BE Hagerstown	39.667	-77.732	189	CWOP	M	Present	NO
AC5YO-10 Brambleton	38.982	-77.528	101	CWOP	M	Present	NO
CW0146 Round Hill	39.134	-77.766	168	CWOP	M	Present	NO
CW1180 Frederick	39.429	-77.433	120	CWOP	M	Present	NO
CW1323 Hagerstown	39.642	-77.702	158	CWOP	M	Present	NO
CW1459 Smithsburg	39.633	-77.6	213	CWOP	M	Present	NO
CW1662 Hagerstown	39.687	-77.758	177	CWOP	M	Present	NO
CW1672 Martinsburg	39.467	-78.007	165	CWOP	M	Present	NO
CW2950 Purcellville	39.172	-77.765	204	CWOP	M	Present	NO
CW3774 Leesburg	39.098	-77.587	112	CWOP	M	Present	NO
CW4264 Middletown	39.437	-77.549	162	CWOP	M	Present	NO
CW4571 Bluemont	39.095	-77.807	208	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4966 Halltown	39.337	-77.794	419	CWOP	M	Present	NO
CW5048 Winchester	39.169	-78.099	195	CWOP	M	Present	NO
CW5204 Harpers Ferry	39.337	-77.79	142	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5406 Purcellville	39.158	-77.699	162	CWOP	M	Present	NO
CW5498 Lovettsville	39.264	-77.584	133	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
CW5741 Berryville	39.161	-77.989	192	CWOP	M	Present	NO
Hagerstown	39.55	-77.71	155	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Frederick Municipal AP	39.417	-77.383	94	SAO	10/1/1933	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Martinsburg E WV Reg.	39.402	-77.984	163	SAO	1/1/1926	Present	NO
Frederick AF	39.433	-77.45	100	WBAN	8/1/1946	4/30/1955	NO
Locust Hill GC	39.292	-77.907	173	WX4U	M	Present	NO
Monocacy National Battlefield Park (MONO)							
Boonsboro	39.517	-77.65	226	COOP	5/1/1960	11/15/1972	NO
Boonsboro 1 NE	39.517	-77.65	192	COOP	11/1/1972	4/30/1977	NO
Boyds 2 NW	39.217	-77.333	177	COOP	12/1/1919	2/1/1991	NO
Bridgeport	39.679	-77.234	104	COOP	7/1/1996	1/9/2003	NO
Brighton Dam	39.191	-77.01	101	COOP	8/1/1948	Present	NO
Brookville	39.183	-77.057	122	COOP	2/1/1995	Present	NO
Catoctin Mountain Park	39.645	-77.483	491	COOP	9/1/1965	Present	NO
Charles Town 2 SE	39.298	-77.834	158	COOP	11/1/1992	10/1/2001	NO
Chewsville-Bridgeport	39.65	-77.667	174	COOP	1/1/1899	8/1/1973	NO
Damascus 2	39.291	-77.203	122	COOP	9/1/1992	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
Damascus 2 SW	39.267	-77.233	220	COOP	8/1/1973	1/1/1992	NO
Damascus 3 SSW	39.265	-77.232	212	COOP	1/1/1993	Present	NO
Dawsonville	39.128	-77.335	65	COOP	9/3/1987	Present	NO
Edgemont	39.667	-77.55	276	COOP	1/1/1893	12/1/1995	NO
Emmitsburg	39.683	-77.35	220	COOP	1/1/1893	5/31/1956	NO
Emmitsburg 2 SE	39.681	-77.29	127	COOP	5/1/1956	10/1/2005	NO
Frederick	39.417	-77.417	92	COOP	8/1/1948	6/30/1949	NO
Frederick 2 NNE	39.434	-77.392	85	COOP	1/23/2003	Present	NO
Frederick 3 E	39.4	-77.367	117	COOP	12/20/1948	6/1/1990	NO
Frederick Gas Plant	39.45	-77.4	88	COOP	3/1/1994	4/1/1994	NO
Frederick Municipal AP	39.417	-77.383	94	COOP	10/1/1933	Present	NO
Frederick Police Brk.	39.416	-77.439	116	COOP	7/1/1894	7/1/2002	NO
Frederick Telemark	39.404	-77.366	71	COOP	8/1/1969	Present	NO
Frederick Wastewater	39.433	-77.383	79	COOP	7/1/1994	10/1/1997	NO
Frederick WFMD	39.417	-77.467	133	COOP	11/1/1963	12/31/1970	NO
Gambrill State Park	39.467	-77.5	491	COOP	9/1/1964	1/31/1970	NO
Germantown	39.167	-77.383	140	COOP	8/1/1948	2/28/1953	NO
Germantown 2 W	39.174	-77.294	122	COOP	11/13/1997	4/1/1998	NO
Hagerstown Police Brk.	39.604	-77.733	171	COOP	7/1/1958	Present	NO
Harpers Ferry Natl. Park	39.317	-77.733	88	COOP	6/1/1958	3/1/1975	NO
Harpers Ferry River	39.323	-77.729	75	COOP	7/1/1889	Present	NO
Hipsley Mill Floren	39.277	-77.111	168	COOP	5/6/1993	Present	NO
Keedysville	39.483	-77.7	128	COOP	11/1/1904	5/31/1960	NO
Leesburg	39.117	-77.567	98	COOP	11/1/1944	6/30/1949	NO
Lincoln	39.088	-77.693	152	COOP	9/26/1900	Present	NO
Lisbon 1 W	39.35	-77.1	223	COOP	8/1/1949	6/30/1954	NO
Martinsburg Radio Re	39.167	-77.5	128	COOP	9/1/1963	10/31/1969	NO
Millville	39.282	-77.79	89	COOP	3/13/1961	Present	NO
Point Of Rocks	39.274	-77.543	61	COOP	2/1/1965	Present	NO
Potomac Filter Plant	39.04	-77.254	82	COOP	11/1/1961	Present	NO
Rockville 1 NE	39.101	-77.149	134	COOP	12/17/1907	Present	NO
Sharpsburg	39.45	-77.731	95	COOP	2/17/1988	Present	NO
Sharpsburg 5 S	39.398	-77.722	152	COOP	2/1/1998	Present	NO
Shepherdstown	39.434	-77.802	86	COOP	8/1/1967	Present	NO
Smithsburg 2 NW	39.664	-77.583	204	COOP	4/1/1994	Present	NO
Unionville	39.45	-77.183	131	COOP	7/1/1940	12/1/1996	NO
Waterford	39.183	-77.6	162	COOP	11/1/1944	12/31/1963	NO
CW0146 Round Hill	39.134	-77.766	168	CWOP	M	Present	NO
CW0351 Brookeville	39.167	-77.068	147	CWOP	M	Present	NO
CW0433 Montgomery Village	39.163	-77.2	106	CWOP	M	Present	NO
CW0626 Germantown	39.173	-77.295	154	CWOP	M	Present	NO
CW0666 Reston	38.991	-77.333	133	CWOP	M	Present	NO
CW1180 Frederick	39.429	-77.433	120	CWOP	M	Present	NO
CW1323 Hagerstown	39.642	-77.702	158	CWOP	M	Present	NO
CW1414 Great Falls	39.025	-77.307	104	CWOP	M	Present	NO

Name	Lat.	Lon.	Elev. (m)	Network	Start	End	In Park?
CW1459 Smithsburg	39.633	-77.6	213	CWOP	M	Present	NO
CW1764 Germantown	39.214	-77.209	122	CWOP	M	Present	NO
CW2057 Rockville	39.094	-77.162	138	CWOP	M	Present	NO
CW2463 Laytonsville	39.205	-77.131	182	CWOP	M	Present	NO
CW2950 Purcellville	39.172	-77.765	204	CWOP	M	Present	NO
CW3774 Leesburg	39.098	-77.587	112	CWOP	M	Present	NO
CW3791 Germantown	39.191	-77.277	147	CWOP	M	Present	NO
CW4047 Laytonsville	39.266	-77.188	200	CWOP	M	Present	NO
CW4264 Middletown	39.437	-77.549	162	CWOP	M	Present	NO
CW4293 Union Bridge	39.567	-77.18	155	CWOP	M	Present	NO
CW4384 Germantown	39.166	-77.273	137	CWOP	M	Present	NO
CW4868 Boyds	39.185	-77.316	128	CWOP	M	Present	NO
CW4966 Halltown	39.337	-77.794	419	CWOP	M	Present	NO
CW4981 N.Potomac	39.108	-77.242	99	CWOP	M	Present	NO
CW5204 Harpers Ferry	39.337	-77.79	142	CWOP	M	Present	NO
CW5368 Westminster	39.476	-77.032	222	CWOP	M	Present	NO
CW5376 Leesburg	39.119	-77.556	106	CWOP	M	Present	NO
CW5406 Purcellville	39.158	-77.699	162	CWOP	M	Present	NO
CW5498 Lovettsville	39.264	-77.584	133	CWOP	M	Present	NO
CW5698 Ashburn	39.036	-77.481	91	CWOP	M	Present	NO
K3CHZ Dayton	39.243	-76.998	163	CWOP	M	Present	NO
N3OK Monrovia	39.344	-77.248	202	CWOP	M	Present	NO
W3ALF Union Bridge	39.567	-77.167	123	CWOP	M	Present	NO
Hagerstown	39.55	-77.71	155	GPS-MET	M	Present	NO
Leesburg	39.1	-77.54	112	GPS-MET	M	Present	NO
Camp David Thurmont	39.65	-77.467	569	SAO	M	Present	NO
Frederick Municipal AP	39.417	-77.383	94	SAO	10/1/1933	Present	NO
Gaithersburg Montgomery County	39.167	-77.167	0	SAO	8/1/1975	Present	NO
Leesburg Executive Airport	39.078	-77.558	119	SAO	M	Present	NO
Frederick AF	39.433	-77.45	100	WBAN	8/1/1946	4/30/1955	NO

5.0. Conclusions and Recommendations

We have based our findings on an examination of the available records and the environmental characteristics of NCRN park units, discussions with NPS staff and other collaborators, and prior knowledge of the area. Here, we offer an evaluation and general comments pertaining to the status, prospects, and needs for climate-monitoring capabilities in the NCRN.

5.1. National Capital Region Inventory and Monitoring Network

Most of the park units in NCRN had few or no stations within park boundaries. Many of these park units are historical sites such as battlefields or other memorials. Sites such as these are quite small and therefore must rely heavily on stations outside of the park units for their weather and climate data.

This is particularly true for the NCRN park units in the greater Washington metropolitan area. Fortunately, there are numerous manual and automated weather/climate stations around most of these NCRN park units, due to their urban setting. Many of SAO stations at the major airports in the region, such as Reagan National Airport, provide reliable data going back to the early twentieth century and now provide real-time data for the region. Due to its location in the more-populated areas in the eastern U.S., the NCRN is surrounded by many long-term climate stations, including several stations with data records that go back to the 1800s. These stations provide valuable records for the NCRN. We advise the continued operation of any such sites that are located within NCRN park boundaries.

There are some NCRN park units with no current weather/climate stations, for which the addition of weather/climate stations could be considered. Both ROCR and PRWI are located within the urban setting of the Washington metropolitan area. These two park units encompass lands that will have either very limited or no further urban development for years to come. The placement of stations within these parks would allow for future climate trends to be monitored in relatively-protected locations. Due to their protected locations, these sites would be less sensitive to local microclimate changes and more sensitive to climate changes affecting the Washington area in general. Installing an automated station at these park units would include the added benefit of providing near-real-time data for the park units.

