Oscar Experiment High-Density Network Data Report

Event 3 April 16-17, 1981

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December 1984

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OSCAR EXPERIMENT HIGH-DENSITY NETWORK
DATA REPORT
Event 3 - April 16-17, 1981

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PREFACE

This report is one of a series of four reports that summarize data taken by Pacific Northwest Laboratory at the high-density network component of the Oxidation and Scavenging Characteristics of April Rains (OSCAR) experiment in April 1981. Four storm events were studied during the experiment, and a separate report has been prepared for each event:

- PNL-5152, Pt. 1. Event 1 - April 8-9, 1981
- PNL-5152, Pt. 2. Event 2 - April 13, 1981
- PNL-5152, Pt. 3. Event 3 - April 16-17, 1981
- PNL-5152, Pt. 4. Event 4 - April 21-23, 1981

The OSCAR experiment was a cooperative project, and reports from other participants are noted in the introduction.

SUMMARY

The OSCAR (Oxidation and Scavenging Characteristics of April Rains) experiment, conducted during April 1981, was a cooperative field investigation of wet removal in cyclonic storm systems. The high-density component of OSCAR was located in northeast Indiana and included sequential precipitation chemistry measurements on a 100 by 100 km network, as well as airborne air chemistry and cloud chemistry measurements, surface air chemistry measurements, and supporting meteorological measurements.

Four separate storm events were studied during the experiment. This report summarizes data taken by Pacific Northwest Laboratory (PNL) during the third storm event, April 16-17. The report contains the high-density network precipitation chemistry data, air chemistry and cloud chemistry data from the PNL aircraft, and meteorological data for the event, including standard National Weather Service products and radar and rawindsonde data from the network.

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SECTION 1

INTRODUCTION

The Oxidation and Scavenging Characteristics of April Rains (OSCAR) experiment, conducted during April 1981, was a cooperative field investigation of wet removal by cyclonic storms. The design and operational aspects of the experiment have been described in detail in an earlier report⁽¹⁾, and a brief summary is given below. This report is one of a series of four volumes that present data collected at the high-density network during each of the four OSCAR storm events. This particular report covers the April 16-17, 1981, storm event.

The report is divided into three sections: meteorological data, precipitation chemistry data, and aircraft data. It should be noted that the report is limited in scope to data collected by Pacific Northwest Laboratory (PNL) participants in the experiment. Other relevant data collected at the high density network are being/have been reported elsewhere and include: Brookhaven National Laboratory (BNL) surface air chemistry and aircraft data,^(a) Argonne National Laboratory (ANL) aerosol data,⁽²⁾ and hydrogen-peroxide measurements made by G. Kok.⁽³⁾

The primary design requirement for OSCAR was to characterize, in as much detail as possible, the physicochemical and dynamical features of selected cyclonic (or "frontal") storm systems as they traversed the eastern portion of the North American continent. The formal objectives of the study were:

- To assess spatial and temporal variability of precipitation chemistry in cyclonic storm systems and to test the adequacy of existing networks to characterize this variability
- To provide a comprehensive, high-resolution data base for prognostic, regional deposition model development

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(a) Benkovitz, C. M. et al. Oxidation and Scavenging Characteristics of April Rains Data Report. Report in preparation by Atmospheric Sciences Division of Brookhaven National Laboratory, Upton, Long Island, New York for U.S. Environmental Protection Agency.

- To develop increased understanding of the transport, dynamical, and physicochemical mechanisms that combine to make up the composite wet-removal process, and to identify source areas responsible for deposition at receptor sites.

The OSCAR field experiment was designed to maximize the attainment of these goals, within the practical and financial limitations imposed. Two complementary, sequentially operated precipitation chemistry networks formed the foundation of the experiment. Spatial and temporal resolution were the primary factors considered in network design. A nested high-density and intermediate-density network design was chosen to allow both regional coverage over the MAP3S/RAINE geographical region, and intensive measurements over a limited area to resolve wet-removal mechanisms in cyclonic storms. The networks are depicted schematically in Figures 1.1 and 1.2. The high-density network consisted of 47 stations in a 110 by 110 km area in northeast Indiana/northwest Ohio.

Additional measurements in support of the two networks characterized surface and aloft air chemistry, cloud chemistry, and meteorological variables. The April operational period for OSCAR was chosen so that most precipitation would be rain rather than snow and the storm systems would still be more cyclonic rather than convective in nature.

FIGURE 1.1. OSCAR Intermediate-Density Sampling Station and High-Density Network Position

FIGURE 1.2. Organization of the OSCAR High-Density Precipitation Chemistry Network. Numbers Indicate Sampling Site Locations. Site 62 Coincide with the Surface Air Chemistry Site. The Weather Radar and Rawinsonde Were Located at FWA (Fort Wayne Airport).

SECTION 2

METEOROLOGICAL DATA

This section describes the synoptic weather events that occurred during the April 16-17 storm (Event 3), with particular emphasis on weather in the high-density network area. Event 3 was unique in that no surface frontal system was associated with the precipitation over the high-density network, which began during the afternoon (local time) of April 16. The precipitation resulted from the influx of a deep layer of moist air from the Gulf of Mexico into Texas early in the period, and the formation of an upper trough along the east slopes of the Rocky Mountains which moved eastward in step with the moisture pattern. Because of this non-frontal nature, the intermediate-density network was not activated during Event 3.

Data utilized in the analyses and interpretations include standard National Weather Service (NWS) products and data collected as part of the high-density network experiment. Surface weather charts at 3-hour intervals (Figures 2.1 through 2.12), and upper air charts for 850 mb and 700 mb at 12-hour intervals (Figures 2.13 through 2.18) show the progression of the precipitation area which accompanied the upper air trough as it moved eastward over the sampling networks. Photographs of the NWS weather radar at Fort Wayne airport (FWA) show the changing precipitation pattern over the high-density network (Figures 2.20 through 2.22). A series of rawinsonde observations taken at FWA during the surface and aircraft sampling periods show the changes in the temperature and moisture profiles which occurred (Figure 2.23). Plots of total and hourly precipitation amounts over the network sites are presented (Figures 2.24 through 2.32). Trajectory charts for 24 and 30 hours back in time are drawn to show estimated source regions for air parcels transported at 305 m (1000 ft) above ground level (AGL) and at 850 mb (Figures 2.33 and 2.34).

The surface weather map for 2100 Greenwich Mean Time (GMT), April 15 (Figure 2.1), shows all of the eastern United States covered by the large high pressure area that had settled over the region in the wake of the storm which had produced rain for OSCAR Event 2. A weak stationary front lay along the

Gulf of Mexico coastline, and a frontal wave was situated in Saskatchewan with the warm front reaching upper Michigan. Deep onshore flow of Gulf air (to at least 500 mb) coming around the backside of the eastern high was producing an area of precipitation in the Texas-Oklahoma panhandle, and an upper trough was forming east of the Rocky Mountains.

