2007 Annual Report

CLEAN AIR STATUS AND TRENDS NETWORK SITE AUDIT PROGRAM

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List of Acronyms and Abbreviations

% diff	percent difference
A/D	analog to digital converter
ARS	Air Resource Specialist, Inc.
ASTM	American Society for Testing and Materials
CASTNET	Clean Air Status and Trends Network
DAS	data acquisition system
DC	direct current
deg	degree
DVM	digital voltmeter
EEMS	Environmental, Engineering & Measurement Services, Inc.
EPA	U.S. Environmental Protection Agency
ESC	Environmental Systems Corporation
FSAD	Field Site Audit Database
g-cm	gram centimeter
GPS	geographical positioning system
k	kilo (1000)
km	kilometer
lpm	liters per minute
MLM	Multilayer Model
m/s	meters per second
mv	milivolt
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
QAPP	Quality Assurance Project Plan
SOP	standard operating procedure
TEI	Thermo Environmental Instruments
USNO	United States Naval Observatory
V	volts
WRR	World Radiation Reference

1.0 INTRODUCTION

The Clean Air Status and Trends Network (CASTNET) is a national air monitoring program developed under mandate of the 1990 Clean Air Act Amendments. Each site in the network measures dry acid and other forms of atmospheric pollution using a continuous collection filter aggregated over a one week period. Hourly averages of surface ozone concentrations and selected meteorological variables are also measured.

Site measurements are used to estimate deposition rates of the various pollutants with the objective of determining relationships between emissions, air quality, deposition, and ecological effects. In conjunction with other national monitoring networks, CASTNET data are used to determine the effectiveness of national emissions control programs and to assess temporal trends and spacial deposition patterns in atmospheric pollutants. CASTNET data are also used for long-range transport model evaluations and effects research.

CASTNET pollutant flux estimates are calculated as the aggregate product of weekly measured chemical concentrations and model-estimated deposition velocities. Currently, the National Oceanic and Atmospheric Administration's multilayer inferential model (NOAA-MLM) described by Meyers et al. [1998] is used to derive deposition velocity estimates.

As of January 2007, the network is comprised of 87 active rural sampling sites across the Untied States and Canada, cooperatively operated by the Environmental Protection Agency (EPA), the National Park Service (NPS), and Environment Canada. MACTEC E & C is responsible for operating the EPA and Environment Canada sponsored sites, and Air Resource Specialist, Inc. (ARS) is responsible for operating the NPS sponsored sites.

2.0 PROJECT OBJECTIVES

The objectives of this project are to establish an independent and unbiased program of performance and systems audits for all CASTNET sampling sites. Ongoing Quality Assurance (QA) programs are an essential part of any long-term monitoring network.

Performance audits verify that all evaluated parameters are consistent with the accuracy goals as defined in the CASTNET Quality Assurance Project Plan (QAPP). The parameter specific accuracy goals are presented in Table 2.1.

Table 2.1 Performance Audit Challenge and Acceptance Criteria

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Precipitation	Response	10 manual tips	1 DAS count per tip
Precipitation	Accuracy	2 introductions of known amounts of water	≤ ±10.0% of input amount
Relative Humidity	Accuracy	Compared to reference instrument or standard solution	≤ ±5.0% above 85.0% RH; ≤ ±20.0% at or below 85.0% RH
Solar Radiation	Accuracy	Compared to WRR traceable standard	≤ ±10.0% of daytime average
Surface Wetness	Response	Distilled water spray mist	Positive response
Surface Wetness	Sensitivity	1% decade resistance	N/A
Temperature	Accuracy	Comparison to 3 NIST measured baths (~ 0° C, ambient, ~ full-scale)	≤ ± 0.5° C

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Delta Temperature	Accuracy	Comparison to temperature sensor at same test point	≤ ± 0.50° C
Wind Direction	Orientation Accuracy	Parallel to alignment rod/crossarm, or sighted to distant point	≤ ±5° from degrees true
Wind Direction	Linearity	Eight cardinal points on test fixture	≤ ±5° mean absolute error
Wind Direction	Response Threshold	Starting torque tested with torque gauge	< 10 g-cm Climatronics; < 20 g-cm R. M. Young
Wind Speed	Accuracy	Shaft rotational speed generated and measured with certified synchronous motor	≤ ±0.5 mps below 5.0 mps input; ≤ ±5.0% of input at or above 5.0 mps
Wind Speed	Starting Threshold	Starting torque tested with torque gauge	< 0.5 g-cm
Mass Flow Controller	Flow Rate	Comparison with Primary Standard	≤ ± 5.0% of designated rate
Ozone	Slope	Linear regression of multi-point test gas concentration as measured with a certified transfer standard	0.9000 ≤ m ≤ 1.1000
	Intercept		-5.0 ppb ≤ b ≤ 5.0 ppb
	Correlation Coefficient		0.9950 ≤ r
	Percent Difference	Comparison with Standard Concentration	≤ ±10.0% of test gas concentration
DAS	Accuracy	Comparison with certified standard	≤ ± 0.003 VDC

Performance audits are conducted using standards that are certified as currently traceable to the National Institute of Standards and Technology (NIST), or another authoritative organization.

Site systems audits are intended to provide a qualitative appraisal of the total measurement system. Site planning, organization, and operation are evaluated to ensure that good Quality Assurance/Quality Control (QA/QC) practices are being applied. At a minimum the following audit issues are addressed at each site systems audit:

- Site locations and configurations match those provided in the CASTNET QAPP.
- Meteorological instruments are in good physical and operational condition and are sited to meet EPA ambient monitoring guidelines (EPA-600/4-82-060).
- Sites are accessible, orderly, and if applicable, compliant with OSHA safety standards.
- Sampling lines are free of leaks, kinks, visible contamination, weathering, and moisture.
- Site shelters provide adequate temperature control.
- All ambient air quality instruments are functional, being operated in the appropriate range, and the zero air supply desiccant is unsaturated.
- All instruments are in current calibration.
- Site documentation (maintenance schedules, on-site SOPs, etc.) is current and log book records are complete.
- All maintenance and on-site SOPs are performed on schedule.
- Corrective actions are documented and appropriate for required maintenance/repair activity.
- Site operators demonstrate an adequate knowledge and ability to perform required site activities, including documentation and maintenance activities.

3.0 CASTNET SITES VISITED – 2007

This report covers the CASTNET sites audited in 2007. From February through November 2007, EEMS conducted field performance and systems audits at forty-four monitoring locations on forty-six individual monitoring stations. Thirty-one of the sites visited were EPA sponsored and fifteen sites were NPS sponsored. The locations and dates of the audits are presented in Table 3.1.

