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Project Summary

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) Site Visitation Program (October 1986 through September 1987)

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The proper collection of precipitation and the accurate measurement of its constituents are important steps in attaining a better understanding of the distribution and effects of "acid rain" in the United States. One of NAPAP Task Group IV's major programs concerns wet deposition monitoring. One of that program's projects, 4A-15, "Quality Assurance Support for Wet Deposition Monitoring," is sponsored by EPA to evaluate the sample collection process of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) precipitation networks through a site visitation program. Research Triangle Institute, as contractor to EPA, conducts these visits. If deficiencies or nonstandard procedures are noted, the site operator and supervisor are notified. Brief reports are sent to the EPA Principal Investigator and the NADP/NTN Quality Assurance Manager. In this way, necessary changes can be made promptly.

All NADP/NTN sites were visited in 1985-1986. A second round of visits began in October 1986, with the goal of visiting approximately one-third of the 200 sites each year over the three-year span 1986-1989. This document is a summary report of the findings from the 1986-1987 (fiscal year 1987) site visitation program to 62 of the sites that comprise the NADP/NTN precipitation networks, referred to collectively as the NADP/NTN network. In its present configuration, the NADP/NTN network's research and monitoring programs are supported and operated by the U.S. Geological Survey, State Agricultural Experiment Stations, the Departments of Agriculture, Interior, Commerce, and Energy, and the Environmental Protection Agency. Additional support is provided by state agencies, public utilities, and industry.

Protocols and procedures followed in conducting the site visits are described. Results of systems and performance audits are discussed for siting, collection equipment, and the field support laboratories.

Where exceptions are found, the potential effects of nonstandard siting, improperly operating equipment, and improper sample handling or analysis technique on the data base are discussed. Recommendations are given for improvement and standardization of individual sites and the network as a whole.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a

separate report of the same title (see Project Report ordering information at back).

Introduction

This document is the summarizing report of quality assurance assistance and findings from site visits made to the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) precipitation collection stations in the period October 1986 through September 1987. Each site is located and operated according to protocols and procedures as given in the siting and operating manuals for the networks[1,2,3,4]. The purposes of the site visitation program, sponsored by the U.S. Environmental Protection Agency, are to verify that each site is operated according to established procedures and to provide technical assistance as required.

Sixty-two of the 201 sites that were in operation as of June 30, 1987, were visited during this time frame.

The goals of the site visitation program for quality assurance assistance to the NADP/NTN collection sites are to:

1. Provide a qualitative assessment of each site and its surroundings, the operator's adherence to sample collection and analysis procedures, and the condition of the site's collection and analysis equipment through an on-site systems survey;
2. Provide a quantitative assessment of the operation of the precipitation collector and the accuracy of response of field and laboratory measurement devices for precipitation depth, mass, temperature, conductivity, and pH through an on-site performance survey;
3. Provide technical assistance to the operator by verbal explanation, minor troubleshooting, repair and calibration of equipment, and by making recommendations for sources of corrective action;
4. Prepare brief reports for each site detailing site characteristics, results of quality assurance tests, and technical assistance provided;
5. Computerize results of all information gathered from each site and submit this to the NADP/NTN Quality Assurance (QA) Manager on a quarterly basis;
6. Document the sites and their surroundings by assembling a collection of site maps and color photographs.

This project summary describes procedures and results from quality assurance visits made to the sites in 1986 and 1987. Recommendations for improvement are also given.

Procedures

Scheduling

Each NADP/NTN site was to be visited once in a three-year period. About one-third of the 201 active sites were visited in the first year (1986-1987). Prior to the scheduling of site visits, RTI consulted with the NADP/NTN QA Manager and Central Analytical Laboratory (CAL) site liaison to determine which sites, if any, should be seen on a priority basis. Whenever possible, visits were planned so that several sites in the same vicinity could be seen in the same trip.

The following sequence was followed when arranging a visit to a collection site.