5.2. Spatial Variations in Mean Climate

If only a few stations will be emplaced, the primary goal should be overall characterization of the main climate elements (temperature and precipitation and their joint relative, snow). Once these goals are met, additional stations would be best used for two important and somewhat competing purposes: (a) add redundancy as backup for loss of data from current stations (or loss of the physical stations) or (b) provide added information on spatial heterogeneity in climate arising from topographic diversity.

5.3. Climate Change Detection

The desire for credible, accurate, complete, and long-term climate records—from any location—cannot be overemphasized. Thus, this consideration always should have a high priority. However, because of spatial diversity in climate, monitoring that fills knowledge gaps and provides information on long-term temporal variability in short-distance relationships also will be valuable. We cannot be sure that climate variability and climate change will affect all parts of a given park unit equally. In fact, it is appropriate to speculate that this is not the case, and spatial variations in temporal variability extend to small spatial scales (a few kilometers or less in some cases).

The NCRN region has experienced extensive urbanization over the past several decades. This urbanization is still occurring, with corresponding impacts on the natural systems of the NCRN. Weather/climate stations within those NCRN park units that are protected from further urban development provide ideal locations for monitoring climate changes due to future urbanization and other human impacts in the NCRN.

5.4. Aesthetics

This issue arises frequently enough to deserve comment. Standards for quality climate measurements require open exposures away from heat sources, buildings, pavement, close vegetation and tall trees, and human intrusion (thus away from property lines). By their nature, sites that meet these standards are usually quite visible. In many settings (such as heavily forested areas) these sites also are quite rare, making them precisely the same places that managers wish to protect from aesthetic intrusion. The most suitable and scientifically defensible sites frequently are rejected as candidate locations for weather/climate stations. Most weather/climate stations, therefore, tend to be "hidden" but many of these hidden locations have inferior exposures. Some measure of compromise is nearly always called for in siting weather and climate stations.

The public has vast interest and curiosity in weather and climate, and within the NPS I&M networks, such measurements consistently rate near or at the top of desired public information. There seem to be many possible opportunities for exploiting and embracing this widespread interest within the interpretive mission of the NPS. One way to do this would be to highlight rather than hide these stations and educate the public about the need for adequate siting. A number of weather displays we have encountered during visits have proven inadvertently to serve as counterexamples for how measurements should not be made.

5.5. Information Access

Access to information promotes its use, which in turn promotes attention to station care and maintenance, better data, and more use. An end-to-end view that extends from sensing to decision support is far preferable to isolated and disconnected activities and aids the support infrastructure that is ultimately so necessary for successful, long-term climate monitoring.

Decisions about improvements in monitoring capacity are facilitated greatly by the ability to examine available climate information. Various methods are being created at WRCC to improve access to that information. Web pages providing historic and ongoing climate data, and information from NCRN park units can be accessed at http://www.wrcc.dri.edu/nps. In the event that this URL changes, there still will be links from the main WRCC Web page entitled "Projects" under NPS.

The WRCC has been steadily developing software to summarize data from hourly sites. This has been occurring under the aegis of the RAWS program and a growing array of product generators ranging from daily and monthly data lists to wind roses and hourly frequency distributions. All park data are available to park personnel via an access code (needed only for data listings) that can be acquired by request. The WRCC RAWS Web page is located at http://www.wrcc.dri.edu/wraws or http://www.raws.dri.edu.

Web pages have been developed to provide access not only to historic and ongoing climate data and information from NCRN park units but also to climate-monitoring efforts for NCRN. These pages can be found through http://www.wrcc.dri.edu/nps.

Additional access to more standard climate information is accessible though the previously mentioned Web pages, as well as through http://www.wrcc.dri.edu/summary. These summaries are generally for COOP stations.

5.6. Summarized Conclusions and Recommendations

- Much of original natural system in the NCRN (forests, riparian/wetland areas) has been impacted by human influences such as urbanization.
- Most NCRN park units are surrounded by numerous long-term climate stations and real-time weather/climate stations.
- Records from several long-term stations in the NCRN go back to the 1800s, providing valuable data for monitoring climate changes associated with urbanization and other human impacts on the NCRN.
- Some NCRN park units in the greater Washington area that currently have no weather/climate stations, such as PRWI and ROCR, are largely protected from further urban development and thus provide ideal locations for installing new stations that can monitor future climate changes.

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Appendix A. Climate-monitoring principles.

Since the late 1990s, frequent references have been made to a set of climate-monitoring principles enunciated in 1996 by Tom Karl, director of the NOAA NCDC in Asheville, North Carolina. These monitoring principles also have been referred to informally as the "Ten Commandments of Climate Monitoring." Both versions are given here. In addition, these principles have been adopted by the Global Climate Observing System (GCOS 2004).

(Compiled by Kelly Redmond, Western Regional Climate Center, Desert Research Institute, August 2000.)

A.1. Full Version (Karl et al. 1996)

A. Effects on climate records of instrument changes, observing practices, observation locations, sampling rates, etc., must be known before such changes are implemented. This can be ascertained through a period where overlapping measurements from old and new observing systems are collected or sometimes by comparing the old and new observing systems with a reference standard. Site stability for in situ measurements, both in terms of physical location and changes in the nearby environment, also should be a key criterion in site selection. Thus, many synoptic network stations, which are primarily used in weather forecasting but also provide valuable climate data, and dedicated climate stations intended to be operational for extended periods must be subject to this policy.

B. Processing algorithms and changes in these algorithms must be well documented. Documentation should be carried with the data throughout the data-archiving process.

C. Knowledge of instrument, station, and/or platform history is essential for interpreting and using the data. Changes in instrument sampling time, local environmental conditions for in situ measurements, and other factors pertinent to interpreting the observations and measurements should be recorded as a mandatory part in the observing routine and be archived with the original data.

D. In situ and other observations with a long, uninterrupted record should be maintained. Every effort should be applied to protect the data sets that have provided long-term, homogeneous observations. "Long-term" for space-based measurements is measured in decades, but for more conventional measurements, "long-term" may be a century or more. Each element in the observational system should develop a list of prioritized sites or observations based on their contribution to long-term climate monitoring.

E. Calibration, validation, and maintenance facilities are critical requirements for long-term climatic data sets. Homogeneity in the climate record must be assessed routinely, and corrective action must become part of the archived record.

F. Where feasible, some level of "low-technology" backup to "high-technology" observing systems should be developed to safeguard against unexpected operational failures.

G. Regions having insufficient data, variables and regions sensitive to change, and key measurements lacking adequate spatial and temporal resolution should be given the highest priority in designing and implementing new climate-observing systems.

H. Network designers and instrument engineers must receive long-term climate requirements at the outset of the network design process. This is particularly important because most observing systems have been designed for purposes other than long-term climate monitoring. Instruments must possess adequate accuracy with biases small enough to document climate variations and changes.

I. Much of the development of new observational capabilities and the evidence supporting the value of these observations stem from research-oriented needs or programs. A lack of stable, long-term commitment to these observations and lack of a clear transition plan from research to operations are two frequent limitations in the development of adequate, long-term monitoring capabilities. Difficulties in securing a long-term commitment must be overcome in order to improve the climate-observing system in a timely manner with minimal interruptions.

J. Data management systems that facilitate access, use, and interpretation are essential. Freedom of access, low cost, mechanisms that facilitate use (directories, catalogs, browse capabilities, availability of metadata on station histories, algorithm accessibility and documentation, etc.) and quality control should guide data management. International cooperation is critical for successful management of data used to monitor long-term climate change and variability.

A.2. Abbreviated version, “Ten Commandments of Climate Monitoring”

A. Assess the impact of new climate-observing systems or changes to existing systems before they are implemented.

“Thou shalt properly manage network change.” (assess effects of proposed changes)

B. Require a suitable period where measurement from new and old climate-observing systems will overlap.

“Thou shalt conduct parallel testing.” (compare old and replacement systems)

C. Treat calibration, validation, algorithm-change, and data-homogeneity assessments with the same care as the data.

"Thou shalt collect metadata." (fully document system and operating procedures)

D. Verify capability for routinely assessing the quality and homogeneity of the data including high-resolution data for extreme events.

“Thou shalt assure data quality and continuity.” (assess as part of routine operating procedures)

E. Integrate assessments like those conducted by the International Panel on Climate Change into global climate-observing priorities.

“Thou shalt anticipate the use of data.” (integrated environmental assessment; component in operational plan for system)

F. Maintain long-term weather and climate stations.

“Thou shalt worship historic significance.” (maintain homogeneous data sets from long–term, climate-observing systems)

G. Place high priority on increasing observations in regions lacking sufficient data and in regions sensitive to change and variability.

"Thou shalt acquire complementary data." (new sites to fill observational gaps)

H. Provide network operators, designers, and instrument engineers with long-term requirements at the outset of the design and implementation phases for new systems.

“Thou shalt specify requirements for climate observation systems.” (application and usage of observational data)

I. Carefully consider the transition from research-observing system to long-term operation.

“Thou shalt have continuity of purpose.” (stable long-term commitments)

J. Focus on data-management systems that facilitate access, use, and interpretation of weather data and metadata.

“Thou shalt provide access to data and metadata.” (readily-available weather and climate information)

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Appendix B. Glossary.

Climate—Complete and entire ensemble of statistical descriptors of temporal and spatial properties comprising the behavior of the atmosphere. These descriptors include means, variances, frequency distributions, autocorrelations, spatial correlations and other patterns of association, temporal lags, and element-to-element relationships. The descriptors have a physical basis in flows and reservoirs of energy and mass. Climate and weather phenomena shade gradually into each other and are ultimately inseparable.

Climate Element—(same as Weather Element) Attribute or property of the state of the atmosphere that is measured, estimated, or derived. Examples of climate elements include temperature, wind speed, wind direction, precipitation amount, precipitation type, relative humidity, dewpoint, solar radiation, snow depth, soil temperature at a given depth, etc. A derived element is a function of other elements (like degree days or number of days with rain) and is not measured directly with a sensor. The terms “parameter” or “variable” are not used to describe elements.

Climate Network—Group of climate stations having a common purpose; the group is often owned and maintained by a single organization.

Climate Station—Station where data are collected to track atmospheric conditions over the long-term. Often, this station operates to additional standards to verify long-term consistency. For these stations, the detailed circumstances surrounding a set of measurements (siting and exposure, instrument changes, etc.) are important.

Data—Measurements specifying the state of the physical environment. Does not include metadata.

Data Inventory—Information about overall data properties for each station within a weather or climate network. A data inventory may include start/stop dates, percentages of available data, breakdowns by climate element, counts of actual data values, counts or fractions of data types, etc. These properties must be determined by actually reading the data and thus require the data to be available, accessible, and in a readable format.

NPS I&M Network—A set of NPS park units grouped by a common theme, typically by natural resource and/or geographic region.

Metadata—Information necessary to interpret environmental data properly, organized as a history or series of snapshots—data about data. Examples include details of measurement processes, station circumstances and exposures, assumptions about the site, network purpose and background, types of observations and sensors, pre-treatment of data, access information, maintenance history and protocols, observational methods, archive locations, owner, and station start/end period.

Quality Assurance—Planned and systematic set of activities to provide adequate confidence that products and services are resulting in credible and correct information. Includes quality control.

Quality Control—Evaluation, assessment, and improvement of imperfect data by utilizing other imperfect data.

Station Inventory—Information about a set of stations obtained from metadata that accompany the network or networks. A station inventory can be compiled from direct and indirect reports prepared by others.

Weather—Instantaneous state of the atmosphere at any given time, mainly with respect to its effects on biological activities. As distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, precipitation, humidity, wind, sky condition, visibility, and cloud conditions.