Table 3.1 Site Audits - 2007

Site ID	Sponsor Agency	Site Location	Visit dates
ALC188	EPA	Alabama-Coushatta	February 20
BBE401	NPS	Big Bend NP	February 22
CAD150	EPA	Caddo Valley	February 25
CHE185	EPA	Cherokee Nation	February 27
CVL151	EPA	Coffeeville	March 2
CDZ171	EPA	Cadiz	March 3
MAC426	NPS	Mammoth Cave NP	March 5
MCK231	EPA	Mackville (precision site)	March 7
MCK131	EPA	Mackville	March 7
DEV412	NPS	Death Valley NM	April 16
LAV410	NPS	Lassen Volcanic NP	April 19
YOS404	NPS	Yosemite NP	April 23
PIN414	NPS	Pinnacles NM	April 25
SEK430	NPS	Sequoia NP - Ash Mountain	April 27
CKT136	EPA	Crockett	May 19
DCP114	EPA	Deer Creek St. Park	May 20

Site ID	Sponsor Agency	Site Location	Visit dates
OXF122	EPA	Oxford	May 22
QAK172	EPA	Quaker City	May 31
GTH161	EPA	Gothic	June 7
ROM206	EPA	Rocky Mountain NP	June 9
ROM406	NPS	Rocky Mountain NP (NPS)	June 10
CNT169	EPA	Centennial	June 13
PND165	EPA	Pinedale	June 15
YEL408	NPS	Yellowstone NP	June 16
VIN140	EPA	Vincennes	July 16
ALH157	EPA	Alhambra	July 17
KNZ184	EPA	Konza Prairie	July 20
SAN189	EPA	Santee Sioux	July 24
STK138	EPA	Stockton	July 26
BVL130	EPA	Bondville	July 29
PRK134	EPA	Perkinstown	August 17
VOY413	NPS	Voyageurs NP	August 20
THR422	NPS	Theodore Roosevelt NP	August 22
WNC429	NPS	Wind Cave NP	August 23
GLR468	NPS	Glacier NP	August 27
VPI120	EPA	Horton Station	September 21
PED108	EPA	Prince Edward	September 22
GRS420	NPS	Great Smoky Mountains NP	September 24
BWR139	EPA	Blackwater NWR	October 8
WSP144	EPA	Washington Crossing St. Park	October 10

Site ID	Sponsor Agency	Site Location	Visit dates
CND125	EPA	Candor	October 14
BFT142	EPA	Beaufort	October 16
CDR119	EPA	Cedar Creek St. Park	November 5
PAR107	EPA	Parsons	November 6
LRL117	EPA	Laurel Hill St. Park	November 9
SHN418	NPS	Shenandoah NP - Big Meadows	November 12

4.0 PERFORMANCE AUDIT RESULTS

Table 4.1 summarizes the number of test failures by variable tested. All test results are those recorded from the site's primary logger. Any back-up dataloggers encountered were disregarded since they are no longer maintained and supported at the CASTNET sites. Some conditions that were encountered that impact data accuracy but are not part of the performance tests are also included in the summary. Those conditions include temperature sensor blower function, wind speed cup or propeller integrity, flow system leak tests, and sensor siting criteria.

It is significant to point out that all but three of the variable test results summarized in table 4.1 improved from the audit results of 2006. Only the results for wind direction staring torque, wind speed starting torque, and temperature showed no improvement since 2006.

Performance audit results are discussed for each variable in the following sections. Tables are included to summarize the average and maximum error between the audit challenges and site results as recorded by the on-site Data Acquisition System (DAS). Linear regression and percent difference (% diff) calculation results are included where appropriate. Results that are outside the CASTNET QAPP acceptance criteria are shaded in the tables.

The errors presented in the tables in the following sections, are reported as the difference of the measurement recorded by the DAS and the audit standard. Where appropriate, negative values indicate readings that were lower than the standard, and positive values are readings that were above the standard value. The errors appear to be random, and without bias. The results are also arranged by audit date. Viewing the results in this order helps to detect any errors that could have been caused by the degradation or drift of the audit standards during the year. The audit standards are transported and handled with care, and properly maintained to help prevent such occurrences. No problems with the standards were apparent during the year. All standards were within specifications when re-certified at the end of the year.

Detailed reports of the field site audits, which contain all of the test points for each variable at each site, can be found in Appendix 1. The variable specific data forms included in Appendix 1 for each site contain the challenge input values, the output of the DAS, additional relevant information pertaining to the variable and equipment, and all available means of identification of the sensors and equipment.

Table 4.1 Performance Audit Results by Variable Tested

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Ozone	46	4	8.7
Flow Rate	46	3	6.5
Wind Direction Orientation Average Error	46	5	10.9
Orientation Maximum Error	46	15	32.6
Wind Direction Linearity Average Error	46	1	2.2
Linearity Maximum Error	46	3	6.5
Wind Direction Starting Torque	46	4	8.7
Wind Speed Low Range Average Error	46	0	0.0
Low Range Maximum Error	46	1	2.2
Wind Speed High Range Average Error	46	2	4.3
High Range Maximum Error	46	4	8.7
Wind Speed Starting Torque	46	10	21.7
Temperature	46	4	8.7
2 Meter Temperature	4	0	0.0
Delta Temperature	42	3	7.1
Relative Humidity Low Range	46	0	0.0

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Relative Humidity High Range	46	13	28.3
Solar Radiation	46	9	19.6
Precipitation	46	2	4.3
Surface Wetness	46	1	2.2
DAS Analog to Digital	46	1	2.2
DAS Battery Backup	32	1	3.1

4.1 Ozone

Forty-six ozone analyzers were audited during 2007. Each was challenged with ozone-free air and four up-scale concentrations. Two challenges were in the range of 30 – 80 ppb, and one in each of the ranges of 150 – 200 ppb, and 360 – 450 ppb. The ozone test gas concentrations were generated and measured with a NIST-traceable standard that was certified quarterly by USEPA. Certifications took place at Region 4 on two separate occasions, and once each at Region 7 and Research Triangle Park. Of the 46 analyzers tested, four were outside the acceptance criteria of ≤ ±10.0% of the test gas concentration, two were outside the slope acceptance criteria, and two were outside the intercept acceptance criteria established in the CASTNET QAPP. The results are presented in Table 4.2. Overall only four analyzers of the forty-six audited (8.7%) did not meet acceptance criteria.

4.2 Flow Rate

The dry deposition filter pack sampling system flow rates at all forty-six sites were audited. A NIST-traceable dry-piston primary flow rate device was used for the tests. Only three, or 6.5% of the systems checked were outside the acceptance criterion of ± 5.0%. The results are summarized in Table 4.2.

Two other systems (MCK131 and YOS404) were not operating at the target flow rate. The filter pack flow system was repaired after the audit at site YOS404 by the site operator during a routine site visit with assistance from the field operations staff. A subsequent check of the flow system indicated that it was accurate and at the target rate following the repair.