At 1200 GMT, April 16 (Figure 2.2), the high was centered over Chesapeake Bay. The eastern portion of the frontal remnant in the Gulf of Mexico had passed south beyond the tip of Florida. It extended northwest through southern Louisiana into Texas then curved southward. The Canadian front (about 100 miles north of the Canadian border) now lay east-west from Lake Superior to the Continental Divide and westward. The upper level trough, which was an important feature in producing precipitation during Event 3, had moved to the Plains states. Areas of upper moisture and precipitation associated with this trough had increased in size and moved to northern Missouri and into Iowa.

Overrunning and thickening cloud types were advancing from the southwest over Fort Wayne early on April 16, and rain was forecast to begin by evening. A decision was made to sample on the high-density network; the intermediate-density network was not activated. Precipitation-chemistry collectors were set out that afternoon. By 1500 GMT (Figure 2.3), the main mass of precipitation was over Iowa, and isolated areas of precipitation were reported in Illinois, Kentucky, and southern Indiana.

By 1800 GMT, April 16 (Figure 2.4), a narrow band of precipitation associated with the upper trough stretched from Iowa eastward into central Indiana. By 2100 GMT precipitation had spread over northern Indiana and Illinois and into Wisconsin (Figure 2.5). Aircraft sampling over the high-density network took place between 2000 GMT April 16 and 0100 GMT April 17.

Photographs of the FWA radar screen for 1845-2110 GMT on the 16th (Figure 2.20) show how the area of precipitation increased in size as it approached and entered the southwestern portion of the high-density network. (The position of the high-density network with respect to the radar coverage is shown in Figure 2.19). Rain amounts were lighter in the central section of the network (Figure 2.24). After 2240 GMT nearly all the precipitation cells shown by radar were located north of FWA (Figures 2.21 and 2.22). There was a trend

toward formation of a line of precipitation cells that became quite solid by 0141 GMT on April 17. Total precipitation falling on the high-density network ranged from less than 0.5 to 8.5 mm. The first surge of precipitation across the network put down measurable rain at nearly all sites between 2100 GMT, April 16 and 0100 GMT April 17 (Figures 2.25 and 2.26). During the following 6 hours (0100-0700 GMT) hourly amounts were quite light (Figures 2.27 through 2.29). A second band of precipitation crossed the network between 0700 and 1000 GMT on the 17th (Figures 2.30 and 2.31), and sites on the southern tier of the network continued to receive light precipitation until 1300 GMT on the 17th (Figure 2.32).

Rawinsondes were taken at 2040 and 2245 GMT on April 16 and at 0025 April 17 (Figure 2.23). At 2040 GMT, April 16, the air was quite dry below 750 mb, but a moist layer above 750 mb extended to at least 400 mb. By 2225 GMT the moist layer extended down to 850 mb, but some drying aloft was noted at about 650 mb. The sounding for 0025 GMT on the 17th shows moist upper layers at 800 mb and 650 mb. From 500 mb to the sounding cutoff at 400 mb, the air is relatively moist. The wind direction profiles were quite consistent during the aircraft sampling period though the speed at 650 mb showed an increase on the 2225 GMT sounding. The 850 mb wind direction field over the FWA network changed little between 1200 GMT on the 16th and 0000 GMT on the 17th (Figures 2.13 and 2.15), but 700 mb winds during the same period showed backing from west toward southwest (Figures 2.14 and 2.16). During the following 12 hours, the wind at both levels became more westerly (Figures 2.17 and 2.18).

At 0000 GMT, April 17 (Figure 2.6), the precipitation area was still intact over northern Indiana and Ohio and southern Lake Michigan. The east-west line of radar echoes shown in Figure 2.22 indicates part of this larger area of precipitation. The upper trough was now showing signs of filling, but moisture was still evident in the vicinity of convergence zones over the Mississippi River valley from Wisconsin to Arkansas at 500 mb and below. Two low centers had developed on the east-west front along the Canadian border, one in Saskatchewan and the other in Manitoba. A cold front from the low in Manitoba dropped southward through North Dakota then southwestward to beyond

the Rocky Mountains. These fronts were still not near enough to Fort Wayne to have any effect on the weather over the sampling network.

Surface weather maps for 0300 and 0600 GMT, April 17 (Figures 2.7 and 2.8), show the area of precipitation moving slowly eastward. The cold front to the west had reached Minnesota, South Dakota, and Wyoming at 0900 GMT (Figure 2.9). At 1200 GMT, April 17 (Figure 2.10), the precipitation reports from Michigan, New York, and Pennsylvania southwestward to Tennessee and Arkansas were closely matched by the moisture pattern aloft at 850 mb. Though the upper trough had become quite broad by this time, the mesoscale layer of moist air aloft remained coherent and continued to produce precipitation over the Ohio River valley. The cold front had just crossed into Wisconsin and Iowa and then trailed westward. The MAP3S region at both surface and aloft was still experiencing southwesterly and westerly air flow from around the back side of the high pressure cell, which now had its center well out over the Atlantic.

At 1500 GMT, April 17 (Figure 2.11), the precipitation area associated with the upper trough had moved to eastern Ohio. The cold front to the west had reached Wisconsin and Iowa. Figure 2.12 shows three positions of this front during the 12 hours preceding its arrival at the high-density network. This figure also shows the eastward progression of the leading edge of the non-frontal rain area which was sampled during Event 3. By 0000 GMT, April 18, this precipitation area was over Vermont, New Hampshire, and Maine and was producing scattered showers and thundershowers along the Appalachian Mountains to Tennessee. The upper trough was still evident, but had become very shallow above 20,000 ft. The high level moisture pattern had moved over New England. The cold front was now in eastern Michigan and northern Indiana and trailed out to Kansas. A few thundershowers accompanied it, but FWA received no precipitation, although frequent lightning was observed to the north of FWA during the evening of the 17th (local time).

To obtain a first impression of air-mass trajectories, 24- and 30-hour back trajectories at 305 m (1000 ft) AGL and at 850 mb were calculated. The winds used in calculating the trajectories are from NWS rawinsonde data. No estimates of vertical motion were included in the calculations. Wind flow maps

were constructed for each observation time. Wind speed for locations between rawinsonde stations were interpolated, and wind velocity was vector averaged over intervals of 6 hours to gain a first estimate of air parcels' locations back in time.

The 305-m back trajectories (Figure 2.33) are plotted for three separate arrival times at FWA. The estimated source regions for the three trajectories show a clockwise displacement with time from eastern Ohio to western North Carolina, then finally to northeast Kansas for respective start times of 1500 and 2100 GMT on April 15 and 1200 GMT on April 16.

The 24-hour 850-mb level back trajectories are shown in Figure 2.34. The short travel trajectory for the plot ending at 1200 GMT on April 16 is a result of light winds. The two subsequent trajectories show effects of increasing wind speeds and the gradual clockwise shift in wind direction with time at 850 mb. The probable source regions are central Illinois for air arriving over FWA at 1200 GMT April 16, and central Arkansas and the Texas panhandle for arrivals at 0000 GMT and 1200 GMT on April 17.