- About two months before the anticipated date of visit, RTI selects a set of sites in a location suitable for a trip lasting up to two weeks and sets a tentative schedule for visits. As many as eight sites may be visited in this time frame, depending on the proximity of the sites.
- The NADP/NTN QA Manager, the CAL of the Illinois State Water Survey, and the sponsoring agency are notified by letter of the proposed visits. CAL supplies pertinent information to RTI concerning each site.
- Each site's supervisor is telephoned to set up the visit. Depending on the wishes of the site supervisor, the supervisor contacts the operator or RTI contacts the operator to confirm the date, time, and place of the visit. When the supervisor makes the arrangements, he contacts RTI prior to the planned visit to confirm or alter the initial plan.
- EA form letter is sent to each site's supervisor and operator that confirms the date, time, and place of the visit. This letter also gives a brief agenda for the visit and an estimate of the time to set aside for the visit (usually 4 to 5 hours).

Site Survey Visits

An auditor accompanied the supervisor and/or operator to each collection site and field laboratory with the dual aims of (1) documenting the site and its immediate surroundings, its operation, and th accuracy of its instrument's responses t various quality assurance tests and (: providing information, training, an instruction for operators and supervisor: equipment calibration and minor mair tenance as needed, and establishing cor tacts for further information and/or majc repairs.

Systems Survey

A quality assurance systems surve was conducted at each site to qualit tively assess the site, its surrounding: and the operator's adherence to proce dures specified in the NTN design doc ment[1] and in the NADP/NTN site oper tor's instruction manual[3]. Criteria fc siting an NADP/NTN precipitation statio are illustrated in Figure 1. The operat was asked to demonstrate sample colle tion and analysis procedures. These wer observed with specific attention given t calibration procedures and sample har dling technique. Site equipment was e amined for signs of wear or faulty opera tion. It was noted whether solutions an equipment were properly stored. Site log books and rain gauge charts (if presen were examined for legibility, complete ness, and accuracy.

Information from the systems surve was entered in the systems survey ques tionnaire. Photographs (color slides) c the sites were taken. The directions N, E S, and W were photographed with th precipitation collector in the foregrounc Additional views were taken as specifie in the questionnaire.

Performance Survey

A quantitative performance survey wa conducted at each site. Criteria for eva uating performance are specified in th NADP Quality Assurance Plan[2]. All info mation was recorded in the performanc survey questionnaire. Several items hav ing to do with quality assurance te equipment, materials, and procedures ar discussed in the next section.

Sequence Of Site Visitation Activities

I. Select Site For Visit And Initia Communications

- Advise QA Manager, CAL, site spor sor of plans; request site informatio receive go-ahead