Table 4.2 Performance Audit Results for Ozone and Flow Rate

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
ALC188	2.9	-7.3	1.0197	-3.6309	0.99999	1.497	1.50	0.20
BBE401	2.0	2.6	1.03099	-2.0992	0.99999	3.067	2.99	-2.52
CAD150	2.3	-2.6	0.9777	-0.16614	1.00000	1.522	1.50	-1.45
CHE185	1.8	5.7	0.99484	1.74574	0.99999	1.475	1.49	0.99
CVL151	0.5	1.2	0.99806	0.68462	1.00000	1.518	1.51	-0.55
CDZ171	0.9	-1.9	1.00982	-1.19579	0.99999	1.556	1.50	-3.57
MAC426	2.2	3.3	1.00698	2.36829	0.99995	1.560	1.52	-2.35
MCK231	1.7	-4.2	0.99221	-0.48105	0.99999	1.506	1.49	-1.06
MCK131	1.9	-2.4	0.97748	0.22104	1.00000	0.685	**0.69***	0.67
DEV412	1.0	-1.7	1.01934	-1.78435	1.00000	3.062	3.00	-2.04
LAV410	1.3	-1.8	1.01348	-1.34582	0.99999	3.105	3.01	-3.07
YOS404	2.9	3.9	1.01369	1.66905	0.99999	2.086	**1.99***	-4.83
PIN414	0.4	-0.8	0.99141	0.83969	0.99999	3.041	3.00	-1.34
SEK430	2.7	-4.5	0.98403	-0.87094	0.99999	3.050	3.00	-1.62
CKT136	1.4	-1.9	0.98012	0.48643	1.00000	1.531	1.49	-2.69
DCP114	2.3	-3.9	0.95352	3.17744	0.99999	1.480	1.51	2.05
OXF122	1.5	-1.9	0.97651	1.62077	1.00000	1.490	1.51	1.36
QAK172	3.5	-3.8	0.9682	-0.18906	1.00000	1.502	1.50	-0.16

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
GTH161	2.5	-4.1	0.95199	2.87594	1.00000	2.941	3.01	2.33
ROM206	2.2	-3.2	0.96286	1.97795	1.00000	2.953	3.00	1.59
ROM406	0.9	-1.6	0.98948	1.12349	0.99996	3.214	3.01	**-6.35**
CNT169	5.5	-5.8	0.94734	0.41464	0.99997	2.984	3.00	0.52
PND165	3.8	-4.3	0.95573	1.32241	0.99998	2.953	3.01	1.93
YEL408	2.7	-4.4	0.95244	2.01124	1.00000	3.021	**2.87***	**-5.01**
VIN140	6.8	**-10.8**	0.94878	0.05232	0.99988	1.540	1.50	-2.58
ALH157	**11.4**	**-12.4**	**0.87949**	0.85759	0.99996	1.485	1.51	1.72
KNZ184	1.5	-2.4	0.9780	0.41212	0.99999	2.987	3.00	0.44
SAN189	**26.2**	**-31.0**	**0.67791**	**5.3478**	1.00000	3.019	3.00	-0.62
STK138	0.2	0.2	1.0024	-0.1516	1.00000	1.522	1.50	-1.42
BVL130	1.3	-1.9	0.97635	1.18729	0.99999	1.509	1.50	-0.62
PRK134	1.0	2.0	1.02263	-1.23134	1.00000	1.479	1.50	1.44
VOY413	1.1	1.5	1.01649	-0.76836	1.00000	3.024	3.00	-0.80
THR422	1.4	-2.4	0.99121	-0.31347	1.00000	3.137	3.02	-3.73
WNC429	5.7	-8.3	0.91475	2.91868	0.99986	3.281	3.10	**-5.53**
GLR468	1.3	-2.4	1.01326	-1.50117	1.00000	3.084	3.00	-2.72
VPI120	0.5	-1.1	0.99529	-0.11463	1.00000	1.503	1.51	0.71
PED108	1.1	2.6	0.99576	1.41115	1.00000	1.480	1.50	1.33
GRS420	2.2	2.6	1.02202	-0.21563	1.00000	3.158	3.00	-5.00
BWR139	0.2	-0.5	0.99369	0.70676	1.00000	1.543	1.50	-2.76
WSP144	3.8	-4.9	0.96903	-1.10959	0.99999	1.486	1.50	0.94
CND125	0.1	0.2	1.00018	-0.6259	0.99999	1.500	1.50	0.00
BFT142	1.4	-2.6	1.0019	-1.67385	1.00000	1.514	1.49	-1.56

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
CDR119	5.2	**13.0**	0.9647	**6.5346**	1.00000	1.485	1.50	1.03
PAR107	1.3	2.5	0.98218	1.32736	1.00000	1.490	1.50	0.69
LRL117	1.2	2.5	0.99008	1.57819	1.00000	1.576	1.50	-4.84
SHN418	1.4	2.6	0.99675	2.04913	0.99999	1.502	1.50	-0.11

* **Note:** The filter pack sampling system was not operating at the target flow rate.

4.3 Wind Speed

The wind speed sensors at all forty-six sites equipped for meteorological measurements were audited. When the acceptance criteria are applied to the average error of the wind speed sensors tests, two sensors are outside acceptance criteria. However, the CASTNET QAPP states that the acceptance criteria are applied to any test value. If the acceptance criteria are applied to the maximum error observed for each sensor, the number of failures increases to five. The results of the wind speed performance audits are presented in Table 4.3.

4.3.1 Wind Speed Starting Threshold

The condition of the wind speed bearings was evaluated as part of the performance audits. The data acceptance criterion for wind speed bearing torque is not defined in the QAPP. However, ***Appendix 1: CASTNET Field Standard Operating Procedures***, states that the wind speed bearing torque should be ≤ 0.2 g-cm. To establish the wind speed bearing torque criterion for audit purposes the rational described in the QAPP for data quality objectives (DQO) was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically field criteria are set at approximately one-half the DQO. Therefore, 0.5 g-cm was used for the acceptance limit for audit purposes. This value is within the manufacture's specifications for a properly maintained system. Ten of the sites had wind speed sensors with bearing starting torque measured to be 0.5 g-cm or higher.

4.4 Wind Direction

Two separate tests were performed to evaluate the accuracy of each wind direction sensor. A linearity test was performed to evaluate the ability of the sensor to function properly and accurately throughout the range from 1 to 360 degrees. This test evaluates the sensor independently of orientation and can be performed with the sensor mounted on a test fixture. A separate orientation test was used to determine if the sensor was installed and operating properly aligned to measure wind direction accurately in degrees true. An audit standard compass was used to perform the orientation tests.

Using the average error of the orientation tests for each of the forty-six sensors tested, five were outside the acceptance criterion of ± 5 degrees. Of the forty-six sensors tested for linearity, the results were considerably better with only one test average outside the acceptance limit. However, the CASTNET QAPP states that the acceptance criteria are applied to any test value. When the acceptance criteria are expanded to include the maximum errors observed for each sensor, the number of failures increases to fifteen for orientation and three for linearity. The results of the wind direction performance audits are presented in Table 4.3.

4.4.1 Wind Direction Starting Threshold

The condition of the wind direction bearings was evaluated as part of the performance audits. The data acceptance criterion for wind direction bearing torque is not defined in the QAPP. However, ***Appendix 1: CASTNET Field Standard Operating Procedures***, states that the wind direction bearing torque should be ≤ 10 g-cm for R. M. Young sensors. The manufacturer states that a properly maintained sensor will be accurate up to a starting threshold of 11 g-cm. To establish the wind direction bearing torque criterion for audit purposes the rational described in the QAPP for data quality objectives (DQO) was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically field criteria are set to approximately one-half the DQO. For audit purposes 20 g-cm was used for the acceptance limit for R. M. Young sensors. Climatronics sensors typically have a lower starting torque. For audit purposes a threshold of 10 g-cm was selected for Climatronics sensors.

Four of the forty-six wind direction sensors that were tested for starting threshold torque were found to be above the audit criteria. The test results are provided in Table 4.3. One of the four sensors (at site CKT136) was found to be assembled with the wind direction vane thumb-wheel misaligned and contacting the potentiometer assembly. This condition caused the vane to stop at that position in the rotation. The starting threshold was the torque required to move the vane past that position.