FIGURE 2.1. Synoptic Weather Map for 2100 GMT, April 15, 1981.

FIGURE 2.2. Synoptic Weather Map for 1200 GMT, April 16, 1981.

FIGURE 2.3. Synoptic Weather Map for 1500 GMT, April 16, 1981.

FIGURE 2.4. Synoptic Weather Map for 1800 GMT, April 16, 1981.

FIGURE 2.5. Synoptic Weather Map for 2100 GMT, April 16, 1981.

FIGURE 2.6. Synoptic Weather Map for 0000 GMT, April 17, 1981.

FIGURE 2.7. Synoptic Weather Map for 0300 GMT, April 17, 1981.

FIGURE 2.8. Synoptic Weather Map for 0600 GMT, April 17, 1981.

FIGURE 2.9. Synoptic Weather Map for 0900 GMT, April 17, 1981.

FIGURE 2.10. Synoptic Weather Map for 1200 GMT, April 17, 1981.

FIGURE 2.11. Synoptic Weather Map for 1500 GMT, April 17, 1981.

FIGURE 2.12. Leading Edge of the Non-frontal Precipitation Area at 6-hour Intervals Across the OSCAR Networks, and Positions of the Frontal System that Approached FWA After the Sampling Period.

FIGURE 2.13. 850-Millibar Chart for 1200 GMT, April 16, 1981.

FIGURE 2.15. 850-Millibar Chart for 0000 GMT, April 17, 1981.

FIGURE 2.16. 700-Millibar Chart for 0000 GMT, April 17, 1981.

FIGURE 2.17. 850-Millibar Chart for 1200 GMT, April 17, 1981.

FIGURE 2.18. 700-Millibar Chart for 1200 GMT, April 17, 1981.

FIGURE 2.19. High-Density Network Boundary and the 230-km Range (50-km Range Marks) of the Fort Wayne, Indiana Weather Radar.

FT. WAYNE WEATHER RADAR - OSCAR EVENT 3, APRIL 1981

16/1845 Z

16/1905 Z

16/1946 Z

16/2016 Z

16/2030 Z

16/2110 Z

FIGURE 2.20. Fort Wayne Radar Precipitation Echoes for 1845 GMT to 2110 GMT, April 16, 1981.

FT. WAYNE WEATHER RADAR - OSCAR EVENT 3, APRIL 1981

16/2130 Z

16/2152 Z

16/2214 Z

16/2240 Z

16/2312 Z

16/2331 Z

FT. WAYNE WEATHER RADAR - OSCAR EVENT 3, APRIL 1981

16/2350 Z

17/0011 Z

17/0030 Z

17/0051 Z

17/0120 Z

17/0141 Z

FIGURE 2.22. Fort Wayne Radar Precipitation Echoes for 2350 GMT, April 16 to 0141 GMT, April 17, 1981.

FIGURE 2.23. Rawinsonde Profiles of Temperature and Moisture Observed on April 16, 1981, at Fort Wayne, Indiana.

FIGURE 2.24. Precipitation Over the High-Density Network from 2100 GMT April 16 to 1300 GMT, April 17, 1981. Right Side Shows Precipitation Amounts (mm) at Each Network Site ("x" indicates missing data). Left Side Shows Contours of the Data (contour levels every 2 mm)

FIGURE 2.25. Hourly Precipitation Amounts (mm) Over the High-Density Network for 2100-2200 (left) and 2200-2300 GMT (right) April 16. "-" Indicates No Precipitation, "x" Indicates Missing Data, and "T" Indicates Trace Amount.

FIGURE 2.26. Hourly Precipitation Amounts (mm) Over the High-Density Network for 2300-2400 April 16 (left) and 0000-0100 GMT (right) April 17. "-" Indicates No Precipitation, "x" Indicates Missing Data, and "T" Indicates Trace Amount.

FIGURE 2.27. Hourly Precipitation Amounts (mm) Over the High-Density Network for 0100-0200 (left) and 0200-0300 GMT (right) April 16. "-" Indicates No Precipitation, "x" Indicates Missing Data, and "T" Indicates Trace Amount.

FIGURE 2.28. Hourly Precipitation Amounts (mm) Over the High-Density Network for 0300-0400 (left) and 0400-0500 GMT (right) April 17. "-" Indicates No Precipitation, "x" Indicates Missing Data, and "T" Indicates Trace Amount.

FIGURE 2.29. Hourly Precipitation Amounts (mm) Over the High-Density Network for 0500-0600 (left) and 0600-0700 GMT (right) April 17. "-" Indicates No Precipitation, "x" Indicates Missing Data, and "T" Indicates Trace Amount.

FIGURE 2.31. Hourly Precipitation Amounts (mm) Over the High-Density Network for 0900-1000 (left) and 1000-1100 GMT (right) April 17. "-" Indicates No Precipitation, "x" Indicates Missing Data, and "T" Indicates Trace Amount.

FIGURE 2.32. Hourly Precipitation Amounts (mm) Over the High-Density Network for 1100-1200 (left) and 1200-1300 GMT (right) April 17. "-" Indicates No Precipitation, and "x" Indicates Missing Data.

FIGURE 2.33. Composite of Three 24- to 30-hour, Constant Level Back Trajectories From Fort Wayne, Indiana at 305 m (1000 ft) AGL. April 16-17 1981.

FIGURE 2.34. Composite of Three 24-hour Constant Level Back Trajectories from Fort Wayne, Indiana at 850 mb. April 16-17 1981.

100' 200' 300' 400' 500' 600' 700' 800' 900' 1000'

SECTION 3

PRECIPITATION CHEMISTRY DATA

Precipitation samples for chemical analysis were collected at the 47 sites of the OSCAR intensive network as shown in Figure 1.2. Each site was outfitted with a standard weighing rain gauge and an automatic sequential bulk collector (ASBC). Details on collector design and construction and of sampling and handling procedures may be found in the overview report.⁽¹⁾ The ASBC consisted of a 1000 cm² funnel, tubing, and a box containing a manifold of nine collector bottles, or stages. As precipitation occurred, the stages filled in sequence, and, except for the last stage (which was allowed to overflow if necessary), were sealed by hollow floating balls. The first eight stages each contained 67 ml of sample, or about 0.7 mm of precipitation. The ninth stage was much larger (1130 ml), giving a total rainfall capacity of 16.7 mm. All sample contact surfaces in the collector were polyethylene or polystyrene.

Since the ASBC funnels were not automatically exposed, the collectors were deployed as close as possible to the predicted onset of precipitation so as to minimize dry deposition. In the case of event 3, the prerrainfall exposure time averaged 3.6 hours, and was 11 to 12 hours at several sites.

Soon after the event, the collectors were returned to the central staging area and the stages separated, identified, sealed, and stored at refrigerator temperature. The samples were shipped by air freight to the PNL precipitation chemistry laboratory for chemical analysis. The event 3 samples arrived at the laboratory within a few days of the storm.