Weather Element (same as Climate Element)—Attribute or property of the state of the atmosphere that is measured, estimated, or derived. Examples of weather elements include temperature, wind speed, wind direction, precipitation amount, precipitation type, relative humidity, dewpoint, solar radiation, snow depth, soil temperature at a given depth, etc. A derived weather element is a function of other elements (like degree days or number of days with rain) and is not measured directly. The terms “parameter” and “variable” are not used to describe weather elements.

Weather Network—Group of weather stations usually owned and maintained by a particular organization and usually for a specific purpose.

Weather Station—Station where collected data are intended for near-real-time use with less need for reference to long-term conditions. In many cases, the detailed circumstances of a set of measurements (siting and exposure, instrument changes, etc.) from weather stations are not as important as for climate stations.

Appendix C. Factors in operating a climate network.

C.1. Climate versus Weather

- Climate measurements require *consistency through time.*

C.2. Network Purpose

- Anticipated or desired lifetime.
- Breadth of network mission (commitment by needed constituency).
- Dedicated constituency—no network survives without a dedicated constituency.

C.3. Site Identification and Selection

- Spanning gradients in climate or biomes with transects.
- Issues regarding representative spatial scale—site uniformity versus site clustering.
- Alignment with and contribution to network mission.
- Exposure—ability to measure representative quantities.
- Logistics—ability to service station (Always or only in favorable weather?).
- Site redundancy (positive for quality control, negative for extra resources).
- Power—is AC needed?
- Site security—is protection from vandalism needed?
- Permitting often a major impediment and usually underestimated.

C.4. Station Hardware

- Survival—weather is the main cause of lost weather/climate data.
- Robustness of sensors—ability to measure and record in any condition.
- Quality—distrusted records are worthless and a waste of time and money.
  - High quality—will cost up front but pays off later.
  - Low quality—may provide a lower start-up cost but will cost more later (low cost can be expensive).
- Redundancy—backup if sensors malfunction.
- Ice and snow—measurements are much more difficult than rain measurements.
- Severe environments (expense is about two–three times greater than for stations in more benign settings).

C.5. Communications

- Reliability—live data have a much larger constituency.
- One-way or two-way.
  - Retrieval of missed transmissions.
  - Ability to reprogram data logger remotely.
  - Remote troubleshooting abilities.
  - Continuing versus one-time costs.
- Back-up procedures to prevent data loss during communication outages.
- Live communications increase problems but also increase value.

C.6. Maintenance

- Main reason why networks fail (and most networks do eventually fail!).

- Key issue with nearly every network.
- Who will perform maintenance?
- Degree of commitment and motivation to contribute.
- Periodic? On-demand as needed? Preventive?
- Equipment change-out schedules and upgrades for sensors and software.
- Automated stations require skilled and experienced labor.
- Calibration—sensors often drift (climate).
- Site maintenance essential (constant vegetation, surface conditions, nearby influences).
- Typical automated station will cost about $2K per year to maintain.
- Documentation—photos, notes, visits, changes, essential for posterity.
- Planning for equipment life cycle and technological advances.

C.7. Maintaining Programmatic Continuity and Corporate Knowledge

- Long-term vision and commitment needed.
- Institutionalizing versus personalizing—developing appropriate dependencies.

C.8. Data Flow

- Centralized ingest?
- Centralized access to data and data products?
- Local version available?
- Contract out work or do it yourself?
- Quality control of data.
- Archival.
- Metadata—historic information, not a snapshot. Every station should collect metadata.
- Post-collection processing, multiple data-ingestion paths.

C.9. Products

- Most basic product consists of the data values.
- Summaries.
- Write own applications or leverage existing mechanisms?

C.10. Funding

- Prototype approaches as proof of concept.
- Linking and leveraging essential.
- Constituencies—every network needs a constituency.
- Bridging to practical and operational communities? Live data needed.
- Bridging to counterpart research efforts and initiatives—funding source.
- Creativity, resourcefulness, and persistence usually are essential to success.

C.11. Final Comments

- Deployment is by far the easiest part in operating a network.
- Maintenance is the main issue.
- Best analogy: Operating a network is like raising a child; it requires constant attention.

Source: Western Regional Climate Center (WRCC)

Appendix D. Master metadata field list.

Field Name	Field Type	Field Description
begin_date	date	Effective beginning date for a record.
begin_date_flag	char(2)	Flag describing the known accuracy of the begin date for a station.
best_elevation	float(4)	Best known elevation for a station (in feet).
clim_div_code	char(2)	Foreign key defining climate division code (primary in table: clim_div).
clim_div_key	int2	Foreign key defining climate division for a station (primary in table: clim_div.
clim_div_name	varchar(30)	English name for a climate division.
controller_info	varchar(50)	Person or organization who maintains the identifier system for a given weather or climate network.
country_key	int2	Foreign key defining country where a station resides (primary in table: none).
county_key	int2	Foreign key defining county where a station resides (primary in table: county).
county_name	varchar(31)	English name for a county.
description	text	Any description pertaining to the particular table.
end_date	date	Last effective date for a record.
end_date_flag	char(2)	Flag describing the known accuracy of station end date.
fips_country_code	char(2)	FIPS (Federal Information Processing Standards) country code.
fips_state_abbr	char(2)	FIPS state abbreviation for a station.
fips_state_code	char(2)	FIPS state code for a station.
history_flag	char(2)	Describes temporal significance of an individual record among others from the same station.
id_type_key	int2	Foreign key defining the id_type for a station (usually defined in code).
last_updated	date	Date of last update for a record.
latitude	float(8)	Latitude value.
longitude	float(8)	Longitude value.
name_type_key	int2	“3”: COOP station name, “2”: best station name.
name	varchar(30)	Station name as known at date of last update entry.
ncdc_state_code	char(2)	NCDC, two-character code identifying U.S. state.
network_code	char(8)	Eight-character abbreviation code identifying a network.
network_key	int2	Foreign key defining the network for a station (primary in table: network).
network_station_id	int4	Identifier for a station in the associated network, which is defined by id_type_key.
remark	varchar(254)	Additional information for a record.
src_quality_code	char(2)	Code describing the data quality for the data source.
state_key	int2	Foreign key defining the U.S. state where a station resides (primary in table: state).
state_name	varchar(30)	English name for a state.
station_alt_name	varchar(30)	Other English names for a station.
station_best_name	varchar(30)	Best, most well-known English name for a station.
time_zone	float4	Time zone where a station resides.
ucan_station_id	int4	Unique station identifier for every station in ACIS.
unit_key	int2	Integer value representing a unit of measure.

Field Name	Field Type	Field Description
updated_by	char(8)	Person who last updated a record.
var_major_id	int2	Defines major climate variable.
var_minor_id	int2	Defines data source within a var_major_id.
zipcode	char(5)	Zipcode where a latitude/longitude point resides.
nps_netcode	char(4)	Network four-character identifier.
nps_netname	varchar(128)	Displayed English name for a network.
parkcode	char(4)	Park four-character identifier.
parkname	varchar(128)	Displayed English name for a park/
im_network	char(4)	NPS I&M network where park belongs (a net code)/
station_id	varchar(16)	Station identifier.
station_id_type	varchar(16)	Type of station identifier.
network.subnetwork.id	varchar(16)	Identifier of a sub-network in associated network.
subnetwork_key	int2	Foreign key defining sub-network for a station.
subnetwork_name	varchar(30)	English name for a sub-network.
slope	integer	Terrain slope at the location.
aspect	integer	Terrain aspect at the station.
gps	char(1)	Indicator of latitude/longitude recorded via GPS (global positioning system).
site_description	text(0)	Physical description of site.
route_directions	text(0)	Driving route or site access directions.
station_photo_id	integer	Unique identifier associating a group of photos to a station. Group of photos all taken on same date.
photo_id	char(30)	Unique identifier for a photo.
photo_date	datetime	Date photograph taken.
photographer	varchar(64)	Name of photographer.
maintenance_date	datetime	Date of station maintenance visit.
contact_key	Integer	Unique identifier associating contact information to a station.
full_name	varchar(64)	Full name of contact person.
organization	varchar(64)	Organization of contact person.
contact_type	varchar(32)	Type of contact person (operator, administrator, etc.)
position_title	varchar(32)	Title of contact person.
address	varchar(32)	Address for contact person.
city	varchar(32)	City for contact person.
state	varchar(2)	State for contact person.
zip_code	char(10)	Zipcode for contact person.
country	varchar(32)	Country for contact person.
email	varchar(64)	E-mail for contact person.
work_phone	varchar(16)	Work phone for contact person.
contact_notes	text(254)	Other details regarding contact person.
equipment_type	char(30)	Sensor measurement type; i.e., wind speed, air temperature, etc.
eq_manufacturer	char(30)	Manufacturer of equipment.
eq_model	char(20)	Model number of equipment.
serial_num	char(20)	Serial number of equipment.
eq_description	varchar(254)	Description of equipment.
install_date	datetime	Installation date of equipment.
remove_date	datetime	Removal date of equipment.
ref_height	integer	Sensor displacement height from surface.
sampling_interval	varchar(10)	Frequency of sensor measurement.

Appendix E. General design considerations for weather/ climate-monitoring programs.

The process for designing a climate-monitoring program benefits from anticipating design and protocol issues discussed here. Much of this material is been excerpted from a report addressing the Channel Islands National Park (Redmond and McCurdy 2005), where an example is found illustrating how these factors can be applied to a specific setting. Many national park units possess some climate or meteorology feature that sets them apart from more familiar or “standard” settings.

E.1. Introduction

There are several criteria that must be used in deciding to deploy new stations and where these new stations should be sited.

- Where are existing stations located?
- Where have data been gathered in the past (discontinued locations)?
- Where would a new station fill a knowledge gap about basic, long-term climatic averages for an area of interest?
- Where would a new station fill a knowledge gap about how climate behaves over time?
- As a special case for behavior over time, what locations might be expected to show a more sensitive response to climate change?
- How do answers to the preceding questions depend on the climate element? Are answers the same for precipitation, temperature, wind, snowfall, humidity, etc.?
- What role should manual measurements play? How should manual measurements interface with automated measurements?
- Are there special technical or management issues, either present or anticipated in the next 5–15 years, requiring added climate information?
- What unique information is provided in addition to information from existing sites? “Redundancy is bad.”
- What nearby information is available to estimate missing observations because observing systems always experience gaps and lose data? “Redundancy is good.”
- How would logistics and maintenance affect these decisions?

In relation to the preceding questions, there are several topics that should be considered. The following topics are not listed in a particular order.

E.1.1. Network Purpose

Humans seem to have an almost reflexive need to measure temperature and precipitation, along with other climate elements. These reasons span a broad range from utilitarian to curiosity-driven. Although there are well-known recurrent patterns of need and data use, new uses are always appearing. The number of uses ranges in the thousands. Attempts have been made to categorize such uses (see NRC 1998; NRC 2001). Because climate measurements are accumulated over a long time, they should be treated as multi-purpose and should be undertaken in a manner that serves the widest possible applications. Some applications remain constant, while others rise and fall in importance. An insistent issue today may subside, while the next pressing issue of tomorrow barely may be anticipated. The notion that humans might affect the climate of the entire Earth was nearly unimaginable when the national USDA (later NOAA) cooperative weather network began in the late 1800s. Abundant experience has shown, however, that there always will be a demand for a history record of climate measurements and their properties. Experience also shows that there is an expectation that climate measurements will be taken and made available to the general public.