Table 4.3 Performance Audit Results for Wind Sensors

Site	Wind Direction					Wind Speed				
	Orientation Error		Linearity Error		Starting Torque (g-cm)	Low Range Error		High Range Error		Starting Torque (g-cm)
	Ave (deg)	Max (deg)	Ave (deg)	Max (deg)		Ave (m/s)	Max (m/s)	Ave (% diff)	Max (% diff)	
ALC188	4.0	**6***	0.2	1	15	0.13	0.31	0.5	0.8	**0.6**
BBE401	4.4	**6***	1	2	9	0.01	0.03	0.3	0.3	0.3
CAD150	4.2	**7***	1.5	3	7.5	0.03	0.08	0.7	1.6	0.2
CHE185	2.5	5	1.8	4	17.5	0.30	**0.67***	0.8	1.5	0.3
CVL151	1.6	3	1	4	5	0.04	0.10	0.3	0.4	0.2
CDZ171	0.3	1	0.8	2	7.5	0.08	0.10	0.3	1.0	0.3
MAC426	0.8	2	1.3	3	7.5	0.01	0.02	0.1	0.2	0.2
MCK231	1.8	4	1.5	4	12.5	0.11	0.18	0.5	1.0	0.3
MCK131	2.3	4	1.3	2	9	0.16	0.24	0.9	1.9	0.3
DEV412	2.8	5	1	2	6.5	0.02	0.03	0.5	0.7	0.4
LAV410	4.8	**6***	1	3	9	0.06	0.12	1.3	1.6	0.2
YOS404	2.2	3	1	2	5	0.04	0.08	1.8	1.8	0.2
PIN414	3.8	4	1.3	2	5	0.01	0.01	0.5	0.5	**0.5**
SEK430	1.3	2	0.8	2	9	0.06	0.19	0.3	0.7	0.4
CKT136	1.8	2	0.5	1	**35**	0.13	0.28	1.5	2.3	0.3
DCP114	3.3	**6***	1.8	5	9	0.08	0.15	0.8	1.1	0.2
OXF122	1.8	3	1	2	5	0.01	0.03	0.3	0.6	0.2
QAK172	3.5	**6***	0.8	1	10	0.06	0.10	2.2	3.0	0.3

Site	Wind Direction					Wind Speed				
	Orientation Error		Linearity Error		Starting Torque (g-cm)	Low Range Error		High Range Error		Starting Torque (g-cm)
	Ave (deg)	Max (deg)	Ave (deg)	Max (deg)		Ave (m/s)	Max (m/s)	Ave (% diff)	Max (% diff)	
GTH161	1.5	3	0.8	2	6.5	0.36	0.48	4.2	**7.1***	0.3
ROM206	**42.7**	**47***	1.3	3	6.5	0.08	0.10	2.4	2.6	0.3
ROM406	1.3	2	1	3	6.5	0.16	0.26	**5.2**	**6.0***	0.3
CNT169	2.5	3	0.5	2	5	0.08	0.18	1.5	2.3	0.3
PND165	3	4	0.8	1	6.5	0.12	0.30	1.2	1.5	**1.2**
YEL408	2.4	5	1.8	4	6.5	0.07	0.20	0.5	1.1	0.3
VIN140	3	4	1	2	6.5	0.01	0.03	0.2	0.6	0.2
ALH157	1.8	5	1.5	4	6.5	0.01	0.03	0.5	0.9	0.3
KNZ184	2.5	4	1.3	2	11.5	0.11	0.18	1.1	1.6	0.3
SAN189	**5.5**	**8***	1.3	3	12.5	0.07	0.10	0.4	0.7	**0.7**
STK138	4.5	**6***	1.5	4	14	0.14	0.30	4.6	5.0	0.4
BVL130	1.4	2	2.3	4	5.5	0.05	0.10	0.5	1.5	0.1
PRK134	**22.8**	**45***	**13.3**	**53***	18	0.17	0.30	**6.5**	**7.2***	**0.5**
VOY413	1.8	4	1.5	3	6.5	0.02	0.03	0.4	0.5	**0.7**
THR422	1.2	2	1	3	**12**	0.01	0.02	1.0	1.1	**0.6**
WNC429	5	**8***	2	4	14	0.33	0.50	2.3	**7.5***	**0.8**
GLR468	**5.8**	**7***	0.8	3	8.5	0.05	0.20	0.0	0.0	**0.5**
VPI120	1.4	2	1	3	8	0.01	0.03	0.1	0.3	0.3
PED108	3	**7***	2.8	**8***	6.5	0.09	0.13	0.1	0.3	0.2
GRS420	2	2	0.8	2	9	0.09	0.15	0.7	1.3	**0.5**
BWR139	3.3	4	0.3	1	9	0.12	0.30	0.7	1.0	0.4
WSP144	5	**7***	1.8	3	**30**	0.06	0.10	1.0	1.4	0.4
CND125	**14.2**	**17***	1.8	5	5	0.07	0.12	3.3	3.6	0.2

Site	Wind Direction					Wind Speed				
	Orientation Error		Linearity Error		Starting Torque (g-cm)	Low Range Error		High Range Error		Starting Torque (g-cm)
	Ave (deg)	Max (deg)	Ave (deg)	Max (deg)		Ave (m/s)	Max (m/s)	Ave (% diff)	Max (% diff)	
BFT142	1.3	3	0.8	2	**25.5**	0.19	0.30	4.1	4.3	0.4
CDR119	1	2	0.8	2	6	0.01	0.03	0.1	0.3	0.4
PAR107	1	2	1	3	8	0.12	0.17	0.8	1.6	0.4
LRL117	1	1	1	3	4	0.04	0.10	0.2	0.6	0.4
SHN418	2.2	5	1.8	**7***	4.5	0.01	0.02	0.4	0.5	0.2

* **Note:** The wind systems acceptance criteria were applied to the average of the results. The data validation section of the CASTNET QAPP states that if any wind direction or wind speed challenge result is outside the acceptance criterion the variable is flagged. Maximum error values outside criteria and systems that fail for other reasons are denoted.

4.5 Temperature, Two Meter Temperature, and Delta Temperature

The temperature measurement systems at all forty-six sites equipped to measure meteorological variables consist of a temperature sensor mounted at 9 meters on the meteorological tower. Forty-two of those sites employed a second sensor to measure delta temperature, or temperature difference, between the 9-meter sensor and a second sensor mounted at approximately 2 meters from the ground. R. M. Young systems calculate delta temperature as the upper sensor minus the lower sensor, and Climatronics systems calculate delta temperature as the lower sensor minus the upper sensor.

Four of the forty-six sites utilized a sensor to measure temperature at approximately two meters from the ground (2-meter temperature). It is assumed that delta temperature at these four sites is calculated as part of the data management process and the result of that calculation is not recorded on-site.

All of the sites use shields to house the sensors that are designed to be mechanically aspirated with forced air blowers. The sensors were removed from the sensor shields, and placed in a uniform temperature bath with a precision NIST-traceable RTD, during the audit.

All of the NPS sponsored sites with Climatronics systems were configured to report the delta temperature as the upper sensor minus the lower, by reversing the zero and full-scale settings for the delta temperature channel in the DAS configuration. This is not a problem provided the data validation procedures account for the system configuration. This is a difference from the EPA sponsored site configuration.