Complete location, rainfall, and chemical analysis results for each site are listed in Appendix A. An examination of the chemical stability of the samples during the period of analysis is presented in the data report for event 4.⁽⁴⁾ The following subsections describe the chemical and rainfall results graphically and statistically.

INDIVIDUAL SITE DATA

Figures 3.1 through 3.3 show, for all sites, concentrations of the major ionic species [SO_4^{--} , H^+ (from pH), NO_3^- , NH_4^+ , Ca^{++}] and rainfall rate versus stage number. Each figure shows results from sites in each north-south "column" of sites (see Figure 1.2). The rainfall rates are stage averages, using stage start and end times derived from the stage volumes and rain gauge chart records.

Figure 3.4 show the rainfall rates plotted versus time (on April 16-17, 1981). The rainfall rates here are not stage averages as in Figure 3.2, but are real-time rates determined from rain gauge chart records. Figure 3.4 illustrates the showery and spatially inhomogeneous rainfall rates for this event, which were noted also in Section 2. Since a large portion of the rain fell in a short time at many sites, there is considerably more error potential in defining stage timing. Therefore, time plots for concentrations are not presented, as they were for the other OSCAR events.

The assessment of the potential for dry deposition and scavenging of local material affecting early stage concentrations is likewise difficult. Concentrations of calcium are considerable in the first stages of most sites, which suggests similar local effects as observed for events 1, 2, and 4.

SPATIALLY AVERAGED DATA

Figures 3.5 through 3.7 show volume-weighted concentrations for the stages, averaged over all the active sites. These concentrations, C_j , were calculated using

$$C_j = \frac{\sum_i c_{ji} v_{ji}}{\sum_i v_{ji}} \quad (3.1)$$

where i = site number

j = stage number

c_{ji} = corresponding species concentrations

v_{ji} = stage rain volumes.

The weighted averages, incidentally, are the same as the arithmetic averages for all stages except the "last" stage (usually the ninth) since all the volumes are the same.

Figures 3.8 through 3.10 show ratios of selected species for site-composite stages. The ratios are generally constant with accumulated rainfall. In particular, the sulfur/nitrate does not increase with stage number, suggesting different relative scavenging rates from those for the other events). A potentially significant effect is the tendency for higher rainfall rates in the later stages, a different pattern than was exhibited in events 1, 2 and 4.

Simple statistics for single stages and all stages combined are listed in Table 3.1. The number of sites, N, is less than 47 for the single stage statistics and less than 423 for the combined statistics because of missing values for certain species (see Appendix A for reasons for missing values), and because some sites had less than 9 stages of rainfall (see Figure 3.1). Listed are minima, maxima, arithmetic means and standard deviations, and geometric means and standard deviations for concentrations. Stages 3 through 8 are not listed because the results for these stages follow the general trends shown by the preceding figures, and the statistical variability exhibited by stage 2. Stage 1 and 9 statistics reflect the event beginning and ending situations, the latter being influenced by the much larger stage volume and subsequently longer time averaging. The stage 9 values have lower variances probably because of the much larger averaging time resulting from the large stage volume and the lower likelihood of dryfall contamination. The "ALL" row does not show this feature because the treatment of all the sites includes all the stages, rather than the composites of all the stages for each site.

Similar statistical calculations were performed on the event average (volume-weighted mean of all stages) concentration data; the results of these are listed in Table 3.2. Since some (or all) stage concentrations from certain sites are missing for various reasons (see Appendix A), those sites whose event average for a species represents less than 80% of the total precipitation collected at the sites were not included in the summary statistics. The

TABLE 3.1. OSCAR High-Density Network Event 3 Statistics for Single Stages and All Stages Combined. Units are: $\mu\text{mho/cm}$ for Conductivity; $\mu\text{eq/L}$ for H^+ , Anion Sum, and Cation Sum; $\mu\text{mol/L}$ for All Other Species.

Species	Stage	N	Min	Max	Arithmetic		Geometric	
					Mean	S.D.	Mean	S.D.
SO_4^{--}	1	44	42.0	240.0	101.0	35.7	95.6	1.4
	2	35	17.0	330.0	70.1	49.9	61.4	1.6
	ALL	149	9.7	330.0	71.6	41.9	61.7	1.7
NO_3^-	1	44	18.0	160.0	85.7	31.3	79.8	1.5
	2	35	15.0	305.0	61.9	47.5	52.7	1.7
	ALL	149	8.5	305.0	63.8	39.1	53.7	1.8
Cl^-	1	44	9.3	45.0	22.7	10.3	20.5	1.6
	2	35	0.3	99.0	17.5	16.7	12.4	2.5
	ALL	149	0.3	99.0	17.6	13.4	13.3	2.2
Anion Sum	1	46	0.0	676.0	297.1	119.9	295.2	1.4
	2	35	55.6	1064.0	222.4	162.4	192.9	1.6
	ALL	152	0.0	1064.0	220.9	134.9	193.3	1.8
Conductivity	1	40	27.0	140.0	57.3	23.3	53.4	1.4
	2	33	14.0	77.0	45.2	16.1	42.3	1.5
	ALL	134	9.5	140.0	47.4	22.6	42.5	1.6
H^+	1	44	0.3	199.5	71.8	55.5	37.6	5.2
	2	34	22.9	154.9	77.1	33.4	70.0	1.6
	ALL	144	0.3	239.9	74.8	45.3	56.2	2.8
NH_4^+	1	44	19.0	330.0	78.0	47.9	68.9	1.6
	2	35	3.9	190.0	48.7	32.2	39.1	2.1
	ALL	149	3.9	330.0	55.9	36.6	46.9	1.9
Na^+	1	44	5.4	51.0	21.7	12.3	18.8	1.7
	2	35	1.7	96.0	16.3	17.3	10.6	2.6
	ALL	149	0.8	96.0	16.3	14.6	11.0	2.6
Ca^{++}	1	41	10.0	57.0	31.2	10.1	29.6	1.4
	2	35	3.7	62.0	16.4	11.2	13.9	1.8
	ALL	139	1.1	62.0	18.0	13.0	13.4	2.3
Mg^{++}	1	41	5.8	47.0	17.5	8.9	15.6	1.6
	2	35	1.3	39.0	9.1	7.4	7.2	1.9
	ALL	140	0.4	47.0	9.7	8.7	6.4	2.7
Cation Sum	1	43	0.0	501.3	253.3	94.4	255.0	1.3
	2	34	51.6	323.9	183.6	68.1	170.2	1.5
	ALL	141	0.0	501.3	196.2	98.2	177.6	1.7

TABLE 3.2. OSCAR High-Density Network Event 3 Statistics for Site Event Data. Chem Coverage is the Fraction of the Precipitation for Which Chemistry Data for the Corresponding Species was Available; Sites with Chem Coverage Less Than 0.80 were not Included in the Statistics. N is the Number of Sites Used for Each Species. Units are: mm for Precipitation, $\mu\text{mho}/\text{cm}$ for Conductivity; $\mu\text{eq}/\ell$ for H^+ , Anion Sum, and Cation Sum; $\mu\text{mol}/\ell$ for Other Species.