An exhaustive list of uses for data would fill many pages and still be incomplete. In broad terms, however, there are needs to document environmental conditions that disrupt or otherwise affect park operations (e.g., storms and droughts). Design and construction standards are determined by climatological event frequencies that exceed certain thresholds. Climate is a determinant that sometimes attracts and sometimes discourages visitors. Climate may play a large part in the park experience (e.g., Death Valley and heat are nearly synonymous). Some park units are large enough to encompass spatial or elevation diversity in climate, and the sequence of events can vary considerably inside or close to park boundaries. That is, temporal trends and statistics may not be the same everywhere, and this spatial structure should be sampled. The granularity of this structure depends on the presence of topography or large climate gradients or both, such as that found along the U.S. West Coast in summer with the rapid transition from the marine layer to the hot interior.

Plant and animal communities and entire ecosystems react to every nuance in the physical environment. No aspect of weather and climate goes undetected in the natural world. Wilson (1998) proposed “an informal rule of biological evolution” that applies here: “If an organic sensor can be imagined that is capable of detecting any particular environmental signal, a species exists somewhere that possesses this sensor.” Every weather and climate event, whether dull or extraordinary to humans, matters to some organism. Dramatic events and creeping incremental change both have consequences to living systems. Extreme events or disturbances can “reset the clock” or “shake up the system” and lead to reverberations that last for years to centuries or longer. Slow change can carry complex nonlinear systems (e.g., any living assemblage) into states where chaotic transitions and new behavior occur. These changes are seldom predictable, typically are observed after the fact, and understood only in retrospect. Climate changes may not be exciting, but as a well-known atmospheric scientist, Mike Wallace, from the University of Washington once noted, “subtle does not mean unimportant”.

Thus, individuals who observe the climate should be able to record observations accurately and depict both rapid and slow changes. In particular, an array of artificial influences easily can confound detection of slow changes. The record as provided can contain both real climate variability (that took place in the atmosphere) and fake climate variability (that arose directly from the way atmospheric changes were observed and recorded). As an example, trees growing near a climate station with an excellent anemometer will make it appear that the wind gradually slowed down over many years. Great care must be taken to protect against sources of fake climate variability on the longer-time scales of years to decades. Processes leading to the observed climate are not stationary; rather these processes draw from probability distributions that vary with time. For this reason, climatic time series do not exhibit statistical stationarity. The implications are manifold. There are no true climatic “normals” to which climate inevitably must return. Rather, there are broad ranges of climatic conditions. Climate does not demonstrate exact repetition but instead continual fluctuation and sometimes approximate repetition. In addition, there is always new behavior waiting to occur. Consequently, the business of climate monitoring is never finished, and there is no point where we can state confidently that "enough" is known.

E.1.2. Robustness

The most frequent cause for loss of weather data is the weather itself, the very thing we wish to record. The design of climate and weather observing programs should consider the meteorological equivalent of "peaking power" employed by utilities. Because environmental disturbances have significant effects on ecologic systems, sensors, data loggers, and communications networks should be able to function during the most severe conditions that realistically can be anticipated over the next 50–100 years. Systems designed in this manner are less likely to fail under more ordinary conditions, as well as more likely to transmit continuous, quality data for both tranquil and active periods.

E.1.3. Weather versus Climate

For "weather" measurements, pertaining to what is approximately happening here and now, small moves and changes in exposure are not as critical. For "climate" measurements, where values from different points in time are compared, siting and exposure are critical factors, and it is vitally important that the observing circumstances remain essentially unchanged over the duration of the station record.

Station moves can affect different elements to differing degrees. Even small moves of several meters, especially vertically, can affect temperature records. Hills and knolls act differently from the bottoms of small swales, pockets, or drainage channels (Geiger et al. 2003; Whiteman 2000). Precipitation is probably less subject to change with moves of 50–100 m than other elements (that is, precipitation has less intrinsic variation in small spaces) except if wind flow over the gauge is affected.

E.1.4. Physical Setting

Siting and exposure, and their continuity and consistency through time, significantly influence the climate records produced by a station. These two terms have overlapping connotations. We use the term "siting" in a more general sense, reserving the term "exposure" generally for the particular circumstances affecting the ability of an instrument to record measurements that are representative of the desired spatial or temporal scale.

E.1.5. Measurement Intervals

Climatic processes occur continuously in time, but our measurement systems usually record in discrete chunks of time: for example, seconds, hours, or days. These measurements often are referred to as "systematic" measurements. Interval averages may hide active or interesting periods of highly intense activity. Alternatively, some systems record "events" when a certain threshold of activity is exceeded (examples: another millimeter of precipitation has fallen, another kilometer of wind has moved past, the temperature has changed by a degree, a gust higher than 9.9 m/s has been measured). When this occurs, measurements from all sensors are reported. These measurements are known as “breakpoint” data. In relatively unchanging conditions (long calm periods or rainless weeks, for example), event recorders should send a signal that they are still “alive and well.” If systematic recorders are programmed to note and periodically report the highest, lowest, and mean value within each time interval, the likelihood is reduced that interesting behavior will be glossed over or lost. With the capacity of modern data loggers, it is recommended to record and report extremes within the basic time increment (e.g., hourly or 10 minutes). This approach also assists quality-control procedures.

There is usually a trade-off between data volume and time increment, and most automated systems now are set to record approximately hourly. A number of field stations maintained by WRCC are programmed to record in 5- or 10-minute increments, which readily serve to construct an hourly value. However, this approach produces 6–12 times as much data as hourly data. These systems typically do not record details of events at sub-interval time scales, but they easily can record peak values, or counts of threshold exceedance, within the time intervals.

Thus, for each time interval at an automated station, we recommend that several kinds of information—mean or sum, extreme maximum and minimum, and sometimes standard deviation—be recorded. These measurements are useful for quality control and other purposes. Modern data loggers and office computers have quite high capacity. Diagnostic information indicating the state of solar chargers or battery voltages and their extremes is of great value. This topic will be discussed in greater detail in a succeeding section.

Automation also has made possible adaptive or intelligent monitoring techniques where systems vary the recording rate based on detection of the behavior of interest by the software. Sub-interval behavior of interest can be masked on occasion (e.g., a 5-minute extreme downpour with high-erosive capability hidden by an innocuous hourly total). Most users prefer measurements that are systematic in time because they are much easier to summarize and manipulate.

For breakpoint data produced by event reporters, there also is a need to send periodically a signal that the station is still functioning, even though there is nothing more to report. “No report” does not necessarily mean “no data,” and it is important to distinguish between the actual observation that was recorded and the content of that observation (e.g., an observation of “0.00” is not the same as “no observation”).

E.1.6. Mixed Time Scales

There are times when we may wish to combine information from radically different scales. For example, over the past 100 years we may want to know how the frequency of 5-minute precipitation peaks has varied or how the frequency of peak 1-second wind gusts have varied. We may also want to know over this time if nearby vegetation gradually has grown up to increasingly block the wind or to slowly improve precipitation catch. Answers to these questions require knowledge over a wide range of time scales.

E.1.7. Elements

For manual measurements, the typical elements recorded included temperature extremes, precipitation, and snowfall/snow depth. Automated measurements typically include temperature, precipitation, humidity, wind speed and direction, and solar radiation. An exception to this exists in very windy locations where precipitation is difficult to measure accurately. Automated measurements of snow are improving, but manual measurements are still preferable, as long as shielding is present. Automated measurement of frozen precipitation presents numerous challenges that have not been resolved fully, and the best gauges are quite expensive ($3–8K). Soil temperatures also are included sometimes. Soil moisture is extremely useful, but measurements are not made at many sites. In addition, care must be taken in the installation and maintenance of instruments used in measuring soil moisture. Soil properties vary tremendously in short distances as well, and it is often very difficult (“impossible”) to accurately document these variations (without digging up all the soil!). In cooler climates, ultrasonic sensors that detect snow depth are becoming commonplace.

E.1.8. Wind Standards

Wind varies the most in the shortest distance, since it always decreases to zero near the ground and increases rapidly (approximately logarithmically) with height near the ground. Changes in anemometer height obviously will affect distribution of wind speed as will changes in vegetation, obstructions such as buildings, etc. A site that has a 3-m (10-ft) mast clearly will be less windy than a site that has a 6-m (20-ft) or 10-m (33-ft) mast. Historically, many U.S. airports (FAA and NWS) and most current RAWS sites have used a standard 6-m (20-ft) mast for wind measurements. Some NPS RAWS sites utilize shorter masts. Over the last decade, as Automated Surface Observing Systems (ASOSs, mostly NWS) and Automated Weather Observing Systems (AWOSs, mostly FAA) have been deployed at most airports, wind masts have been raised to 8 or 10 m (26 or 33 ft), depending on airplane clearance. The World Meteorological Organization recommends 10 m as the height for wind measurements (WMO 1983; 2005), and more groups are migrating slowly to this standard. The American Association of State Climatologists (AASC 1985) have recommended that wind be measured at 3 m, a standard geared more for agricultural applications than for general purpose uses where higher levels usually are preferred. Different anemometers have different starting thresholds; therefore, areas that frequently experience very light winds may not produce wind measurements thus affecting long-term mean estimates of wind speed. For both sustained winds (averages over a short interval of 2–60 minutes) and especially for gusts, the duration of the sampling interval makes considerable difference. For the same wind history, 1–second gusts are higher than gusts averaging 3 seconds, which in turn are greater than 5-second averages, so that the same sequence would be described with different numbers (all three systems and more are in use). Changes in the averaging procedure, or in height or exposure, can lead to “false” or “fake” climate change with no change in actual climate. Changes in any of these should be noted in the metadata.

E.1.9. Wind Nomenclature

Wind is a vector quantity having a direction and a speed. Directions can be two- or three-dimensional; they will be three-dimensional if the vertical component is important. In all common uses, winds always are denoted by the direction they blow *from* (north wind or southerly breeze). This convention exists because wind often brings weather, and thus our attention is focused upstream. However, this approach contrasts with the way ocean currents are viewed. Ocean currents usually are denoted by the direction they are moving *towards* (eastward current moves from west to east). In specialized applications (such as in atmospheric modeling), wind velocity vectors point in the direction that the wind is blowing. Thus, a southwesterly wind (from the southwest) has both northward and eastward (to the north and to the east) components. Except near mountains, wind cannot blow up or down near the ground, so the vertical component of wind often is approximated as zero, and the horizontal component is emphasized.

E.1.10. Frozen Precipitation

Frozen precipitation is more difficult to measure than liquid precipitation, especially with automated techniques. Goodison et al. (1998), Sevruk and Harmon (1984), and Yang et al. (1998, 2001) provide many of the reasons to explain this. The importance of frozen precipitation varies greatly from one setting to another. This subject was discussed in greater detail in a related inventory and monitoring report for the Alaska park units (Redmond et al. 2005).

In climates that receive frozen precipitation, a decision must be made whether or not to try to record such events accurately. This usually means that the precipitation must be turned into liquid either by falling into an antifreeze fluid solution that is then weighed or by heating the precipitation enough to melt and fall through a measuring mechanism such as a nearly-balanced tipping bucket. Accurate measurements from the first approach require expensive gauges; tipping buckets can achieve this resolution readily but are more apt to lose some or all precipitation. Improvements have been made to the heating mechanism on the NWS tipping-bucket gauge used for the ASOS to correct its numerous deficiencies making it less problematic; however, this gauge is not inexpensive. A heat supply needed to melt frozen precipitation usually requires more energy than renewable energy (solar panels or wind recharging) can provide thus AC power is needed. The availability of AC power is severely limited in many cold or remote U. S. settings. Furthermore, periods of frozen precipitation or rime often provide less-than-optimal recharging conditions with heavy clouds, short days, low-solar-elevation angles and more horizon blocking, and cold temperatures causing additional drain on the battery.