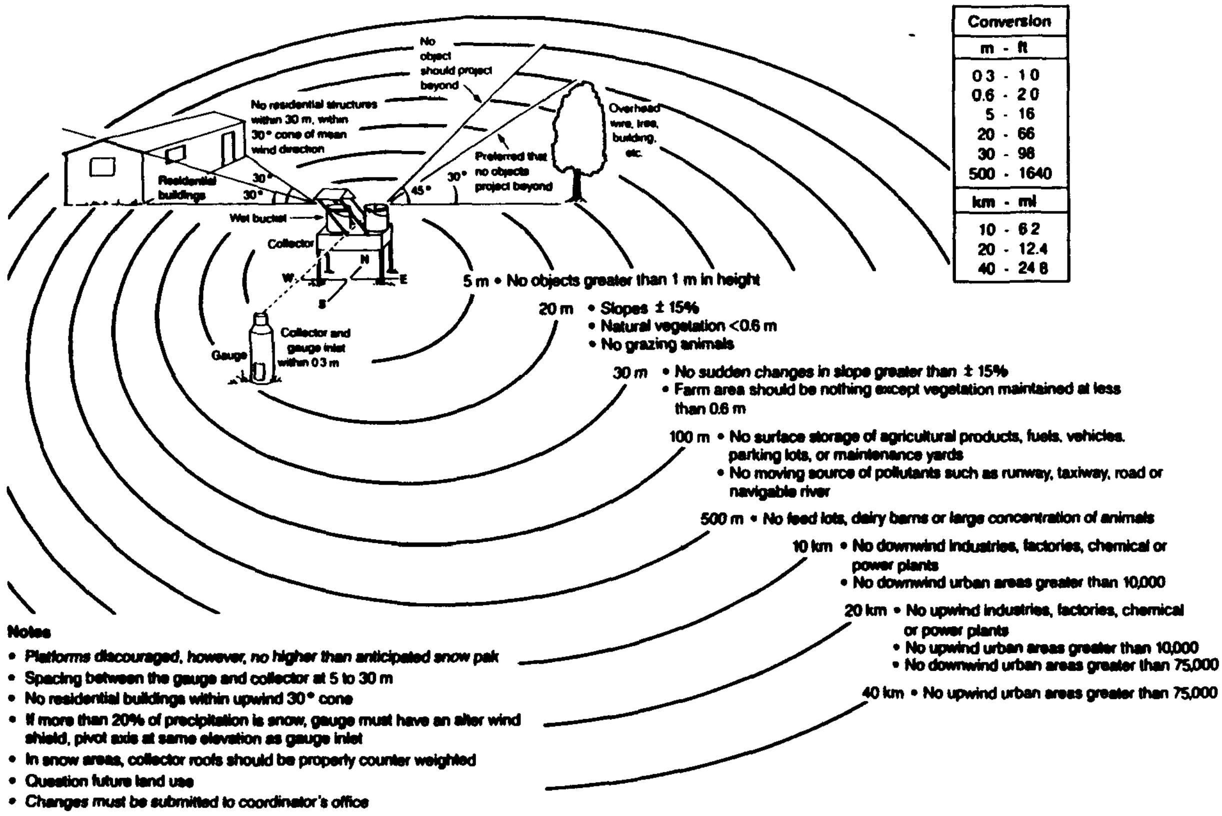

Figure 1. NADP/NTN Siting Criteria.

- Contact site supervisor, site operator, sponsoring agency
- Send letter of confirmation to supervisor, operator, agency
- Advise EPA that trip plans are complete

II. Pre-Trip Preparation

- Make travel arrangements (air, car, hotel)
- Prepare and test quality assurance materials
- Review site-specific quality control information (maps, QC test results, etc.)
- Check equipment and supplies
- Prepare site visit notebook

III. Conduct Site Visit

- Outline activities to supervisor and operator
- Assess site and surroundings (map, photographs, obstructions, sources)
- QA tests of precipitation collector and gauge
- Adjust or calibrate collection equipment as required
- Assess operator handling and transport of collection bucket
- QA tests of conductivity and pH meters, temperature, mass
- Examination of site records, rain gauge charts
- Answer questions; provide information
- Prepare short report; conduct exit interview

IV. Reporting

- Short report prepared; left with supervisor or operator
- Copy of short and extended reports forwarded to NADP/NTN QA Manager, to CAL, and to EPA Project Officer
- Copy of site visit notebook sent to NADP/NTN, QA Manager; file original
- Summary reports prepared monthly and annually
- Report presented to NADP/NTN committees

Results and Discussion

Siting Criteria Survey

Collector Height Standard—The collector should be installed on its standard 1-meter high aluminum base. Any of several methods can be used to stabilize or level the collector such as concrete pads or stakes. However, the bucket height of the collector should not vary from its standard height by more than ±0.5 m. An exception to this criteria is permitted in areas with significant accumulations of snow. In this case, the collector may be placed on a platform that is no higher than the highest anticipated snow pack. To prevent obstructions to wind flow, the collector base should not be enclosed.

Eleven of 62 collectors checked (18%) were not at the standard 1-meter above ground height. Of these 11, all were on platforms. All of these sites, with the possible exception of Georgia Station, were in areas where snow pack accumulates and warranted being on platforms. The base was enclosed on five collectors.