Species	N	Min	Max	Arithmetic		Geometric		Chem Coverage	
				Mean	S.D.	Mean	S.D.	Mean	S.D.
Precip.	40	0.2	8.5	2.5	1.7	2.0	2.0		
Conduc.	35	27.0	94.0	48.7	16.9	48.1	1.4	0.95	0.09
SO_4^{--}	39	42.0	158.6	76.0	25.8	77.4	1.5	0.99	0.06
NO_3^-	39	33.7	155.0	69.3	26.9	68.8	1.5	0.99	0.06
Cl^-	39	7.3	52.7	18.9	10.7	17.3	1.7	0.99	0.06
Anion Sum	40	84.6	524.9	236.7	89.5	236.9	1.5	0.99	0.03
H^+	39	2.5	180.5	73.8	39.1	59.5	2.2	0.98	0.07
NH_4^+	39	19.0	147.1	57.7	26.7	55.8	1.6	0.99	0.06
Na^+	39	5.0	57.4	18.0	13.1	15.5	1.9	0.99	0.06
Ca^{++}	38	6.8	49.2	21.6	9.8	20.1	1.6	0.97	0.07
Mg^{++}	38	3.3	40.4	11.9	7.6	10.5	1.8	0.98	0.07
Cation Sum	39	91.3	435.5	210.9	71.6	204.0	1.4	0.98	0.04

average fraction of the total precipitation represented by the averages for each species is listed as "chem coverage."

SCATTER PLOTS AND SPECIES CORRELATIONS

To demonstrate the relationships among species concentrations for individual observations, scatter plots are shown for the major species in Figures 3.11 through 3.14. Presented are plots for stage 1, stage 2, and all stages combined from all sites. The regression relationships shown differ

greatly between stages 1 and 2 (the regression line is only plotted if $r^2 > 0.5$), but for stages following stage 1, they are quite uniform. Figures 3.15 through 3.18 are plots of weighted average concentrations (cf. eq. 3.1) for each stage including all sites. The stage numbers are shown as the data points exhibiting the trend of the relationships with accumulated rainfall during the event.

As with the other events, the scatter is quite large for stage 1 for the species pairs that include H^+ and NH_4^+ . Stage 1 in these cases contributes most of the outliers to the all-stage plots. Sulfate and nitrate, however, have strong positive correlations for all stages, possibly reflecting their common long-range sources. Moreover, the relationship between the two (i.e., the slope of the regression line) is constant as the event progresses, as was seen in the ratio Figure 3.10. The site-composite plots for the stages include considerable smoothing of the variations over the sites, and demonstrate the strong positive correlations among the major species that are normally observed for multiple events at one site.

SPATIAL DISTRIBUTIONS

In this subsection, the precipitation chemistry data for the April 16-17 storm are examined for spatial patterns in the concentration and deposition. The location of the high-density network in northeastern Indiana was largely chosen because of the absence of strong pollutant sources on or near the network, with the hope that wet deposition would be relatively uniform across the network. For the April 16-17 storm, the spatial distribution of the precipitation chemistry shows high variability (the highest of all 4 OSCAR events). Much of this variability may be attributed to the light and highly variable nature of the precipitation during the event, although variability in air chemistry over the network must also have affected the precipitation chemistry.

Figures 3.19 through 3.23 show the spatial distributions of total sulfur, NO_3^- , H^+ , NH_4^+ , and Ca^{++} concentrations over the network for the entire storm event. The spatial distributions of event total deposition for the same five species are shown in Figures 3.24 through 3.28. Some patterns are weakly

apparent in the data. In the concentration figures, few if any of the higher concentrations are found in the southern half of the network. The deposition patterns reflect the total precipitation pattern somewhat (Figure 2.24). The overall variability in all the patterns is substantial. The geometric standard deviations for the major ions averages 1.7 (see Table 3.2).

Figures 3.29 through 3.33 shown the spatial distributions of the same five ions in the first collector stage. The spatial distributions for the first stage show less organization than the event totals, even though the overall variability is somewhat lower for the first stage data than the event totals. (Compare the stage 1 rows in Table 3.1 to Table 3.2. H^+ is an exception.)

Much of the variability in the precipitation chemistry can be attributed to the high variability in the precipitation. Total precipitation amounts had a geometric standard deviation of 2.0 over the network. Temporal variability of the precipitation should also be considered. Examination of the individual site precipitation data (Figure 3.4) shows that two main precipitation periods occurred during the event: one at the start and one near the end, separated by about 8 hours. Some of the sites were more influenced by the first period, while some were more affected by the latter. A large number of air chemistry measurements were made over the network shortly before the onset of precipitation. These data (presented in Section 4) also show a high degree of variability, and thus must also be considered as a cause of spatial variability in the precipitation chemistry.

[Note: The contour lines shown in Figures 3.24 through 3.38 were drawn by a relatively unsophisticated contouring algorithm that utilized a simple $1/r^3$ weighting to interpolate between the sites. The contours have been presented simply to display any dominant spatial patterns in the data (or the lack of them), and are not intended to be a rigorous analysis of the spatial distributions of the data.]

FIGURE 3.1. Sulfate and H^+ (from pH) Versus Stage Number.
a) - g) show Site Columns, North-South, as
Defined by Figure 1.2.

FIGURE 3.1a.

FIGURE 3.1b.

FIGURE 3.1c.

FIGURE 3.1d.

FIGURE 3.1e.

FIGURE 3.1f.

FIGURE 3.1g.

FIGURE 3.2. Precipitation Rate and Nitrate Versus Stage Number
a) - g) Show Site Columns, North-South, as
Defined by Figure 1.2

FIGURE 3.2a.

FIGURE 3.2b.

FIGURE 3.2c.

FIGURE 3.2d.

FIGURE 3.2e.

FIGURE 3.2f.

FIGURE 3.2g.

FIGURE 3.3. Ammonium and Calcium Versus Stage Number.
a) - g) Show Site Columns, North-South,
as Defined by Figure 1.2

FIGURE 3.3a.

FIGURE 3.3b.

FIGURE 3.3c.

FIGURE 3.3d.

FIGURE 3.3e.

FIGURE 3.3f.

FIGURE 3.3g.

FIGURE 3.4. Precipitation Rate Versus Time (April 17, 1982). a) - g) Show Site Columns, North-South, as Defined by Figure 1.2.

FIGURE 3.4a.

FIGURE 3.4b.

FIGURE 3.4c.

FIGURE 3.4d.

FIGURE 3.4e.

FIGURE 3.4f.

FIGURE 3.4g.

FIGURE 3.5. All-Site (Spatial) Volume-Weighted Average H^+ (from pH) and Sulfate Versus Stage Number.