E.1.11. Save or Lose

A second consideration with precipitation is determining if the measurement should be saved (as in weighing systems) or lost (as in tipping-bucket systems). With tipping buckets, after the water has passed through the tipping mechanism, it usually just drops to the ground. Thus, there is no checksum to ensure that the sum of all the tips adds up to what has been saved in a reservoir at some location. By contrast, the weighing gauges continually accumulate until the reservoir is emptied, the reported value is the total reservoir content (for example, the height of the liquid column in a tube), and the incremental precipitation is the difference in depth between two known times. These weighing gauges do not always have the same fine resolution. Some gauges only record to the nearest centimeter, which is usually acceptable for hydrology but not necessarily for other needs. (For reference, a millimeter of precipitation can get a person in street clothes quite wet.) This is how the NRCS/USDA Snowfall Telemetry (SNOTEL) system works in climates that measure up to 3000 cm of snow in a winter. (See http://www.wcc.nrcs.usda.gov/publications for publications or http://www.wcc.nrcs.usda.gov/factpub/aib536.html for a specific description.) No precipitation is lost this way. A thin layer of oil is used to suppress evaporation, and anti-freeze ensures that frozen precipitation melts. When initially recharged, the sum of the oil and starting antifreeze solution is treated as the zero point. The anti-freeze usually is not sufficiently environmentally friendly to discharge to the ground and thus must be hauled into the area and then back out. Other weighing gauges are capable of measuring to the 0.25-mm (0.01-in.) resolution but do not have as much capacity and must be emptied more often. Day/night and storm-related thermal expansion and contraction and sometimes wind shaking can cause fluid pressure from accumulated totals to go up and down in SNOTEL gauges by small increments (commonly 0.3-3 cm, or 0.01–0.10 ft) leading to "negative precipitation" followed by similarly non-real light precipitation when, in fact, no change took place in the amount of accumulated precipitation.

E.1.12. Time

Time should always be in local standard time (LST), and daylight savings time (DST) should never be used under any circumstances with automated equipment and timers. Using DST leads to one duplicate hour, one missing hour, and a season of displaced values, as well as needless confusion and a data-management nightmare. Absolute time, such as Greenwich Mean Time (GMT) or Coordinated Universal Time (UTC), also can be used because these formats are unambiguously translatable. Since measurements only provide information about what already *has* occurred or *is* occurring and not what *will* occur, they should always be assigned to the *ending time* of the associated interval with hour 24 marking the end of the last hour of the day. In this system, midnight always represents the end of the day, not the start. To demonstrate the importance of this differentiation, we have encountered situations where police officers seeking corroborating weather data could not recall whether the time on their crime report from a year ago was the starting midnight or the ending midnight! Station positions should be known to within a few meters, easily accomplished with GPS, so that time zones and solar angles can be determined accurately.

E.1.13. Automated versus Manual

Most of this report has addressed automated measurements. Historically, most measurements are manual and typically collected once a day. In many cases, manual measurements continue because of habit, usefulness, and desire for continuity over time. Manual measurements are extremely useful and when possible should be encouraged. However, automated measurements are becoming more common. For either, it is important to record time in a logically consistent manner.

It should not be automatically assumed that newer data and measurements are "better" than older data or that manual data are "worse" than automated data. Older or simpler manual measurements are often of very high quality even if they sometimes are not in the most convenient digital format.

There is widespread desire to use automated systems to reduce human involvement. This is admirable and understandable, but every automated weather/climate station or network requires significant human attention and maintenance. A telling example concerns the Oklahoma Mesonet (see Brock et al. 1995, and bibliography at www.mesonet.ou.edu), a network of about 115 high–quality, automated meteorological stations spread over Oklahoma, where about 80 percent of the annual ($2–3M) budget is nonetheless allocated to humans with only about 20 percent allocated to equipment.

E.1.14. Manual Conventions

Manual measurements typically are made once a day. Elements usually consist of maximum and minimum temperature, temperature at observation time, precipitation, snowfall, snow depth, and sometimes evaporation, wind, or other information. Since it is not actually known when extremes occurred, the only logical approach, and the nationwide convention, is to ascribe the entire measurement to the time-interval date and to enter it on the form in that way. For morning observers (for example, 8 am to 8 am), this means that the maximum temperature written for today often is from yesterday afternoon and sometimes the minimum temperature for the 24-hr period actually occurred yesterday morning. However, this is understood and expected. It is often a surprise to observers to see how many maximum temperatures do not occur in the afternoon and how many minimum temperatures do not occur in the predawn hours. This is especially true in environments that are colder, higher, northerly, cloudy, mountainous, or coastal. As long as this convention is strictly followed every day, it has been shown that truly excellent climate records can result (Redmond 1992). Manual observers should reset equipment only one time per day at the official observing time. Making more than one measurement a day is discouraged strongly; this practice results in a hybrid record that is too difficult to interpret. The only exception is for total daily snowfall. New snowfall can be measured up to four times per day with no observations closer than six hours. It is well known that more frequent measurement of snow increases the annual total because compaction is a continuous process.

Two main purposes for climate observations are to establish the long-term averages for given locations and to track variations in climate. Broadly speaking, these purposes address topics of absolute and relative climate behavior. Once absolute behavior has been “established” (a task that is never finished because long-term averages continue to vary in time)—temporal variability quickly becomes the item of most interest.

E.2. Representativeness

Having discussed important factors to consider when new sites are installed, we now turn our attention to site “representativeness.” In popular usage, we often encounter the notion that a site is “representative” of another site if it receives the same annual precipitation or records the same annual temperature or if some other element-specific, long-term average has a similar value. This notion of representativeness has a certain limited validity, but there are other aspects of this idea that need to be considered.

A climate monitoring site also can be said to be representative if climate records from that site show sufficiently strong temporal correlations with a large number of locations over a sufficiently large area. If station A receives 20 cm a year and station B receives 200 cm a year, these climates obviously receive quite differing amounts of precipitation. However, if their monthly, seasonal, or annual correlations are high (for example, 0.80 or higher for a particular time scale), one site can be used as a surrogate for estimating values at the other if measurements for a particular month, season, or year are missing. That is, a wet or dry month at one station is also a wet or dry month (relative to its own mean) at the comparison station. Note that high correlations on one time scale do not imply automatically that high correlations will occur on other time scales.

Likewise, two stations having similar mean climates (for example, similar annual precipitation) might not co-vary in close synchrony (for example, coastal versus interior). This may be considered a matter of climate “affiliation” for a particular location.

Thus, the representativeness of a site can refer either to the basic climatic averages for a given duration (or time window within the annual cycle) or to the extent that the site co-varies in time with respect to all surrounding locations. One site can be representative of another in the first sense but not the second, or vice versa, or neither, or both—all combinations are possible.

If two sites are perfectly correlated then, in a sense, they are “redundant.” However, redundancy has value because all sites will experience missing data especially with automated equipment in rugged environments and harsh climates where outages and other problems nearly can be guaranteed. In many cases, those outages are caused by the weather, particularly by unusual weather and the very conditions we most wish to know about. Methods for filling in those values will require proxy information from this or other nearby networks. Thus, redundancy is a virtue rather than a vice.

In general, the cooperative stations managed by the NWS have produced much longer records than automated stations like RAWS or SNOTEL stations. The RAWS stations often have problems with precipitation, especially in winter, or with missing data, so that low correlations may be data problems rather than climatic dissimilarity. The RAWS records also are relatively short, so correlations should be interpreted with care. In performing and interpreting such analyses, however, we must remember that there are physical climate reasons and observational reasons why stations within a short distance (even a few tens or hundreds of meters) may not correlate well.

E.2.1. Temporal Behavior

It is possible that high correlations will occur between station pairs during certain portions of the year (i.e., January) but low correlations may occur during other portions of the year (e.g., September or October). The relative contributions of these seasons to the annual total (for precipitation) or average (for temperature) and the correlations for each month are both factors in the correlation of an aggregated time window of longer duration that encompasses those seasons (e.g., one of the year definitions such as calendar year or water year). A complete and careful evaluation ideally would include such a correlation analysis but requires more resources and data. Note that it also is possible and frequently is observed that temperatures are highly correlated while precipitation is not or vice versa, and these relations can change according to the time of year. If two stations are well correlated for all climate elements for all portions of the year, then they can be considered redundant.

With scarce resources, the initial strategy should be to try to identify locations that do not correlate particularly well, so that each new site measures something new that cannot be guessed easily from the behavior of surrounding sites. (An important caveat here is that lack of such correlation could be a result of physical climate behavior and not a result of faults with the actual measuring process; i.e., by unrepresentative or simply poor-quality data. Unfortunately, we seldom have perfect climate data.) As additional sites are added, we usually wish for some combination of unique and redundant sites to meet what amounts to essentially orthogonal constraints: new information and more reliably-furnished information.

A common consideration is whether to observe on a ridge or in a valley, given the resources to place a single station within a particular area of a few square kilometers. Ridge and valley stations will correlate very well for temperatures when lapse conditions prevail, particularly summer daytime temperatures. In summer at night or winter at daylight, the picture will be more mixed and correlations will be lower. In winter at night when inversions are common and even the rule, correlations may be zero or even negative and perhaps even more divergent as the two sites are on opposite sides of the inversion. If we had the luxury of locating stations everywhere, we would find that ridge tops generally correlate very well with other ridge tops and similarly valleys with other valleys, but ridge tops correlate well with valleys only under certain circumstances. Beyond this, valleys and ridges having similar orientations usually will correlate better with each other than those with perpendicular orientations, depending on their orientation with respect to large-scale wind flow and solar angles.

Unfortunately, we do not have stations everywhere, so we are forced to use the few comparisons that we have and include a large dose of intelligent reasoning, using what we have observed elsewhere. In performing and interpreting such analyses, we must remember that there are physical climatic reasons and observational reasons why stations within a short distance (even a few tens or hundreds of meters) may not correlate well.

Examples of correlation analyses include those for the Channel Islands and for southwest Alaska, which can be found in Redmond and McCurdy (2005) and Redmond et al. (2005). These examples illustrate what can be learned from correlation analyses. Spatial correlations generally vary by time of year. Thus, results should be displayed in the form of annual correlation cycles—for monthly mean temperature and monthly total precipitation and perhaps other climate elements like wind or humidity—between station pairs selected for climatic setting and data availability and quality.

In general, the COOP stations managed by the NWS have produced much longer records than have automated stations like RAWS or SNOTEL stations. The RAWS stations also often have problems with precipitation, especially in winter or with missing data, so that low correlations may be data problems rather than climate dissimilarity. The RAWS records are much shorter, so correlations should be interpreted with care, but these stations are more likely to be in places of interest for remote or under-sampled regions.

E.2.2. Spatial Behavior

A number of techniques exist to interpolate from isolated point values to a spatial domain. For example, a common technique is simple inverse distance weighting. Critical to the success of the simplest of such techniques is that some other property of the spatial domain, one that is influential for the mapped element, does not vary significantly. Topography greatly influences precipitation, temperature, wind, humidity, and most other meteorological elements. Thus, this criterion clearly is not met in any region having extreme topographic diversity. In such circumstances, simple Cartesian distance may have little to do with how rapidly correlation deteriorates from one site to the next, and in fact, the correlations can decrease readily from a mountain to a valley and then increase again on the next mountain. Such structure in the fields of spatial correlation is not seen in the relatively (statistically) well-behaved flat areas like those in the eastern United States.