In most cases, platforms were short, not more than 2 to 4 feet in height. The higher platforms (Buffalo Pass and Snowy Range) were necessary to raise the collector above snow packs which could exceed 10 feet. The effect of shorter platforms on the sample is believed to be minimal.

Wet Bucket Orientation—The collector should be mounted with the wet-side bucket to the West and the sensor facing North. In this way, the wet-side bucket is generally upwind of the dry-side bucket (winds generally being from the S to SW in the eastern United States), and the sensor is downwind of the wet-side bucket. This placement is designed to lessen the chance for contamination and to minimize the obstruction of the collector itself to sample entry.

Of 61 sites examined in 1987, 47 (77%) were correctly installed with the wet bucket facing to the SW, W, or NW. Three were installed with the wet bucket facing SSW. These southerly installations probably have no effect on the data. Eight collectors that were installed with the collection bucket facing N or E may cause an aberration in the collection efficiency or sample chemistry. A statistical study of the long-term data base would be required to discern this and may be complicated by other factors.

Ground Slope—The collector should not be located on ground with a slope greater than 15° or 27%. The slope at 7 of 62 sites (11% of the total) exceeded this criterion. Six of the seven sites were located in mountainous regions and were representative of their respective regions.

It is difficult to say what the effect of the steeper slopes is on collection efficiencies. However, to adhere too rigidly to the criterion would effectively eliminate many regions, especially those at higher elevations, from this network.

Collector-Gauge Separation—The collector should be located within a distance of 30 m of the rain gauge but not closer than 5 m. This guideline is set so that the collector and gauge "see" the same precipitation event and so that neith piece of equipment offers an aerod namic interference to the other's colle tion ability.

Twelve of 60 sites (20%) had ra gauges less than 5 m from the collectc The collector and rain gauge we mounted on a platform at several of the: sites and separating them would requi the construction of a second platfor (one site had separate platforms). Son sites not meeting the distance requir ments were enclosed by chain-lir fences for security; meeting the distanc requirements for these sites would r quire enlarging the enclosure or buildir a separate one. Many sites in this ne work may not be able to comply with th criterion due to cost. However, thos gauges which can be removed to th proper distance should be and the mov should be documented. None of the site exceeded the recommended separatic distance of 30 m. The closest separatic was 0.5 m.

Collector and Rain Gauge at Sam Height—The heights above ground of th collection bucket and the rain gaug orifice should be within 1 foot of eac other. Seven of 61 sites (11%) did n meet this criterion. However, in all case the criterion was exceeded by sma amounts and the effect on the data bas is probably negligible.

Immediate Site Surroundings—Th purpose of these criteria is to preve sample contamination or obstruction fro occurring. The presence of urban area or industry at distances of 10 km greater from the site is not considered this report since this information ha already been given in the report of th first round of site visits made in 1985 ar 1986, and the site locations have n changed. Documentation of the presenc of new sources after 1980 is not yet avai able as an NPAP emissions inventory.

Vegetation Within 30 m and the 4 Degree Rule—Vegetation within 30 m the collector should not be more than tw feet tall, and no object should project c the collector from an angle greater tha 45°. These criteria are intended to kee windblown contaminants such as seec or splashing water out of the collectic bucket. Fourteen of 62 sites (23%) ha vegetation of height greater than two fe within 30 m of the collector. Six site (10%) had trees or meteorological towe too near the collectors that violated th 45° siting criterion. Under certain win conditions, it is possible that rai splashing from these objects into th collection bucket could significantly alt the sample chemistry.

Parking Lots, Chemical Storage—The site should not be within 100 m of parking lots or chemical storage. Ten of 62 sites (16%) did not satisfy this criterion.

Transit Sources Closer than 100 m—Transit sources such as well-traveled roads, railroads, and shipping channels should be no closer than 100 m to the sample collector. Five of 61 sites (8%) were judged to be too near such sources.