Results of the tests indicate that all but three temperature sensors were within the acceptance criterion. All of the 2-meter temperature sensors were within criterion. Two of the delta temperature sensors were found to be outside the acceptance criterion. The average errors for all sensors are presented in Table 4.4.

4.5.1 Temperature Shield Blower Motors

The lower blower (delta temperature) at site PRK134 was found to be not functioning. Since this causes inaccurate measurements, this was considered a failed system in Table 4.1.

4.6 Relative Humidity

The relative humidity systems at the sites were tested with a combination of primary standard salt solutions, and a certified transfer standard relative humidity probe. The results of the average and maximum errors for low range tests (RH ≤ 85.0 %) and results of the average error for high range tests (RH > 85.0 %) are presented in Table 4.4.

The relative humidity measurement being made at each of the forty-six sites equipped for meteorological measurements is provided by a sensor supplied by any one of three different manufactures. At EPA sponsored sites with R. M. Young equipment, humidity sensors are operating in naturally aspirated shields. At EPA sponsored sites with Climatronics equipment, humidity sensors are operating in shields designed to be mechanically aspirated with forced-air blowers. All of the NPS sponsored sites operate humidity sensors in shields that are designed to be mechanically aspirated with forced-air blowers.

During audit tests with the primary standard salt solutions, the sensors were removed from the shields and placed in a temperature controlled enclosure. During audit tests with the transfer standard probe, the sensor and transfer were placed in the same ambient conditions. Therefore the audit tests do not account for differences in the operation of the sensors due to shield configurations.

Thirteen of the sensors were outside the acceptance criterion when tested at 85% or higher relative humidity. The average errors for all sensors were within the acceptance criterion below 85%. Only two sensors were outside the acceptance criterion when the maximum error below 85% was evaluated. The results of the tests are included in Table 4.4.

Table 4.4 Performance Audit Results for Temperature and Humidity

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Delta Temperature Ave. Error (deg C)	Relative Humidity		
				Low Range		High Range
				Ave. Error (%)	Max. Error (%)	Ave. Error (%)
ALC188	0.39	0.07		7.7	14.3	1.4
BBE401	0.12		0.11	2.1	3.4	2.8
CAD150	**0.51**		0.01	8.4	10.7	2.1
CHE185	0.11	0.03		2.6	5.7	1.8
CVL151	0.21		0.02	2.3	-3.4	**5.4**
CDZ171	0.11		**2.10**	12.8	15.3	**8.2**
MAC426	0.15		0.26	5.7	6.4	4.8
MCK231	0.08		0.26	3.7	6.0	**6.2**
MCK131	0.07		0.06	4.3	4.9	3.9
DEV412	0.07		0.01	2.7	-4.0	4.2
LAV410	0.09		0.15	1.9	2.1	2.7
YOS404	0.17		0.02	3.3	5.0	0.8
PIN414	0.12		0.01	2.1	-3.3	3.3
SEK430	0.09		0.11	3.0	-4.2	3.7
CKT136	0.50		0.24	5.5	6.9	2.5
DCP114	0.08		0.04	2.7	3.5	2.0

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Delta Temperature Ave. Error (deg C)	Relative Humidity		
				Low Range		High Range
				Ave. Error (%)	Max. Error (%)	Ave. Error (%)
OXF122	0.12		0.02	2.9	-3.2	**6.2**
QAK172	0.15		0.13	1.1	1.9	3.2
GTH161	0.15		0.07	13.5	**29.6***	**6.6**
ROM206	0.18		0.02	2.9	4.9	1.5
ROM406	0.18		0.08	2.2	4.5	2.4
CNT169	**1.18**		0.27	4.8	5.6	3.3
PND165	0.11		0.13	0.9	1.3	**7.0**
YEL408	0.13		0.21	3.2	3.4	**7.5**
VIN140	0.04		0.04	18.8	**21.8***	2.8
ALH157	0.15		0.04	1.9	-3.5	**10.3**
KNZ184	0.06	0.08		4.3	6.4	3.3
SAN189	0.23	0.29		6.5	-7.5	**11.3**
STK138	0.19		0.13	1.6	1.8	0.3
BVL130	0.06		0.02	1.1	-2.3	**5.1**
PRK134	0.36		**0.05****	2.3	2.6	0.8
VOY413	0.07		0.05	4.4	7.1	1.7
THR422	0.11		0.03	2.3	5.0	0.2
WNC429	**1.61**		**2.00**	4.2	5.4	0.4
GLR468	0.37		0.07	3.8	7.9	4.7
VPI120	0.10		0.16	14.9	16.3	1.2
PED108	0.23		0.18	3.0	-3.5	**6.9**
GRS420	0.22		0.15	4.9	5.3	4.8
BWR139	0.31		0.03	3.0	4.4	4.7

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Delta Temperature Ave. Error (deg C)	Relative Humidity		
				Low Range		High Range
				Ave. Error (%)	Max. Error (%)	Ave. Error (%)
WSP144	0.14		0.05	10.6	13.2	**7.5**
CND125	0.09		0.08	1.3	-1.4	2.0
BFT142	0.40		0.03	5.3	9.8	4.7
CDR119	0.13		0.15	6.2	6.2	3.3
PAR107	0.37		0.38	3.7	-5.2	4.7
LRL117	0.20		0.05	2.3	4.0	**5.8**
SHN418	0.28		0.12	1.6	-1.9	1.4

* **Note:** The humidity system acceptance criteria were applied to the average of the results. The data validation section of the CASTNET QAPP does not indicate if the criterion applies to the average error or any error values. Maximum error failures are denoted.

** **Note:** Shield blower failures.

4.7 Solar Radiation

The ambient conditions encountered during the audit visits were suitable, with high enough light levels for accurate comparisons. A NIST-traceable Eppley PSP and translator were used as the audit standard system.

One solar radiation system (at site PRK134) was not operating during the site audit visit due to damage from an electrical storm. Seven of the forty-six sites had results that were outside the acceptance criterion. Two sites are operating sensors that are poorly sited and shaded by trees or other obstructions. Neither of these sites had test results that were outside acceptance criterion. However, the siting conditions were considered to be affecting data quality and therefore the sites are included in the summary results in Table 4.1. Photographs of all the sensors that are poorly sited (CAD150 and CVL151) are included in the systems reports in Appendix 1. The results of the individual tests for each site are included in Table 4.5.

4.8 Precipitation

All forty-six meteorological sites audited used a tipping bucket rain gauge for the obtaining precipitation measurement data. The audit challenges consisted of entering multiple amounts of a known volume of water into the tipping bucket funnel at a rate equal to approximately 2 inches of rain per hour. Equivalent amounts (mm at NPS sites and inches at EPA sites) of water entered were compared to the amount recorded by the DAS. All but one system (at site DCP114) were within the acceptable criterion. The results are summarized in Tables 4.5.

Two sites (SAN189 and ALC188) have tipping bucket rain gauges with heaters that are malfunctioning. Both of the heaters are operating at a temperature that is much too high. Precipitation could be evaporated from the surface of the funnel when the heater is activated. This condition is likely to have a minimal affect on data accuracy and therefore these sites are not included in the summary results found in Table 4.1.

Another site (CDZ171) has a bent and damaged tipping bucket funnel. This does affect the surface area for collection and therefore data quality. This variable was included as a system failure in Table 4.1.