To account for dominating effects such as topography and inland–coastal differences that exist in certain regions, some kind of additional knowledge must be brought to bear to produce meaningful, physically plausible, and observationally based interpolations. Historically, this has proven to be an extremely difficult problem, especially to perform objective and repeatable analyses. An analysis performed for southwest Alaska (Redmond et al. 2005) concluded that the PRISM (Parameter Regression on Independent Slopes Model) maps (Daly et al. 1994; 2002; Gibson et al., 2002; Doggett et al., 2004) were probably the best available. An analysis by Simpson et al. (2005) further discussed many issues in the mapping of Alaska’s climate and resulted in the same conclusion about PRISM.

E.2.3. Climate-Change Detection

Although general purpose climate stations should be situated to address all aspects of climate variability, it is desirable that they also be in locations that are more sensitive to climate change from natural or anthropogenic influences should it begin to occur. The question here is how well we know such sensitivities. The polar regions and especially the North Pole are generally regarded as being more sensitive to changes in radiative forcing of climate because of positive feedbacks. The climate-change issue is quite complex because it encompasses more than just greenhouse gasses.

Sites that are in locations or climates particularly vulnerable to climate change should be favored. How this vulnerability is determined is a considerably challenging research issue. Candidate locations or situations are those that lie on the border between two major biomes or just inside the edge of one or the other. In these cases, a slight movement of the boundary in anticipated direction (toward “warmer,” for example) would be much easier to detect as the boundary moves past the site and a different set of biota begin to be established. Such a vegetative or ecologic response would be more visible and would take less time to establish as a real change than would a smaller change in the center of the distribution range of a marker or key species.

E.2.4. Element-Specific Differences

The various climate elements (temperature, precipitation, cloudiness, snowfall, humidity, wind speed and direction, solar radiation) do not vary through time in the same sequence or manner nor should they necessarily be expected to vary in this manner. The spatial patterns of variability should not be expected to be the same for all elements. These patterns also should not be expected to be similar for all months or seasons. The suitability of individual sites for measurement also varies from one element to another. A site that has a favorable exposure for temperature or wind may not have a favorable exposure for precipitation or snowfall. A site that experiences proper air movement may be situated in a topographic channel, such as a river valley or a pass, which restricts the range of wind directions and affects the distribution of speed-direction categories.

E.2.5. Logistics and Practical Factors

Even with the most advanced scientific rationale, sites in some remote or climatically challenging settings may not be suitable because of the difficulty in servicing and maintaining equipment. Contributing to these challenges are scheduling difficulties, animal behavior, snow burial, icing, snow behavior, access and logistical problems, and the weather itself. Remote and elevated sites usually require far more attention and expense than a rain-dominated, easily accessible valley location.

For climate purposes, station exposure and the local environment should be maintained in their original state (vegetation especially), so that changes seen are the result of regional climate variations and not of trees growing up, bushes crowding a site, surface albedo changing, fire clearing, etc. Repeat photography has shown many examples of slow environmental change in the vicinity of a station in rather short time frames (5–20 years), and this technique should be employed routinely and frequently at all locations. In the end, logistics, maintenance, and other practical factors almost always determine the success of weather- and climate-monitoring activities.

E.2.6. Personnel Factors

Many past experiences (almost exclusively negative) strongly support the necessity to place primary responsibility for station deployment and maintenance in the hands of seasoned, highly qualified, trained, and meticulously careful personnel, the more experienced the better. Over time, even in “benign” climates but especially where harsher conditions prevail, every conceivable problem will occur and both the usual and unusual should be anticipated: weather, animals, plants, salt, sensor and communication failure, windblown debris, corrosion, power failures, vibrations, avalanches, snow loading and creep, corruption of the data logger program, etc. An ability to anticipate and forestall such problems, a knack for innovation and improvisation, knowledge of electronics, practical and organizational skills, and presence of mind to bring the various small but vital parts, spares, tools, and diagnostic troubleshooting equipment are highly valued qualities. Especially when logistics are so expensive, a premium should be placed on using experienced personnel, since the slightest and seemingly most minor mistake can render a station useless or, even worse, uncertain. Exclusive reliance on individuals without this background can be costly and almost always will result eventually in unnecessary loss of data. Skilled labor and an apprenticeship system to develop new skilled labor will greatly reduce (but not eliminate) the types of problems that can occur in operating a climate network.

E.3. Site Selection

In addition to considerations identified previously in this appendix, various factors need to be considered in selecting sites for new or augmented instrumentation.

E.3.1. Equipment and Exposure Factors

E.3.1.1. Measurement Suite: All sites should measure temperature, humidity, wind, solar radiation, and snow depth. Precipitation measurements are more difficult but probably should be attempted with the understanding that winter measurements may be of limited or no value unless an all-weather gauge has been installed. Even if an all-weather gauge has been installed, it is desirable to have a second gauge present that operates on a different principle–for example, a fluid-based system like those used in the SNOTEL stations in tandem with a higher–resolution, tipping bucket gauge for summertime. Without heating, a tipping bucket gauge usually is of use only when temperatures are above freezing and when temperatures have not been below freezing for some time, so that accumulated ice and snow is not melting and being recorded as present precipitation. Gauge undercatch is a significant issue in snowy climates, so shielding should be considered for all gauges designed to work over the winter months. It is very important to note the presence or absence of shielding, the type of shielding, and the dates of installation or removal of the shielding.

E.3.1.2. Overall Exposure: The ideal, general all-purpose site has gentle slopes, is open to the sun and the wind, has a natural vegetative cover, avoids strong local (less than 200 m) influences, and represents a reasonable compromise among all climate elements. The best temperature sites are not the best precipitation sites, and the same is true for other elements. Steep topography in the immediate vicinity should be avoided unless settings where precipitation is affected by steep topography are being deliberately sought or a mountaintop or ridgeline is the desired location. The potential for disturbance should be considered: fire and flood risk, earth movement, wind-borne debris, volcanic deposits or lahars, vandalism, animal tampering, and general human encroachment are all factors.

E.3.1.3. Elevation: Mountain climates do not vary in time in exactly the same manner as adjoining valley climates. This concept is emphasized when temperature inversions are present to a greater degree and during precipitation when winds rise up the slopes at the same angle. There is considerable concern that mountain climates will be (or already are) changing and perhaps changing differently than lowland climates, which has direct and indirect consequences for plant and animal life in the more extreme zones. Elevations of special significance are those that are near the mean rain/snow line for winter, near the tree line, and near the mean annual freezing level (all of these may not be quite the same). Because the lapse rates in wet climates often are nearly moist-adiabatic during the main precipitation seasons, measurements at one elevation may be extrapolated to nearby elevations. In drier climates and in the winter, temperature and to a lesser extent wind will show various elevation profiles.

E.3.1.4. Transects: The concept of observing transects that span climatic gradients is sound. This is not always straightforward in topographically uneven terrain, but these transects could still be arranged by setting up station(s) along the coast; in or near passes atop the main coastal interior drainage divide; and inland at one, two, or three distances into the interior lowlands. Transects need not—and by dint of topographic constraints probably cannot—be straight lines, but the closer that a line can be approximated the better. The main point is to systematically sample the key points of a behavioral transition without deviating too radically from linearity.

E.3.1.5. Other Topographic Considerations: There are various considerations with respect to local topography. Local topography can influence wind (channeling, upslope/downslope, etc.), precipitation (orographic enhancement, downslope evaporation, catch efficiency, etc.), and temperature (frost pockets, hilltops, aspect, mixing or decoupling from the overlying atmosphere, bowls, radiative effects, etc.), to different degrees at differing scales. In general, for measurements to be areally representative, it is better to avoid these local effects to the extent that they can be identified before station deployment (once deployed, it is desirable not to move a station). The primary purpose of a climate-monitoring network should be to serve as an infrastructure in the form of a set of benchmark stations for comparing other stations. Sometimes, however, it is exactly these local phenomena that we want to capture. Living organisms, especially plants, are affected by their immediate environment, whether it is representative of a larger setting or not. Specific measurements of limited scope and duration made for these purposes then can be tied to the main benchmarks. This experience is useful also in determining the complexity needed in the benchmark monitoring process in order to capture particular phenomena at particular space and time scales.

Sites that drain (cold air) well generally are better than sites that allow cold air to pool. Slightly sloped areas (1 degree is fine) or small benches from tens to hundreds of meters above streams are often favorable locations. Furthermore, these sites often tend to be out of the path of hazards (like floods) and to have rocky outcroppings where controlling vegetation will not be a major concern. Benches or wide spots on the rise between two forks of a river system are often the only flat areas and sometimes jut out to give greater exposure to winds from more directions.

E.3.1.6. Prior History: The starting point in designing a program is to determine what kinds of observations have been collected over time, by whom, in what manner, and if these observation are continuing to the present time. It also may be of value to “re-occupy” the former site of a station that is now inactive to provide some measure of continuity or a reference point from the past. This can be of value even if continuous observations were not made during the entire intervening period.

E.3.2. Element-Specific Factors

E.3.2.1. Temperature: An open exposure with uninhibited air movement is the preferred setting. The most common measurement is made at approximately eye level, 1.5–2.0 m. In snowy locations sensors should be at least one meter higher than the deepest snowpack expected in the next 50 years or perhaps 2–3 times the depth of the average maximum annual depth. Sensors should be shielded above and below from solar radiation (bouncing off snow), from sunrise/sunset horizontal input, and from vertical rock faces. Sensors should be clamped tightly, so that they do not swivel away from level stacks of radiation plates. Nearby vegetation should be kept away from the sensors (several meters). Growing vegetation should be cut to original conditions. Small hollows and swales can cool tremendously at night, and it is best avoid these areas. Side slopes of perhaps a degree or two of angle facilitate air movement and drainage and, in effect, sample a large area during nighttime hours. The very bottom of a valley should be avoided. Temperature can change substantially from moves of only a few meters. Situations have been observed where flat and seemingly uniform conditions (like airport runways) appear to demonstrate different climate behaviors over short distances of a few tens or hundreds of meters (differences of 5–10°C). When snow is on the ground, these microclimatic differences can be stronger, and differences of 2–5°C can occur in the short distance between the thermometer and the snow surface on calm evenings.

E.3.2.2. Precipitation (liquid): Calm locations with vegetative or artificial shielding are preferred. Wind will adversely impact readings; therefore, the less the better. Wind effects on precipitation are far less for rain than for snow. Devices that "save" precipitation present advantages, but most gauges are built to dump precipitation as it falls or to empty periodically. Automated gauges give both the amount and the timing. Simple backups that record only the total precipitation since the last visit have a certain advantage (for example, storage gauges or lengths of PVC pipe perhaps with bladders on the bottom). The following question should be asked: Does the total precipitation from an automated gauge add up to the measured total in a simple bucket (evaporation is prevented with an appropriate substance such as mineral oil)? Drip from overhanging foliage and trees can augment precipitation totals.

E.3.2.3. Precipitation (frozen): Calm locations or shielding are a must. Undercatch for rain is only about 5 percent, but with winds of only 2–4 m/s, gauges may catch only 30–70 percent of the actual snow falling depending on density of the flakes. To catch 100 percent of the snow, the standard configuration for shielding is employed by the CRN (Climate Reference Network): the DFIR (Double-Fence Intercomparison Reference) shield with 2.4-m (8-ft.) vertical, wooden slatted fences in two concentric octagons with diameters of 8 m and 4 m (26 ft and 13 ft, respectively) and an inner Alter shield (flapping vanes). Numerous tests have shown this is the only way to achieve complete catch of snowfall (e.g., Yang et al. 1998, 2001). The DFIR shield is large and bulky; it is recommended that all precipitation gauges have at least Alter shields on them.