Grazing Animals or Feedlots—The site should be more than 30 m from grazing animals and more than 500 m from large concentrations of animals such as feedlots, dairy farms, or poultry farms. These criteria are intended to keep sources of compounds which could buffer acidic solutions removed from the site. Five of the 62 sites examined in 1987 were only affected by grazing animals, and the effect here is probably negligible since animals in these situations tend to roam over large areas and are not concentrated near the site. None of the sites, however, were near feedlots or other large concentrations of animals which could affect the sample chemistry.

Equipment and Sample Collection Survey

System and performance checks were made at each site to assess the operational fitness of the Aerochem Metrics precipitation collector* and the Belfort rain gauge. The process of sample retrieval and care was also examined. These are discussed below.

Precipitation Collection System Checks

Collector Level—The precipitation collector should be level so that the collection efficiency will not be biased by wind direction or variations in effective bucket opening areas. Only five of 60 collectors examined (8%) were not level. In most cases, the collectors were off level by small amounts. It is not believed the effect of this variance would be measurable.

Collector Stable—The precipitation collector should be mounted firmly so that it will not move in strong winds. Each of the 61 collectors examined was judged to be stably mounted (i.e., it could not be rocked easily by hand).

Sensor Clean—The collector's sensor should be clean. Each of the 61 collector sensors examined was clean. The usual effect of a dirty sensor is to prolong the length of time the wet bucket stays uncovered after an event, increasing the likelihood of contamination.

Counterweight—The moving bucket lid should be properly counterweighted so the lid can be moved without excessive motor strain or clutch slippage. Improper counterweighting is usually found at sites which have added snow roofs. Only two of 61 site collectors were found to have improper counterweights. For these two, there was no sign of excessive clutch wear.

Clutch Wear—The motor box clutch assembly should not show signs of excessive slippage or wear as evidenced by a shiny clutch surface or rounded-off indent. Fourteen of 60 sites (23%) had evidence of clutch wear or slippage. However, other tests, such as the assembly's ability to lift two or more Belfort gauge weights without slipping, showed that eight of these 14 were operating properly. There are several causes of clutch slippage in addition to improper counterweighting discussed above. The usual result of serious clutch slippage is that samples are not collected because the bucket lid fails to move off the wet bucket at the start of a precipitation event.

Bucket Tie-Down—Both the wet and dry collection buckets should be secured to the collector with tie-down straps to prevent their being blown out during strong winds. Nine of the 61 sites (15%) did not secure the buckets. However, the actual incidence of sample loss due to this variance is probably rare.

Precipitation Collector Performance Checks

Cover Seats Properly on Wet Bucket—The collector's bucket cover should fit tightly and evenly on the rim of the wet (and dry) bucket so that dust cannot enter during dry periods (and so that the lid liner is protected during wet periods). None of the 58 collectors that could be examined in 1987 had bucket lid seal problems.

Lid Tension—The force that the bucket cover exerts against the rim of the collection bucket may be assessed by lifting the lid slightly above the bucket and reading the force (in grams) required to do so. A spring scale is used. Generally, tensions of 1500 g or greater are found. Three sites had lid tension of 1500 g. The average lid tension was 2384 ± 434 g.

Lid Drop Distance—Another measure of adequate lid/ bucket seal tension is the lid drop distance -- the distance the lid drops when the wet bucket is momentarily removed. The CAL of the NADP/NTN network has found that a distance of 3 mm or greater is required to give good, dust-free seals.

Not all collectors were checked in this manner because the test was not used initially in the program. Of 56 site collectors checked, none had a lid drop distance of 3 mm or less. Minimum, maximum, and mean distances were 5, 21, and 14.2 ± 3.7 mm.