FIGURE 3.6. All-Site (Spatial) Volume-Weighted Average for Precipitation Rate and Nitrate Versus Stage Number.

FIGURE 3.7. All-Site (Spatial) Volume-Weighted Average for Ammonium and Calcium Versus Stage Number.

FIGURE 3.8. Sulfate/Ammonium Ratio Versus Stage Number. Data from Figures 3.5 and 3.7.

FIGURE 3.9. Nitrate/Ammonium Ratio Versus Stage Number.
Data from Figures 3.6 and 3.7.

FIGURE 3.10. Sulfate/Nitrate Ratio Versus Stage Number.
Data from Figures 3.5 and 3.6.

FIGURE 3.11. Species-Pair Plots for Sulfate and H^+ (from pH)

FIGURE 3.11a.

FIGURE 3.11b.

FIGURE 3.11c.

FIGURE 3.12. Species-Pair Plots for Nitrate and Sulfate

FIGURE 3.12a.

FIGURE 3.12b.

FIGURE 3.12c.

FIGURE 3.13. Species-Pair Plots for Nitrate and H^+ (from pH)

FIGURE 3.13a.

FIGURE 3.13b.

FIGURE 3.13c.

FIGURE 3.14. Species-Pair Plots for Sulfate and Ammonium

FIGURE 3.14a.

FIGURE 3.14b.

FIGURE 3.14c.

FIGURE 3.15. Weighted Stage Averages for All Sites for Sulfate and H^+ (from pH). Data Points are Stage Numbers.

FIGURE 3.16. Weighted Stage Averages for All Sites for Nitrate and Sulfate. Data Points are Stage Numbers.

FIGURE 3.17. Weighted Stage Averages for All Sites for Nitrate and H^+ (from pH). Data Points are Stage Numbers.

FIGURE 3.18. Weighted Stage Averages for All Sites for Sulfate and Ammonium. Data Points are Stage Numbers.

FIGURE 3.19. Spatial Distribution of Event SO_4^{2-} Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $25 \mu\text{mol/l}$).

FIGURE 3.20. Spatial Distribution of Event NO_3 Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $25 \mu\text{mol/l}$).

FIGURE 3.21. Spatial Distribution of Event H^+ Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = 25 $\mu\text{mol/l}$).

FIGURE 3.22. Spatial Distribution of Event NH_4^+ Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol}/\ell$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $25 \mu\text{mol}/\ell$).

FIGURE 3.23. Spatial Distribution of Event Ca^{++} Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $10 \mu\text{mol/l}$).

FIGURE 3.24. Spatial Distribution of Event SO_4^{2-} Deposition Across the Network. Right-hand Side Shows Deposition in $\mu\text{mol}/\text{m}^2$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $100 \mu\text{mol}/\text{m}^2$).

FIGURE 3.25. Spatial Distribution of Event NO_3^- Deposition Across the Network. Right-hand Side Shows Deposition in $\mu\text{mol}/\text{m}^2$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = 100 $\mu\text{mol}/\text{m}^2$).

FIGURE 3.26. Spatial Distribution of Event H^+ Deposition Across the Network. Right-hand Side Shows Deposition in $\mu\text{mol}/\text{m}^2$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $100 \mu\text{mol}/\text{m}^2$).

FIGURE 3.27. Spatial Distribution of Event NH_4^+ Deposition Across the Network. Right-hand Side Shows Deposition in $\mu\text{mol/m}^2$ (x's Indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $75 \mu\text{mol/m}^2$).

FIGURE 3.28. Spatial Distribution of Event Ca^{++} Deposition Across the Network. Right-hand Side Shows Deposition in $\mu\text{mol/m}^2$ (x's indicate Sites with Missing or Incomplete Data). Left-hand Side Shows the Data Contoured (Contour Interval = $20 \mu\text{mol/m}^2$).

FIGURE 3.29. Spatial Distribution of First Collector Stage SO_4^{2-} Concentration Across the Network. Right-hand Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing Data). Left-hand Side Shows the Data Contoured (Contour Interval = $25 \mu\text{mol/l}$).

FIGURE 3.30. Spatial Distribution of First Collector Stage NO_3^- Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing Data). Left-hand Side Shows the Data Contoured (Contour Interval = 25 $\mu\text{mol/l}$).

FIGURE 3.31. Spatial Distribution of First Collector Stage H^+ Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing Data). Left-hand Side Shows the Data Contoured (Contour Interval = 50 $\mu\text{mol/l}$).

FIGURE 3.32. Spatial Distribution of First Collector Stage NH_4^+ Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing Data). Left-hand Side Shows the Data Contoured (Contour Interval = $25 \mu\text{mol/l}$).

FIGURE 3.33. Spatial Distribution of First Collector Stage Ca^{++} Concentration Across the Network. Right-hand Side Shows Concentration in $\mu\text{mol/l}$ (x's Indicate Sites with Missing Data). Left-hand Side Shows the Data Contoured (Contour Interval = 15 $\mu\text{mol/l}$).

SECTION 4

AIRCRAFT DATA

During the April 16-17 storm event, two aircraft made sampling flights over or near the high-density network: the PNL Douglas DC3 and the PNL Cessna 411. The BNL Islander was not used. The aircraft and their sampling instrumentation are described in the OSCAR overview report(1). The aircraft were used for two types of sampling: first, to measure trace gas and aerosol concentrations in low-level inflow areas of the storm, and second, to collect cloud water samples in the storm for chemical analysis (only the DC3 performed in-cloud sampling).

The DC3 made a single sampling flight on April 16, from 2040 to 2440 GMT. During the first portion of the flight, clear-air sampling was performed. In-cloud sampling was performed during the last hour of the flight. The Cessna 411 also made a single clear-air sampling flight, from 1940 to 2415 GMT.

CLEAR AIR DATA

Most of the important clear-air measurements aboard the aircraft involved filters (for aerosols, SO_2 , and HNO_3) or real-time, trace-gas analyzers (for SO_2 , O_3 , and NO_x). On the April 16 flights, the DC3 collected two sets of filter samples, and the Cessna collected four sets of filters. The aircraft flight tracks during this sampling are shown in Figures 4.1 through 4.3. As can be seen, all of the sampling was to the south and west of FWA and was at altitudes between 700 and 1000 m MSL. Winds during the filter sampling (at the sampling altitudes) were from the south to southwest 190 to 230 degrees). The data from these filter samples, along with data from the operational real-time instruments averaged over the filter collection periods, are presented in Table 4.1. The data show considerable variability between the different samples, particularly the SO_2 and HNO_3 data.