4.9 Surface Wetness

The acceptance criteria established for the surface wetness sensors used at the CASTNET sites requires the sensor has a positive response from a condition of dry to a condition of wet. All but one of the sensors tested exhibited a positive response to a wet condition. This sensor at site DCP114 had a very weathered grid and only responded to water placed near the post connections, and not when one drop was placed in the center of the grid. The condition of this sensor was considered to negatively affect data quality and that result is included in Table 4.1.

In the CASTNET QAPP, ***Appendix 1: CASTNET Field Standard Operating Procedures***, a regular maintenance and calibration procedure is described for the surface wetness sensor. The procedure is a sensitivity adjustment intended to provide consistent response from the surface wetness sensors at all of the CASTNET sites. The procedure requires that a decade resistance device be installed in a test-jack fixture within the surface wetness sensor circuit to by-pass the sensor grid. Then, to adjust the sensor response to the specifications provided, independent of the response to a wet condition. This test was performed during the audits to determine if the sensor responded within the specified range of 235 to 245 k ohms.

Since there are no DQO identified for the sensitivity tests, they are not considered in the evaluation of data quality. The results are presented in Table 4.5 as the resistance required for the sensor response to change from dry to wet (on), and from wet to dry (off). As stated in the paragraph above, all of the sensors responded when the grid surface was wet, and most were near the specified sensitivity.

Table 4.5 Performance Audit Results for Solar Radiation, Precipitation, and Surface Wetness

Site	Solar Radiation Error				Precipitation Ave. Error (% diff)	Surface Wetness	
	Daytime Ave. (% diff)	Max. Value (w/m2)	Max. Observed (w/m2)	Max. Value (% diff)		Sensitivity On (k ohm)	Sensitivity Off (k ohm)
ALC188	3.0	191	186	-2.6	3.0	1200	1100
BBE401	0.4	644	643	-0.2	1.5	230	220
CAD150	6.1	801	797	-0.5	1.5	260	250
CHE185	**26.8**	785	549	**-30.1**	5.0	210	200
CVL151	3.0	830	825	-0.6	2.0	210	200
CDZ171	**12.7**	802	688	**-14.2**	**3.3***	210	200
MAC426	8.8	782	700	**-10.5**	3.0	240	230
MCK231	5.9	748	762	1.9	4.0	110	100
MCK131	5.3	748	762	1.9	2.0	270	260
DEV412	7.7	928	973	4.8	4.0	190	180
LAV410	2.6	900	877	-2.6	4.0	180	170
YOS404	6.2	1013	938	-7.4	0.0	260	250
PIN414	3.8	975	926	-5.0	1.5	200	190
SEK430	5.6	963	908	-5.7	2.2	200	190
CKT136	0.9	1003	1003	0.0	9.0	190	180

Site	Solar Radiation Error				Precipitation Ave. Error (% diff)	Surface Wetness	
	Daytime Ave. (% diff)	Max. Value (w/m2)	Max. Observed (w/m2)	Max. Value (% diff)		Sensitivity On (k ohm)	Sensitivity Off (k ohm)
DCP114	2.3	932	939	0.8	**13.3**	170	160
OXF122	3.5	937	968	3.3	4.0	150	140
QAK172	5.3	689	700	1.6	2.0	140	130
GTH161	**24.5**	577	711	**23.2**	6.0	140	130
ROM206	1.3	1022	1002	-2.0	1.0	190	180
ROM406	1.7	1022	1011	-1.1	4.0	310	300
CNT169	2.5	1092	1059	-3.0	3.0	130	120
PND165	1.4	1011	990	-2.1	2.0	160	150
YEL408	2.3	932	897	-3.8	5.0	200	190
VIN140	4.0	959	878	-8.4	2.7	480	470
ALH157	6.0	968	995	2.8	3.0	170	160
KNZ184	2.1	789	784	-0.6	2.0	170	160
SAN189	3.2	905	865	-4.4	6.0	220	210
STK138	**17.0**	836	628	**-24.9**	5.0	190	180
BVL130	2.0	857	847	-1.2	2.0	260	250
PRK134	**99.9**	759	1	**-99.9**	2.0	**NP***	**NP***
VOY413	1.8	410	400	-2.4	3.3	210	200
THR422	8.6	422	379	**-10.2**	4.0	410	400
WNC429	6.3	755	669	**-11.4**	4.0	170	160
GLR468	4.4	530	527	-0.6	2.0	210	200
VPI120	1.4	533	541	1.5	1.3	170	160
PED108	6.3	684	692	1.2	8.0	140	130
GRS420	5.1	751	714	-4.9	1.0	210	200
BWR139	4.8	677	635	-6.2	2.0	370	360

Site	Solar Radiation Error				Precipitation Ave. Error (% diff)	Surface Wetness	
	Daytime Ave. (% diff)	Max. Value (w/m2)	Max. Observed (w/m2)	Max. Value (% diff)		Sensitivity On (k ohm)	Sensitivity Off (k ohm)
WSP144	2.1	326	325	-0.3	5.0	260	250
CND125	9.3	740	663	**-10.4**	1.0	220	210
BFT142	1.9	568	552	-2.8	4.0	180	170
CDR119	**17.3**	476	453	-4.8	3.0	230	220
PAR107	6.9	395	393	-0.5	2.0	280	270
LRL117	7.8	222	226	1.8	2.0	250	240
SHN418	**10.8**	524	530	1.1	3.0	**NP***	**NP***

* **Note:** NP = not performed due to system failure or test-jack not present.
** **Note:** Tipping bucket funnel damaged.

4.10 Data Acquisition Systems (DAS)

All of the NPS sponsored sites visited utilize an ESC logger as the primary and only DAS. Three of the EPA sponsored sites visited, CND125, PRK134, and SAN189 use loggers manufactured by H2NS. Five EPA sites visited operate ESC loggers. The remainder, and majority of the EPA sponsored sites visited use Odessa dataloggers as the primary DAS. . Four of the EPA sponsored sites visited also use an Odessa logger as a backup DAS. The backup DAS are no longer supported and maintained at the sites and therefore no audit results are reported for backup logger systems. The results presented in tables 4.1 and 4.6 include the tests performed on the primary logger at each site.

4.10.1 Analog Tests

The accuracy of each primary logger was tested on two different channels with a NIST-traceable Fluke digital voltmeter. One logger (at site CKT136) was outside the acceptance criterion of ± 0.003 volts.

4.10.2 Functionality Tests

Other performance tests used to evaluate the DAS included the verification of the date and time, and operation of the battery backup system used to save the DAS date, time, and configuration during a power outage. The results of these tests are included in Table 4.6.

All DAS were set to the correct date; however two loggers were outside the acceptance criterion for time, of ± 5 minutes. One of those (VIN140) was not using local standard time.

Several battery back-up systems were not tested. Only one of the dataloggers (site OXF122) failed the battery back-up test. The datalogger at site ALH157 also reset during a brief power outage, although the battery system was tested and functioning.