Near the coast, much snow is heavy and falls more vertically. In colder locations or storms, light flakes frequently will fly in and then out of the gauge. Clearings in forests are usually excellent sites. Snow blowing from trees that are too close can augment actual precipitation totals. Artificial shielding (vanes, etc.) placed around gauges in snowy locales always should be used if accurate totals are desired. Moving parts tend to freeze up. Capping of gauges during heavy snowfall events is a common occurrence. When the cap becomes pointed, snow falls off to the ground and is not recorded. Caps and plugs often will not fall into the tube until hours, days, or even weeks have passed, typically during an extended period of freezing temperature or above or when sunlight finally occurs. Liquid-based measurements (e.g., SNOTEL "rocket" gauges) do not have the resolution (usually 0.3 cm [0.1 in.] rather than 0.03 cm [0.01 in.]) that tipping bucket and other gauges have but are known to be reasonably accurate in very snowy climates. Light snowfall events might not be recorded until enough of them add up to the next reporting increment. More expensive gauges like Geonors can be considered and could do quite well in snowy settings; however, they need to be emptied every 40 cm (15 in.) or so (capacity of 51 cm [20 in.]) until the new 91-cm (36-in.) capacity gauge is offered for sale. Recently, the NWS has been trying out the new (and very expensive) Ott all-weather gauge. Riming can be an issue in windy foggy environments below freezing. Rime, dew, and other forms of atmospheric condensation are not real precipitation, since they are caused by the gauge.

E.3.2.4. Snow Depth: Windswept areas tend to be blown clear of snow. Conversely, certain types of vegetation can act as a snow fence and cause artificial drifts. However, some amount of vegetation in the vicinity generally can help slow down the wind. The two most common types of snow-depth gauges are the Judd Snow Depth Sensor, produced by Judd Communications, and the snow depth gauge produced by Campbell Scientific, Inc. Opinions vary on which one is better. These gauges use ultrasound and look downward in a cone about 22 degrees in diameter. The ground should be relatively clear of vegetation and maintained in a manner so that the zero point on the calibration scale does not change.

E.3.2.5. Snow Water Equivalent: This is determined by the weight of snow on fluid-filled pads about the size of a desktop set up sometimes in groups of four or in larger hexagons several meters in diameter. These pads require flat ground some distance from nearby sources of windblown snow and shielding that is "just right": not too close to the shielding to act as a kind of snow fence and not too far from the shielding so that blowing and drifting become a factor. Generally, these pads require fluids that possess antifreeze-like properties, as well as handling and replacement protocols.

E.3.2.6. Wind: Open exposures are needed for wind measurements. Small prominences or benches without blockage from certain sectors are preferred. A typical rule for trees is to site stations back 10 tree-heights from all tree obstructions. Sites in long, narrow valleys can obviously only exhibit two main wind directions. Gently rounded eminences are more favored. Any kind of topographic steering should be avoided to the extent possible. Avoiding major mountain chains or single isolated mountains or ridges is usually a favorable approach, if there is a choice. Sustained wind speed and the highest gusts (1-second) should be recorded. Averaging methodologies for both sustained winds and gusts can affect climate trends and should be recorded as metadata with all changes noted. Vegetation growth affects the vertical wind profile, and growth over a few years can lead to changes in mean wind speed even if the "real" wind does not change, so vegetation near the site (perhaps out to 50 m) should be maintained in a quasi-permanent status (same height and spatial distribution). Wind devices can rime up and freeze or spin out of balance. In severely rimed or windy climates, rugged anemometers, such as those made by Taylor, are worth considering. These anemometers are expensive but durable and can withstand substantial abuse. In exposed locations, personnel should plan for winds to be at least 50 m/s and be able to measure these wind speeds. At a minimum, anemometers should be rated to 75 m/s.

E.3.2.7. Humidity: Humidity is a relatively straightforward climate element. Close proximity to lakes or other water features can affect readings. Humidity readings typically are less accurate near 100 percent and at low humidities in cold weather.

E.3.2.8. Solar Radiation: A site with an unobstructed horizon obviously is the most desirable. This generally implies a flat plateau or summit. However, in most locations trees or mountains will obstruct the sun for part of the day.

E.3.2.9. Soil Temperature: It is desirable to measure soil temperature at locations where soil is present. If soil temperature is recorded at only a single depth, the most preferred depth is 10 cm. Other common depths include 25 cm, 50 cm, 2 cm, and 100 cm. Biological activity in the soil will be proportional to temperature with important threshold effects occurring near freezing.

E.3.2.10. Soil Moisture: Soil-moisture gauges are somewhat temperamental and require care to install. The soil should be characterized by a soil expert during installation of the gauge. The readings may require a certain level of experience to interpret correctly. If accurate, readings of soil moisture are especially useful.

E.3.2.11. Distributed Observations: It can be seen readily that compromises must be struck among the considerations described in the preceding paragraphs because some are mutually exclusive.

How large can a “site” be? Generally, the equipment footprint should be kept as small as practical with all components placed next to each other (within less than 10–20 m or so). Readings from one instrument frequently are used to aid in interpreting readings from the remaining instruments.

What is a tolerable degree of separation? Some consideration may be given to locating a precipitation gauge or snow pillow among protective vegetation, while the associated temperature, wind, and humidity readings would be collected more effectively in an open and exposed location within 20–50 m. Ideally, it is advantageous to know the wind measurement precisely at the precipitation gauge, but a compromise involving a short split, and in effect a “distributed observation,” could be considered. There are no definitive rules governing this decision, but it is suggested that the site footprint be kept within approximately 50 m. There also are constraints imposed by engineering and electrical factors that affect cable lengths, signal strength, and line noise; therefore, the shorter the cable the better. Practical issues include the need to trench a channel to outlying instruments or to allow lines to lie atop the ground and associated problems with animals, humans, weathering, etc. Separating a precipitation gauge up to 100 m or so from an instrument mast may be an acceptable compromise if other factors are not limiting.

E.3.2.12. Instrument Replacement Schedules: Instruments slowly degrade, and a plan for replacing them with new, refurbished, or recalibrated instruments should be in place. After approximately five years, a systematic change-out procedure should result in replacing most sensors in a network. Certain parts, such as solar radiation sensors, are candidates for annual calibration or change-out. Anemometers tend to degrade as bearings erode or electrical contacts become uneven. Noisy bearings are an indication, and a stethoscope might aid in hearing such noises. Increased internal friction affects the threshold starting speed; once spinning, they tend to function properly. Increases in starting threshold speeds can lead to more zero-wind measurements and thus reduce the reported mean wind speed with no real change in wind properties. A field calibration kit should be developed and taken on all site visits, routine or otherwise. Rain gauges can be tested with drip testers during field visits. Protective conduit and tight water seals can prevent abrasion and moisture problems with the equipment, although seals can keep moisture in as well as out. Bulletproof casings sometimes are employed in remote settings. A supply of spare parts, at least one of each and more for less-expensive or more-delicate sensors, should be maintained to allow replacement of worn or nonfunctional instruments during field visits. In addition, this approach allows instruments to be calibrated in the relative convenience of the operational home—the larger the network, the greater the need for a parts depot.

E.3.3. Long-Term Comparability and Consistency

E.3.3.1. Consistency: The emphasis here is to hold biases constant. Every site has biases, problems, and idiosyncrasies of one sort or another. The best rule to follow is simply to try to keep biases constant through time. Since the goal is to track climate through time, keeping sensors, methodologies, and exposure constant will ensure that only true climate change is being measured. This means leaving the site in its original state or performing maintenance to keep it that way. Once a site is installed, the goal should be to never move the site even by a few meters or to allow significant changes to occur within 100 m for the next several decades.

Sites in or near rock outcroppings likely will experience less vegetative disturbance or growth through the years and will not usually retain moisture, a factor that could speed corrosion. Sites that will remain locally similar for some time are usually preferable. However, in some cases the intent of a station might be to record the local climate effects of changes within a small-scale system (for example, glacier, recently burned area, or scene of some other disturbance) that is subject to a regional climate influence. In this example, the local changes might be much larger than the regional changes.

E.3.3.2. Metadata: Since the climate of every site is affected by features in the immediate vicinity, it is vital to record this information over time and to update the record repeatedly at each service visit. Distances, angles, heights of vegetation, fine-scale topography, condition of instruments, shielding discoloration, and other factors from within a meter to several kilometers should be noted. Systematic photography should be undertaken and updated at least once every one–two years.

Photographic documentation should be taken at each site in a standard manner and repeated every two–three years. Guidelines for methodology were developed by Redmond (2004) as a result of experience with the NOAA CRN and can be found on the WRCC NPS Web pages at http://www.wrcc.dri.edu/nps and at ftp.wrcc.dri.edu/nps/photodocumentation.pdf.

The main purpose for climate stations is to *track climatic conditions through time*. Anything that affects the interpretation of records through time must to be noted and recorded for posterity. The important factors should be clear to a person who has never visited the site, no matter how long ago the site was installed.

In regions with significant, climatic transition zones, transects are an efficient way to span several climates and make use of available resources. Discussions on this topic at greater detail can be found in Redmond and Simeral (2004) and in Redmond et al. (2005).

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Appendix F. Descriptions of weather/climate monitoring networks.

F.1. Clean Air Status and Trends Network (CASTNet)

- Purpose of network: provide information for evaluating the effectiveness of national emission-control strategies.
- Primary management agency: EPA.
- Data website: http://epa.gov/castnet/.
- Measured weather/climate elements:
  - Air temperature.
  - Precipitation.
  - Relative humidity.
  - Wind speed.
  - Wind direction.
  - Wind gust.
  - Gust direction.
  - Solar radiation.
  - Soil moisture and temperature.
- Sampling frequency: hourly.
- Reporting frequency: hourly.
- Estimated station cost: $13K.
- Network strengths:
  - High-quality data.
  - Sites are well maintained.
- Network weaknesses:
  - Density of station coverage is low.
  - Shorter periods of record for western United States.

CASTNet primarily is an air-quality-monitoring network managed by the EPA. The elements shown here are intended to support interpretation of measured air-quality parameters such as ozone, nitrates, sulfides, etc., which also are measured at CASTNet sites.

F.2. NWS Cooperative Observer Program (COOP)

- Purpose of network:
  - Provide observational, meteorological data required to define U.S. climate and help measure long-term climate changes.
  - Provide observational, meteorological data in near real-time to support forecasting and warning mechanisms and other public service programs of the NWS.
- Primary management agency: NOAA (NWS).
- Data website: data are available from the NCDC (http://www.ncdc.noaa.gov), RCCs (e.g., WRCC, http://www.wrcc.dri.edu), and state climate offices.
- Measured weather/climate elements
  - Maximum, minimum, and observation-time temperature.
  - Precipitation, snowfall, snow depth.

  - Pan evaporation (some stations).
- Sampling frequency: daily.
- Reporting frequency: daily or monthly (station-dependent).
- Estimated station cost: $2K with maintenance costs of $500–900/year.
- Network strengths:
  - Decade–century records at most sites.
  - Widespread national coverage (thousands of stations).
  - Excellent data quality when well maintained.
  - Relatively inexpensive; highly cost effective.
  - Manual measurements; not automated.
- Network weaknesses:
  - Uneven exposures; many are not well-maintained.
  - Dependence on schedules for volunteer observers.
  - Slow entry of data from many stations into national archives.
  - Data subject to observational methodology; not always documented.
  - Manual measurements; not automated and not hourly.