Real-time measurements made aboard the DC3 during its two filter collections are shown in Figures 4.4 and 4.5. As seen in Figure 4.3, the sampling during both collections was in nearly the same location, but at different

TABLE 4.1. Summary of Clear Air Measurements by Cessna and DC3 on April 16

Aircraft: Sampling Period (GMT):	Cessna 2016-2059	Cessna 2106-2138	Cessna 2143-2217	Cessna 2225-2407	DC3 2122-2158	DC3 2206-2248
Altitude (m MSL):	810	830	1020	950	1000	700
Temperature (C):	10	10	9	10	10	12
Relative Humidity (%):	52	55	51	49	37	46
<u>Filter Pack Measurements</u>						
H ⁺ (μg/m ³ as H ₂ SO ₄): (μmol/m ³):	0. 0.	0. 0.	0. 0.	0. 0.	.1 .001	0. 0.
NH ₄ ⁺ (μg/m ³): (μmol/m ³):	.5 .03	.7 .04	.5 .03	.4 .02	.3 .02	.9 .05
NO ₃ ⁻ (μg/m ³): (μmol/m ³):	1.2 .019	2.4 .038	.5 .008	.5 .008	.6 .01	.6 .01
HNO ₃ (μg/m ³): (μmol/m ³):	4.1 .065	3.8 .061	3.5 .057	1.2 .020	.3 .004	.6 .010
SO ₄ ²⁻ (μg/m ³): (μmol/m ³):	1.0 .010	.6 .006	1.8 .019	.6 .006	1.3 .013	2.5 .026
SO ₂ (μg/m ³): (μmol/m ³):	16. .25	0. 0.	52. .81	14. .21	3.4 .053	15. .24
<u>Real-Time Measurements^(a)</u>						
SO ₂ (ppb): (μmol/m ³):	-- --	-- --	-- --	-- --	3.0 .12	7.0 .28
NO _x (ppb): (μmol/m ³):	-- --	-- --	-- --	-- --	.7 .03	11. .45
O ₃ (ppb):	--	--	--	--	81.	64.
b _{scat} (10 ⁻⁴ m ⁻¹):	0.4	0.4	0.3	0.3	0.05	0.2
CNC ^(b) (cm ⁻³):	--	--	--	--	2300.	12000.

(a) Measurements were averaged over the filter collections period. Averages may not correspond exactly to the filter data because of sections of missing data or calibration checks.

(b) Condensation or Aitken nuclei.

altitudes (1000 vs. 700 m). Both the real-time and filter data show higher concentrations (by factor of 2 or more) during the second sampling, indicating significant vertical changes between 700 and 1000 m. The real-time data during the second collection (Figure 4.5) also show significant spatial variation over the sampling track, particularly apparent in the SO_2 and NO_x data.

Real-time measurements made aboard the Cessna during its filter collections are shown in Figures 4.6 and 4.7. The SO_2 data from the Cessna are only qualitative, as inadequate instrument zeroes were obtained during its flight. Nonetheless, the data demonstrate qualitatively the spatial variation of SO_2 concentration during the sampling. As can be seen, significant variations in SO_2 concentration did exist over the network.

IN CLOUD DATA

One set of cloud water samples were collected aboard the DC3, using the supercooled cloud water collectors. The aircraft flight track during the collection is shown in Figure 4.3. Winds during the sample collection were from the west. Data for these samples are summarized in Table 4.2. The samples were obtained at a rather high altitude (3400 m), because the aircraft was unable to locate solid low-level clouds at the time of sampling. Thus, it is quite likely that the samples do not reflect the chemistry of lower level air that could be expected to have higher pollutant loadings and a greater influence on precipitation chemistry. Compared with the precipitation chemistry measurements, the Cl^- and Na^+ concentrations in the cloud water are relatively high, both in an absolute sense and relative to SO_4^{2-} and NO_3^- . This greater abundance of non-anthropogenic species indicates that the samples were collected from air having a relatively low pollutant loading. The low "virtual airborne sulfate concentration" (product of cloud water sulfate concentration and cloud liquid water concentration), which averaged 0.1 g/m^3 for the two samples, also supports this conclusion.

TABLE 4.2. Cloud Water Samples Collected on April 16 by the PNL DC3

Collection Time (GMT)	Alt. (m)	Temp. (°C)	Liq. Water (gm/m ³)	Sample Vol. (ml)	pH	Cond.	Ion Bal.	SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	Anion Sum	H ⁺	NH ₄ ⁺	Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺	Cation Sum
2350-0021	3400	-3	.07	27.	5.18	6.5	.36	14.0	26.0	16.0	70.0	6.6	25.0	27.0	2.4	14.0	5.8	100.6
2353-0023	3400	-3	.07	22.	ISA	ISA	ISA	16.0	27.0	28.0	87.0	ISA	28.0	26.0	13.0	7.1	3.3	ISA

Notes:

1. Units, unless noted, are:
H⁺, Anion Sum, Cation Sum - $\mu\text{eq/l}$
Other species - $\mu\text{mol/l}$
2. ISA means insufficient sample for the analysis
3. Ion balance is $2 \times (\text{Cations} - \text{Anions}) / (\text{Cations} + \text{Anions})$
4. On all samples, PO₄³⁻ was below the detection limit (0.2 $\mu\text{mol/l}$)
5. Samples were collected with the supercooled cloud water collectors.

FIGURE 4.1. Aircraft Flight Tracks for the Cessna During its First Two Filter Sample Collections on April 16. Dotted Line Shows Cessna Position from 2016 to 2059 GMT; Solid Line Shows Position from 2106 to 2138 GMT. Small Squares Show Positions at Start of Each Time Segment. "FWA" is Fort Wayne Airport, and the Large (Dashed) Square Outlines the High-Density Network (see Figure 1.2).

FIGURE 4.2. Aircraft Flight Tracks for the Cessna During its Last Two Filter Sample Collections on April 16. Dotted Line Shows Cessna Position from 2143 to 2217 GMT; Solid Line Shows Position from 2225 to 2407 GMT. Small Squares Show Positions at Start of Each Time Segment. "FWA" is Fort Wayne Airport, and the Large (Dashed) Square Outlines the High-Density Network (see Figure 1.2).

FIGURE 4.3. Aircraft Flight Tracks for the DC3 During its Filter and Cloud Water Sample Collections on April 16. Dotted Line Shows DC3 Position from 2122 to 2158 GMT (First Filter Sample); Solid Line Shows Position from 2206 to 2248 GMT (Second Filter Sample); Dashed Line Shows Position from 2350 to 2423 GMT (Cloud Water Sample). Small Squares Show Positions at Start of Each Time Segment. "FWA" is Fort Wayne Airport, and the Large (Dashed) Square Outlines the High-Density Network (see Figure 1.2).

FIGURE 4.4. Real-time Measurements Aboard the DC3 During its First Filter Sample Collection on April 16.

FIGURE 4.5. Real-time Measurements Aboard the DC3 During its Second Filter Sample Collection on April 16.

FIGURE 4.6. Real-time SO_2 and b_{scat} Measurements Aboard the Cessna During its First Three Filter Sample Collections on April 16. (Note: SO_2 Data is Only Qualitative, Showing Spatial Variability, as Adequate In-Flight Zero Checks Were Not Obtained.)