Table 4.6 Performance Audit Results for Data Acquisition Systems

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)	Battery Test (pass/fail)
	Low Channel		High Channel				
	Average	Maximum	Average	Maximum			
ALC188	0.0002	0.0006	0.0002	0.0005	Y	**9.63**	P
BBE401	0.0002	0.0002	0.0002	0.0002	Y	0.33	P
CAD150	0.0002	0.0004	0.0002	0.0004	Y	2.08	P
CHE185	0.0002	0.0003	0.0001	0.0002	Y	3	not tested
CVL151	0.0010	0.0017	0.0010	0.0017	Y	0.58	P
CDZ171	0.0005	0.0014	0.0005	0.0014	Y	1.37	P
MAC426	0.0014	0.0012	not tested	not tested	Y	0.13	P
MCK231	0.0004	0.0008	0.0004	0.0008	Y	0.75	P
MCK131	0.0007	0.0013	0.0007	0.0013	Y	0.75	P
DEV412	0.0001	0.0001	0.0001	0.0001	Y	0.58	P
LAV410	0.0001	0.0002	0.0001	0.0003	Y	0.42	P
YOS404	0.0001	0.0001	0.0001	0.0002	Y	0.88	not tested

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)	Battery Test (pass/fail)
	Low Channel		High Channel				
	Average	Maximum	Average	Maximum			
PIN414	0.0003	0.0006	0.0001	0.0002	Y	0.17	P
SEK430	0.0001	0.0002	0.0001	0.0002	Y	0.2	P
CKT136	**0.0035**	**0.0050**	0.0009	0.0017	Y	1.07	P
DCP114	0.0003	0.0008	0.0005	0.0009	Y	2.28	P
OXF122	0.0003	0.0010	0.0003	0.0010	Y	1.62	**Fail**
QAK172	0.0018	0.0020	0.0018	0.0020	Y	0.53	P
GTH161	0.0001	0.0002	0.0001	0.0003	Y	0.08	P
ROM206	0.0011	0.0020	0.0011	0.0020	Y	0.28	P
ROM406	0.0001	0.0002	0.0001	0.0002	Y	0.82	not tested
CNT169	0.0001	0.0001	0.0001	0.0001	Y	0.75	not tested
PND165	0.0006	0.0013	0.0006	0.0013	Y	0.08	P
YEL408	0.0002	0.0004	0.0001	0.0002	Y	0.07	not tested
VIN140	0.0021	**0.0037**	0.0021	**0.0037**	Y	**59.67**	P
ALH157	0.0002	0.0007	0.0004	0.0008	Y	0.83	P
KNZ184	0.0000	0.0001	0.0001	0.0002	Y	0.25	not tested
SAN189	0.0006	0.0013	0.0004	0.0013	Y	0.33	not tested
STK138	0.0002	0.0003	0.0002	0.0003	Y	0.58	P
BVL130	0.0006	0.0010	0.0005	0.0008	Y	0.67	P
PRK134	0.0007	0.0013	0.0006	0.0013	Y	2.33	not tested
VOY413	0.0000	0.0001	0.0001	0.0001	Y	0.75	not tested
THR422	0.0001	0.0003	0.0001	0.0002	Y	0.4	not tested
WNC429	0.0001	0.0004	0.0003	0.0005	Y	0.17	not tested
GLR468	0.0006	0.0009	0.0002	0.0004	Y	1	P
VPI120	0.0005	0.0013	0.0006	0.0013	Y	1.28	P

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)	Battery Test (pass/fail)
	Low Channel		High Channel				
	Average	Maximum	Average	Maximum			
PED108	0.0003	0.0008	0.0002	0.0004	Y	1.45	P
GRS420	0.0001	0.0003	0.0001	0.0002	Y	0.47	not tested
BWR139	0.0002	0.0007	0.0002	0.0003	Y	1.45	P
WSP144	0.0002	0.0007	0.0002	0.0007	Y	0.55	P
CND125	0.0002	0.0004	0.0003	0.0014	Y	1	not tested
BFT142	0.0027	**0.0040**	0.0021	**0.0030**	Y	2.28	P
CDR119	0.0002	0.0004	0.0002	0.0004	Y	2.42	P
PAR107	0.0002	0.0004	0.0005	0.0014	Y	0.93	P
LRL117	0.0028	**0.0036**	0.0003	0.0008	Y	0.22	P
SHN418	0.0001	0.0001	0.0001	0.0003	Y	1	not tested

5.0 SYSTEMS AUDIT RESULTS

The following sections summarize the site systems audit findings, and provide information observed regarding the measurement processes at the sites. Conditions that directly affect data accuracy have been reported in the previous sections. Other conditions that affect data quality and improvements to some measurement systems or procedures are suggested in the following sections.

5.1 Siting Criteria

All of the sites that were visited have undergone changes during the period of site operation which include population growth, road construction, and foresting activities. None of those changes were determined to have a significant impact on the siting criteria that did not exist when the site was initially established. Maps of each site with 1 kilometer, 5 kilometer, and 40 kilometer radius circles are provided in the systems reports in Appendix 1.

There are some inconsistencies within the QAPP between the site coordinates listed in the main section and those listed in Appendix 2 of the QAPP. The QAPP inconsistencies and the difference between the listed coordinates and those obtained with the audit Global Positioning System (GPS) are apparent in the 1 kilometer maps included in Appendix 1 of this report. One site (SEK430) had coordinates for a site that is no longer active instead of the current site location.

As described in the solar radiation performance evaluation section, two sites (CAD150 and CVL151) have problems regarding shading of the solar radiation sensors during certain times of the day. Photographs of the sensors and obstructions are included in the systems reports in Appendix 1. At some sites (OXF122, GRS420, SEK430, and VOY143) the lower temperature shield is mounted at a height other than two meters as described in the QAPP, or too close to the shelter.

Some sites that are located in state and national parks are not in open areas, and have trees within the 50 meter criterion established in the QAPP. Given the land use and aesthetic concerns, these sites are acceptable and represent an adequate compromise with regard to siting criteria and the goal of long-term monitoring.

5.2 Sample Inlets

As previously mentioned some sites have trees near the shelters and sample towers. This is more prevalent at NPS sites, particularly YEL408 and SEK430.

With consideration given to the siting criteria compromises described in the previous section, the rest of the analyzer sample trains are sited properly and in accordance with the CASTNET QAPP. The filter packs and ozone inlets are designed to sample from 10 meters. Teflon tubing of adequate diameter is used for the ozone inlets. Most of the filter pack sample lines are also Teflon. Inline filters are present in the sample trains. With the exception of sites THR422 and WNC429 the ozone zero, span, and precision calibration test gases are introduced at the ozone sample inlet, through all filters and the entire sample train.

5.3 Data Acquisition Systems

The performance test results of the DAS at the sites have been discussed in the previous sections. The inaccuracies within the DAS and their impact on data quality have been accounted for by recording each test measurement from the DAS. Other issues that are related to the DAS operation and field systems are presented here.

The H2NS dataloggers did not record the data status flag with the wind channels in the intermediate and final data average. Channels were marked as down during the audit but the flags did not appear on the recorded data. The analog channels on the H2NS logger at PRK134 exhibited interference between channels. A negative voltage input on one channel affected the recorded value on an adjacent channel. This is a problem since malfunctioning sensors can sometimes output negative voltage which may then affect other recorded data that may appear to be accurate and therefore go undetected.

5.4 Infrastructure

Some problems with the infrastructure at the sites were observed. These include the degradation of exposed signal and power cables as depicted in photographs included in the systems report in Appendix 1. This is common at sites particularly where protective conduit is not used. Some conduits are not sealed which allow insects and rodents to gain access and damage cables and connections.