The COOP network has long served as the main climate observation network in the United States. Readings are usually made by volunteers using equipment supplied, installed, and maintained by the federal government. The observer in effect acts as a host for the data-gathering activities and supplies the labor; this is truly a “cooperative” effort. The SAO sites often are considered to be part of the cooperative network as well if they collect the previously mentioned types of weather/climate observations. Typical observation days are morning to morning, evening to evening, or midnight to midnight. By convention, observations are ascribed to the date the instrument was reset at the end of the observational period. For this reason, midnight observations represent the end of a day. The Historical Climate Network is a subset of the cooperative network but contains longer and more complete records.

F.3. Citizen Weather Observer Program (CWOP)

- Purpose of network: collect observations from private citizens and make these data available for homeland security and other weather applications, providing constant feedback to the observers to maintain high data quality.
- Primary management agency: NOAA MADIS program.
- Data Website: http://www.wxqa.com.
- Measured weather/climate elements:
  - Air temperature.
  - Dewpoint temperature.
  - Precipitation.
  - Wind speed and direction.
  - Barometric Pressure.
- Sampling frequency: 15 minutes or less.
- Reporting frequency: 15 minutes.
- Estimated station cost: unknown.
- Network strengths:
  - Active partnership between public agencies and private citizens.

  - Large number of participant sites.
  - Regular communications between data providers and users, encouraging higher data quality.
- Network weaknesses:
  - Variable instrumentation platforms.
  - Metadata are sometimes limited.

The CWOP network is a public-private partnership with U.S. citizens and various agencies including NOAA, NASA (National Aeronautics and Space Administration), and various universities. There are over 4500 registered sites worldwide, with close to 3000 of these sites located in North America.

F.4. NOAA Ground-Based GPS Meteorology (GPS-MET)

- Purpose of network:
  - Measure atmospheric water vapor using ground-based GPS receivers.
  - Facilitate use of these data operational and in other research and applications.
  - Provides data for weather forecasting, atmospheric modeling and prediction, climate monitoring, calibrating and validation other observing systems including radiosondes and satellites, and research.
- Primary management agency: NOAA Earth System Research Laboratory.
- Data website: http://gpsmet.noaa.gov/jsp/index.jsp.
- Measurements:
  - Dual frequency carrier phase measurements every 30 seconds
- Ancillary weather/climate observations:
  - Air temperature.
  - Relative humidity.
  - Pressure.
- Reporting frequency: currently 30 min.
- Estimated station cost: $0-$10K, depending on approach. Data from dual frequency GPS receivers installed for conventional applications (e.g. high accuracy surveying) can be used without modification.
- Network strengths:
  - Frequent, high-quality measurements.
  - High reliability.
  - All-weather operability.
  - Many uses.
  - Highly leveraged.
  - Requires no calibration.
  - Measurement accuracy improves with time.
- Network weakness:
  - Point measurement.
  - Provides no direct information about the vertical distribution of water vapor.

The GPS-MET network is the first network of its kind dedicated to GPS meteorology (see Duan et al. 1996). The GPS-MET network was developed in response to the need for improved moisture observations to support weather forecasting, climate monitoring, and other research activities. GPS-MET is a collaboration between NOAA and several other governmental and university organizations and institutions.

GPS meteorology utilizes the radio signals broadcast by the satellite Global Positioning System for atmospheric remote sensing. GPS meteorology applications have evolved along two paths: ground-based (Bevis et al. 1992) and space-based (Yuan et al. 1993). Both applications make the same fundamental measurement (the apparent delay in the arrival of radio signals caused by changes in the radio-refractivity of the atmosphere along the paths of the radio signals) but they do so from different perspectives.

In ground-based GPS meteorology, a GPS receiver and antenna are placed at a fixed location on the ground and the signals from all GPS satellites in view are continuously recorded. From this information, the exact position of the GPS antenna can be determined over time with high (millimeter-level) accuracy. Subsequent measurements of the antenna position are compared with the known position, and the differences can be attributed to changes in the temperature, pressure and water vapor in the atmosphere above the antenna. By making continuous measurements of temperature and pressure at the site, the total amount of water vapor in the atmosphere at this location can be estimated with high accuracy under all weather conditions. For more information on ground based GPS meteorology the reader is referred to http://gpsmet.noaa.gov.

In space-based GPS meteorology, GPS receivers and antennas are placed on satellites in Low Earth Orbit (LEO), and the signals transmitted by a GPS satellite are continuously recorded as a GPS satellite “rises” or “sets” behind the limb of the Earth. This process is called an occultation or a limb sounding. The GPS radio signals bend more as they encounter a thicker atmosphere and the bending (which causes an apparent increase in the length of the path of the radio signal) can be attributed to changes in temperature, pressure and water vapor along the path of the radio signal through the atmosphere that is nominally about 300 km long. The location of an occultation depends on the relative geometries of the GPS satellites in Mid Earth Orbit and the satellites in LEO. As a consequence, information about the vertical temperature, pressure and moisture structure of the Earth’s atmosphere as a whole can be estimated with high accuracy, but not at any one particular place over time. The main difference between ground and space-based GPS meteorology is one of geometry. A space-based measurement can be thought of as a ground-based measurement turned on its side. For more information on space based GPS meteorology, the reader is referred to http://www.cosmic.ucar.edu/gpsmet/.

F.5. Remote Automated Weather Station (RAWS)

- Purpose of network: provide near-real-time (hourly or near hourly) measurements of meteorological variables for use in fire weather forecasts and climatology. Data from RAWS also are used for natural resource management, flood forecasting, natural hazard management, and air-quality monitoring.
- Primary management agency: WRCC, National Interagency Fire Center.
- Data website: http://www.raws.dri.edu/index.html.
- Measured weather/climate elements:
  - Air temperature.

  - Precipitation.
  - Relative humidity.
  - Wind speed.
  - Wind direction.
  - Wind gust.
  - Gust direction.
  - Solar radiation.
  - Soil moisture and temperature.
- Sampling frequency: 1 or 10 minutes, element-dependent.
- Reporting frequency: generally hourly. Some stations report every 15 or 30 minutes.
- Estimated station cost: $12K with satellite telemetry ($8K without satellite telemetry); maintenance costs are around $2K/year.
- Network strengths:
  - Metadata records are usually complete.
  - Sites are located in remote areas.
  - Sites are generally well-maintained.
  - Entire period of record available on-line.
- Network weaknesses:
  - RAWS network is focused largely on fire management needs (formerly focused only on fire needs).
  - Frozen precipitation is not measured reliably.
  - Station operation is not always continuous.
  - Data transmission is completed via one-way telemetry. Data are therefore recoverable either in real-time or not at all.

The RAWS network is used by many land-management agencies, such as the BLM, NPS, Fish and Wildlife Service, Bureau of Indian Affairs, Forest Service, and other agencies. The RAWS network was one of the first automated weather station networks to be installed in the United States. Most gauges do not have heaters, so hydrologic measurements are of little value when temperatures dip below freezing or reach freezing after frozen precipitation events. There are approximately 1,100 real-time sites in this network and about 1,800 historic sites (some are decommissioned or moved). The sites can transmit data all winter but may be in deep snow in some locations. The WRCC is the archive for this network and receives station data and metadata through a special connection to the National Interagency Fire Center in Boise, Idaho.

F.6. NWS Surface Airways Observation Network (SAO)

- Purpose of network: provide near-real-time (hourly or near hourly) measurements of meteorological variables and are used both for airport operations and weather forecasting.
- Primary management agency: NOAA, FAA.
- Data website: data are available from state climate offices, RCCs (e.g., WRCC, http://www.wrcc.dri.edu), and NCDC (http://www.ncdc.noaa.gov).
- Measured weather/climate elements:
  - Air temperature.
  - Dewpoint and/or relative humidity.
  - Wind speed.

  - Wind direction.
  - Wind gust.
  - Gust direction.
  - Barometric pressure.
  - Precipitation (not at many FAA sites).
  - Sky cover.
  - Ceiling (cloud height).
  - Visibility.
- Sampling frequency: element-dependent.
- Reporting frequency: element-dependent.
- Estimated station cost: $100–$200K with maintenance costs approximately $10K/year.
- Network strengths:
  - Records generally extend over several decades.
  - Consistent maintenance and station operations.
  - Data record is reasonably complete and usually high quality.
  - Hourly or sub-hourly data.
- Network weaknesses:
  - Nearly all sites are located at airports.
  - Data quality can be related to size of airport—smaller airports tend to have poorer datasets.
  - Influences from urbanization and other land-use changes.

These stations are managed by NOAA, U. S. Navy, U. S. Air Force, and FAA. These stations are located generally at major airports and military bases. The FAA stations often do not record precipitation, or they may provide precipitation records of reduced quality. Automated stations are typically ASOSs for the NWS or AWOSs for the FAA. Some sites only report episodically with observers paid per observation.

F.7. USDA NRCS Soil Climate Analysis Network (SCAN)

- Purpose of network: support natural resource assessment and conservation activities.
- Primary management agency: USDA NRCS.
- Data website: http://www.wcc.nrcs.usda.gov/scan.
- Measured weather/climate elements:
  - Air temperature.
  - Precipitation.
  - Relative humidity.
  - Barometric pressure.
  - Wind speed.
  - Wind direction.
  - Solar radiation.
  - Soil temperature.
  - Soil moisture.
  - Snow water content.
  - Snow depth.
- Sampling frequency: element-dependent.

- Reporting frequency: element-dependent.
- Estimated station cost: unknown.
- Network strengths:
  - National distribution of stations.
  - Metadata are usually of high quality.
- Network weaknesses:
  - Stations concentrated primarily in eastern half of U.S.

This network is administered by USDA/NRCS and is a cooperative nationwide soil moisture and climate information system. This network aims to utilize information from existing soil/climate data networks and develop new data collection opportunities through partnerships with other federal and state entities that monitoring natural resources. The SCAN network is concentrated primarily in the agricultural areas of the U.S.

F.8. Weather For You Network (WX4U)

- Purpose of network: allow volunteer weather enthusiasts around the U.S. to observe and share weather data.
- Data website: http://www.met.utah.edu/jhorel/html/mesonet.
- Measured weather/climate elements:
  - Air temperature.
  - Relative humidity and dewpoint temperature.
  - Precipitation.
  - Wind speed and direction.
  - Wind gust and direction.
  - Pressure.
- Sampling frequency: 10 minutes.
- Reporting frequency: 10 minutes.
- Estimated station cost: unknown.
- Network strengths:
  - Stations are located throughout the U.S.
  - Stations provide near-real-time observations
- Network weaknesses:
  - Instrumentation platforms can be variable.
  - Data are sometimes of questionable quality.

The WX4U network is a nationwide collection of weather stations run by local observers. Meteorological elements that are measured usually include temperature, precipitation, wind, and humidity.

Appendix G. Electronic supplements.

G.1. ACIS metadata file for weather and climate stations associated with the NCRN: http://www.wrcc.dri.edu/nps/pub/ncrn/metadata/NCRN_from_ACIS.tar.gz.

G.2. NCRN metadata files for weather and climate stations associated with the NCRN: http://www.wrcc.dri.edu/nps/pub/ncrn/metadata/NCRN_NPS.tar.gz.

The U.S. Department of the Interior (DOI) is the nation’s principal conservation agency, charged with the mission "*to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities."* More specifically, Interior protects America’s treasures for future generations, provides access to our nation’s natural and cultural heritage, offers recreation opportunities, honors its trust responsibilities to American Indians and Alaska Natives and its responsibilities to island communities, conducts scientific research, provides wise stewardship of energy and mineral resources, fosters sound use of land and water resources, and conserves and protects fish and wildlife. The work that we do affects the lives of millions of people; from the family taking a vacation in one of our national parks to the children studying in one of our Indian schools.

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