Voltage to Event Marker—In the wet-side open mode, the Aerochem Metrics unit should send signal of 14 ± 3 volts to the event marker solenoid of the Belfort rain gauge. Zero voltage or values outside the prescribed range are indications of problems with the Aerochem Metrics motor box or the battery, when one is used to power the unit. Of 58 units checked, three were lower and one higher than the acceptable range. The mean voltage was 12.74 ± 1.15. The highest voltage was 17 3 at the Snowy Range-Glacier Lake site. It may be that the solar panel there is overcharging the battery. The low voltages were found at the Niwot Saddle, Quincy, and Verna Well Field sites.

Unactivated Sensor Temperature—Generally, the temperature of the precipitation collector sensor is at ambient level when there is no precipitation. If the ambient temperature is below 4°C, the sensor heater should come on, at a lower power level, to melt ice or snow that may fall. A sensor should not be heating at ambient temperatures above 4°C unless it is raining. If it is heating prior to the rain, light rainfall striking the sensor may evaporate before the circuit can be made to open the lid. None of the 53 sensors checked showed irregular heating at ambient temperatures.

Activated Sensor Temperature—When activated by precipitation, the Aerochem Metrics sensor causes the cover to move off the wet-side collection bucket. To speed precipitation evaporation and thus reduce the time the wet-side bucket is open after precipitation ceases, a heater circuit beneath the base plate of the sensor is energized and the temperature of the sensor (as measured at the base plate) rises. The circuit is thermistor-limited and is adjusted to 50-60°C (122-140°F) at the factory.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

A total of 58 sensors were checked during the 1987 visits. Sensors at four sites were not checked since heavy rains were occurring at the time of the visit. Of the 58, two were not heating (3%), one (Snowy Range-Glacier Lake) was overheating (90°C), and 55 were judged to be heating properly. Temperatures at 51 of the 55 sites were checked using a thermo-couple and digital meter. Of these 51, the lowest temperature was 33°C (Meridian), the highest was 76°C (Sugarloaf), and the average temperature was 58.2 ± 10.8°C. Of those 51, ten (20%) heated below 50°C, 22 (45%) were in the manufactured range of 50-60°C, and 19 (37%) were above 60°C.

Resistance to Trigger Sensor—The sensor of the Aerochem Metrics collector activates circuitry to open the cover when water droplets bridge the gap between the grid and the base plate elements of the sensor assembly. According to factory specifications, this occurs when the resistance between the elements is reduced to 80 Kohms. This resistance is sufficiently sensitive to cause activation by relatively pure water (i.e., water of very low conductivity, such as deionized water).

All of the 56 sensors checked caused the circuit to activate when distilled water was applied to the grid and base plate. The low, high, and average resistances measured by bridging the grid and the base plate through a variable resistance box were 59.1, 110.0, and 82.3 ± 10.3 Kohms.

Rain Gauge System Checks

Gauge Level—The rain gauge should be level so that precipitation collection efficiency is not biased by wind direction or by variation in effective exposure area. Five of the 61 rain gauges inspected (8%) were out of level by small amounts.

Alter Shields—Alter shields may be used with rain gauges in the NADP/NTN network to abate strong winds near the gauge and improve collection efficiency. Fourteen of 62 sites (23%) were so equipped.

Chart Recorders—When checked at the time of the visit, the chart recorders should indicate the correct time ± one hour. The rain gauge chart recorders were off by more than one hour at only 1 of the 61 sites checked.

Dampening Fluid Levels—The Belfort gauge dampening fluid reservoir should be filled to within 0.25 inch of the top to reduce pen "noise" created by strong winds. Charts showing excessive pen noise are difficult to read accurately. The dampening fluid level was low at 10 (17%) of the 60 sites checked.

Rain Gauge Performance Check

The rain gauge calibration was checked using Belfort gauge calibration weights. Fifty-five of the 59 gauges (93%) were in calibration (within ± 0.1 inch) up to 5 inches depth. At a depth of 6 inches, only 76 percent were in calibration. Errors associated with the crossover point increased rapidly at the 6-inch depth point. Because most rain amounts are measured in the 0-5 inch range (except when winterized), and because the event depth is measured as the difference in chart reading before and after the event, few measurable errors in precipitation mass measurements are expected due to inaccurate rain gauge calibration. Twenty of the 51 rain gauges checked (34%) were calibrated during the site visits.