Many of the shelters are showing signs of deterioration from moisture and water damage due to leaks and condensation. Most have signs of rot at the bottoms of the walls and in the corners of the floor. Many have loose or missing floor tiles. Some of the doors are damaged near the hinges and at the top.

5.5 Field Site Maintenance

Nearly all of the aspirated shields used at the sites were functioning and well maintained. Only a few of the shields were not properly maintained and found to be excessively dirty. However, the shields at site STK138 were not the proper type for the sensors installed. The sensors protruded out of the shields slightly and the sensors obstructed the air flow through the shields. Since the sensors were removed from the shields for the audit, it is unclear of the effect on the temperature and delta temperature data.

Other maintenance activities have been conducted during the year at the sites. The focus has been on repairing the shelters. Some leaks in roofs, and rotten floors and doors have been repaired. This is a major task and improvements to the shelters will be ongoing.

5.6 Site Operators

Generally the site operators are very conscientious and eager to complete the site activities correctly. They are willing to, and have performed sensor replacements and repairs at the sites with support provided by the MACTEC and ARS field operations centers. In some cases, where replacements or repairs were made, documentation of the activities was not complete, and did not include serial numbers of the removed and installed equipment

Many of the CASTNET site operators also perform site operator duties for the National Atmospheric Deposition Program (NADP). Many of the NPS site operators also perform other air, or environmental quality functions within their park. All are a valuable resource for the program. Some of the site operators mentioned that the CASTNET features in the NPS "Monitor" are informative, helpful, and appreciated.

Still many of the site operators have not been formally trained to perform the CASTNET duties by either MACTEC or ARS. They had been given instructions by the previous site operators and over the phone instructions from the field operation centers at MACTEC and ARS.

5.6.1 Site Operator Training Program

A new program was begun by MACTEC to address the site operator training concerns. It is the CASTNET Operator Refresher Training Course and had been provided to at least two of the site operators that were audited this year. Those sites were PAR107 and QAK172. Both site operators thought the program was an asset to the operation of the network and site operators.

5.7 Documentation

There were some documentation problems with the Site Status Report Forms (SSRF) completed by the site operators each week during the regular site visits. Common errors included incorrect completion of the "reasonable conditions" checks and improper reporting of "initial flow", "final flow", and "leak check" values. A few operators do not use the "chain-of-custody" label.

The site operator at PAR107 still continues to complete the SSRF on the day the filter is removed and not the day the filter is installed as stated in the QAPP, operator manuals, and training information.

Gloves are not consistently used to handle filter packs. One site operator uses one glove only to install the filter, and then stores it in the filter baggie to use again when the filter is removed. One improvement to filter handling that was observed was the replacement of the clean filter bags and caps at sites that were missing them. Those site operators no longer have to use the bag received to send the filter removed to the lab.

It was observed during the audits of 2007 that site documentation at the NPS sponsored sites has greatly improved over that of the audits of 2006. Previously little or no calibration records were available for review on-site. Procedures have been implemented at the NPS sites that provide complete site calibration and maintenance reports on the site computer.

The NPS site operator procedures are well developed and readily accessible at all of the NPS sites visited. There is an electronic interface, "DataView 2", available to view, analyze, and print site data. There are electronic "checklists" for the site operator to complete during the site visits; however, all of the CASTNET filter pack procedures are not included in the "checklists". Flow rates and leak check results are not recorded electronically.

An electronic logbook is included in the interface software. This system permits easy access to site documentation data. Complete calibration reports have been added to the system and accessible through the site computer.

5.8 Site Sensor and FSAD Identification

Improvement has also been made in the area of documentation of sensors and systems used at the sites. It is important to maintain proper sensor identification for the purposes of site inventory and to properly identify operational sensors for data validation procedures. Many sensors have had new numbers affixed for proper identification. There are some sensors still missing serial numbers and/or client ID numbers (EPA barcodes). Others have numbers that are illegible, so there is still room for improvement in this area. Better identification of the sensors will allow the better tracking and recording of maintenance procedures for the sensors.

Where possible the identification numbers assigned (serial numbers and barcodes) are used within the field site audit database for all the sensors encountered during the site audits. The records are used for both the performance and systems audits. If a sensor is not assigned a serial number by the manufacturer, that field is entered as "none". If it is unknown whether an additional client ID number is assigned to a sensor, and a number is not found, the client ID is also entered as "none". If it is typical for a manufacturer and/or client ID number to be assigned to a sensor, and that number is not present, the field is entered as "missing". If either the serial number or the client ID numbers cannot be read, the field is entered as "illegible". An auto-number field is assigned to each sensor in the database in order to make the records unique.

6.0 SUMMARY AND RECOMMENDATIONS

The CASTNET Site Audit Program has been successful in evaluating the field operations of the sites. The results of performance and systems audits are recorded and archived in a relational database, the Field Site Audit Database (FSAD). Most areas of CASTNET site operations are acceptable. Some differences between actual site operations and operations described in the QAPP have been identified and described. Procedural differences between EPA and NPS sponsored sites have also been described.

Many aspects of the field operations have improved during the last year. Most notable are the performance results discussed in section 4.0. Additional effort has been focused on the maintenance of the sites. Overall the sites visited in 2007 were found in better condition, and providing more accurate results than those visited in 2006. Nevertheless, there is room for further improvement.

As discussed previously the shelters have received some much needed attention. One area where some improvement is needed is the temperature control systems. The original air conditioners are failing and being replaced with units that are not properly sized or matched with the temperature control mechanisms. This has caused problems at two sites in particular. At site BWR139 the breaker tripped every time the air conditioner came on in the afternoon during the audit which was in October. The temperature was not maintained in the acceptable range for the ozone analyzer operation. At site ALH157 both the heat and air conditioner were running simultaneously since the new air conditioner could not be connected to the shelter temperature control unit.

Other routine maintenance areas that could use improvement are Climitronics cups and vanes at NPS sites. Most are still the old style and are degrading. Some cups are loose on the shafts and are not aligned with each other. The vinyl-covered vane tails are cracked and allowing moisture to be absorbed. All of the EPA sites have new style Climitronics cups and vanes and their condition is much better. However one EPA site (KNZ184) was observed to have a mismatched RM Young vane and nosecone.

Another network consistency improvement would be the installation of forced-air blowers for the relative humidity sensors at EPA sites. The NPS sites are using this type of shield successfully and the more humid sites in the east would benefit from these installations.

There were some loose wind direction sensors found in the field during the audits. This can cause inaccurate data collection and premature sensor failure. More care could be taken when rebuilding and assembling the sensors.

The previous paragraphs and sections included some recommendations for improving the field operations systems. One recommendation for improving the audit program is presented in the following section.

6.1 Follow-up visits

It is recommended that some of the conditions encountered during the audits should be addressed when the sites are visited during the next scheduled site maintenance and calibration visit. In order to determine if that occurred some type of follow-up procedure should be established. This procedure may not need to be another audit, and should not be performed two years after the audit when the condition was first discovered.

Additional data validation audits could be conducted to determine if polled data are scaled correctly. For example site CDZ171 was recording delta temperature data incorrectly at the site. However, polled data may be accurate if the polling program is using the correct factors. Review of the polled data and site documentation should be performed routinely to ascertain and correct these types of problems.

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