Sample Collection Procedures

Most operators were using proper collection procedures and no instances of contamination were noted. Operators were also checking for sample contamination while at the site.

Only one site operator was not able to make a weekly equipment check. Seven operators did not bag and box the bucket before transporting it to the field laboratory. In those cases, the sites were within walking distance of the field laboratory.

Field Laboratory Survey

Systems Check of Field Laboratory

Field laboratories had adequate space and were clean. Fourteen sites (23%) did not have air conditioning, but were usually in areas that would need it only rarely. Required records were kept and report forms were filled out correctly in all cases. Rain gauge charts were annotated fully with site name, date, time on, time off, etc. Field samples were shipped to CAL, generally within three days. Proper techniques for weighing samples were followed in all instances.

pH and Conductivity Measurement Techniques

In order to make accurate and precise pH and conductivity measurements, the analyst must be familiar with the measurement equipment, follow appropriate calibration procedures, and use measurement techniques consistent with good laboratory practices. Field person were observed while making pH and c ductivity measurements and adhere to technique was noted.

In general, specified procedures w adhered to and laboratory technique good. Only two sites (3%) had a varia with pH measurement technique. Not sites use the inverted cell technique measuring conductivity. This is usu due to the fact that the site does not the type of electrode that may inverted.

Each site operator rinsed the cond tivity cell with sample before taking second reading. Only one site measu the standard, deionized water, and s ple in the wrong order. NADP/NTN p cedure requires the measurement of ionized water after the 75 µS/cm stand and before the precipitation sample ensure there is no carry-over from standard to the lower ionic strength r sample. Proper analysis procedures w always discussed with site operat whenever the need was evident.

Results of Field Site Analysis o Simulated Precipitation

Each field laboratory was asked analyze a performance audit solution conductivity and pH. These soluti were prepared by dilution of EF supplied performance test solutions; audit value is that designated by E and lies between pH 3.8 and 4.8 and a conductivity between 20 and 77 µS/ Designated quality limits are ± 0.1 for pH and ± 4 µS/cm for conductivity.

Ninety-seven percent of the 60 fi laboratories checked had pH resu within ± 0.1 unit of the designated val The average absolute difference 0.036 ± 0.03 pH unit. Of the two si that exceeded the accuracy requirem one had a faulty pH electrode and other had a faulty meter. Two sites inoperative pH electrodes and could be tested. Ninety-seven percent of field laboratories obtained conducti values which varied by no more than µS/cm from the designated value. average absolute difference was 1.46 1.34 µS/cm.

Balances are used at the sits to we the mass of precipitation collected by Aerochem Metrics collector. They usually triple beam-balances. The b ances were checked with weights rang from approximately 800 to 4000 gra Only three of 58 sites checked had err of greater than 5 grams over the range test weights. The worst case was +10.9 g disagreement at a loading

3292 g. This was discovered to be due to binding of the beam arm dampening attachment in the mechanism of the magnetic damper. This was corrected and the disagreement was only 4.4 g.

Of 58 balances checked, the absolute average of the worst case differences was 2.2 g. This usually occurred at the maximum load applied and corresponded to less than 0.1 percent of the average load of 3736 g, or to less than 0.002 inch of rain (where 1724 grams = 1 inch of rain for the Aerochem Metrics collector).

The full report was submitted in fulfillment of Task 231B of EPA Contract No. 68-02-4125 by Research Triangle Institute. This report covers site visits made during the period October 1, 1986 through September 30, 1987, and all work was completed as of September 30, 1987.

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The complete report, entitled "The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) Site Visitation Program (October 1986 through September 1987)," (Order No. PB 89-151 542/AS; Cost: $15.95, subject to change) will be available only from:
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