FIGURE 4.7. Real-time SO₂ and b_{scat} Measurements Aboard the Cessna During its Final Filter Sample Collection on April 16. (Note: SO₂ Data is Only Qualitative, Showing Spatial Variability, as Adequate In-Flight Zero Checks Were Not Obtained.)

5.0 REFERENCES

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APPENDIX A

DATA TABULATIONS

APPENDIX A

DATA TABULATIONS

OSCAR intensive network site locations are shown in Figure 1.2 and detailed in Table A.1.

Complete precipitation chemistry and rainfall data for Event 3 are listed in Table A.2. Each page contains data from one of the 47 sites. The collection efficiency is the total rainfall collected by the sequential collector, divided by the total rainfall measured by the accompanying weighing rain gauge. For sites where the collector overflowed, and thus collection efficiency was impossible to compute, "DVF" is printed. "START" is the day and time of the start of filling of each stage, "DT" is the duration of each stage, and "R-RATE" is the rainfall rate (stage volume/DT). "ION BAL" is the ion balance check, given by

$$(\text{Cation Sum} - \text{Anion Sum}) / 0.5(\text{Cation Sum} + \text{Anion Sum})$$

(difference of ion totals divided by the mean). The AVG figures are volume-weighted averages for all stages (equivalent to the event-average values), calculated using Equation 3.1. Additional codes, generally following those used by the MAP3S Precipitation Chemistry Network, are listed below.

<	Less than detection limit (given)
NAP	No analysis performed
ISA	Insufficient sample for analysis
RPC	Rejected--probable contamination

TABLE A.1. High-Density Precipitation Chemistry Site Positions

Site No.	Latitude	Longitude	Site No.	Latitude	Longitude
11	41.591	85.603	45	41.129	84.862
12	41.639	85.378	46	41.175	84.646
13	41.638	85.199	51	40.995	85.659
14	41.575	85.038	52	41.001	85.423
15	41.561	84.849	53	41.032	85.293
16	41.588	84.720	54	40.966	84.966
21	41.377	85.624	55	40.986	84.817
22	41.430	85.403	56	41.058	84.710
23	41.439	85.194	57	40.929	84.561
24	41.443	85.059	58	41.015	84.391
25	41.394	84.892	61	40.806	85.679
26	41.409	84.701	62	40.844	85.464
27	41.435	84.482	63	40.914	85.231
31	41.276	85.582	64	40.798	85.153
32	41.331	85.464	65	40.791	84.966
33	41.305	85.178	66	40.860	84.756
34	41.306	85.069	67	40.810	84.521
35	41.251	84.859	71	40.663	85.693
36	41.309	84.564	72	40.665	85.466
37	41.338	84.431	73	40.665	85.303
41	41.175	85.645	74	40.668	85.092
42	41.136	85.489	75	40.665	84.858
43	41.143	85.152	76	40.644	84.628
44	41.198	85.019			

TABLE A.2 OSCAR HIGH-DENSITY NETWORK PRECIPITATION CHEMISTRY
AND RAINFALL DATA.

SITE 11

COLLECTION EFFICIENCY = 0.94

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	0.88	0.03	22.86	3.90	75.0	-0.13
2	4-17	0.91	1.02	0.68	3.86	68.0	-0.08
3	4-17	1.94	6.50	0.11	3.72	100.0	-0.12
4	4-17	8.44	0.04	16.76	4.03	51.0	0.00
5	4-17	8.48	0.04	16.76	RPC	RPC	--
6	4-17	8.52	0.04	16.76	4.57	11.0	-0.01
AVG				0.55	3.94	61.0	-0.07
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	NAP	130.0	0.1	110.0	30.0	<0.2	400.
2	NAP	92.0	0.2	90.0	33.0	<0.2	307.
3	NAP	140.0	0.2	140.0	50.0	<0.2	470.
4	NAP	81.0	0.2	76.0	20.0	<0.2	258.
5	RPC	RPC	RPC	RPC	RPC	RPC	RPC
6	NAP	21.0	0.2	15.0	3.9	<0.2	61.
AVG	--	92.8	0.2	86.2	27.4	--	299.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	125.9	89.0	26.0	1.1	37.0	17.0	350.
2	138.0	67.0	31.0	0.8	16.0	7.1	283.
3	190.5	84.0	53.0	1.4	30.0	15.0	419.
4	93.3	74.0	21.0	5.9	23.0	8.7	258.
5	RPC	RPC	RPC	RPC	RPC	RPC	RPC
6	26.9	21.0	2.6	<0.4	4.1	0.9	61.
AVG	114.9	67.0	26.7	1.8	22.0	9.8	274.

TABLE A.2, CONTINUED.

SITE 12

COLLECTION EFFICIENCY = 0.93

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION PAL
1	4-17	0.50	0.65	1.10	3.72	94.0	-0.04
2	4-17	1.15	0.74	0.97	3.96	51.0	-0.01
3	4-17	1.89	2.04	0.35	3.62	120.0	-0.06
4	4-17	3.93	5.02	0.13	3.74	91.0	-0.06
AVG				0.33	3.74	89.0	-0.04
	S02	S04	N02	N03	CL	P04	AN SUM MEQ/L
1	NAP	130.0	0.2	110.0	35.0	<0.2	405.
2	NAP	65.0	0.1	60.0	19.0	<0.2	209.
3	NAP	140.0	0.3	140.0	52.0	<0.2	472.
4	NAP	120.0	0.2	120.0	32.0	<0.2	392.
AVG	--	113.6	0.2	107.2	34.6	--	369.
	FREE H	NH4	NA	K	CA	MG	CAT SUM MEQ/L
1	190.5	92.0	36.0	1.7	23.0	12.0	390.
2	109.6	46.0	19.0	2.3	10.0	4.8	207.
3	239.9	89.0	53.0	2.3	20.0	11.0	446.
4	182.0	88.0	34.0	1.8	22.0	9.2	368.
AVG	180.5	78.5	35.5	2.0	18.7	9.3	352.

TABLE A.2, CONTINUED.

SITE 13

COLLECTION EFFICIENCY = 0.88

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	0.92	0.99	0.76	3.79	80.0	-0.05
2	4-17	1.91	6.90	0.11	3.81	74.0	-0.03
3	4-17	8.81	0.22	3.34	3.90	72.0	-0.09
4	4-17	9.03	0.04	18.26	4.40	22.0	-0.05
5	4-17	9.07	0.02	18.26	4.52	ISA	0.02
AVG				0.41	3.96	62.0	-0.05
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	0.1	110.0	0.1	98.0	31.0	<0.2	349.
2	0.2	97.0	0.1	93.0	30.0	<0.2	317.
3	<0.2	98.0	<0.1	98.0	25.0	<0.2	319.
4	0.1	28.0	0.3	23.0	5.2	<0.2	84.
5	NAP	21.0	0.3	16.0	3.6	<0.2	62.
AVG	0.1	76.5	0.1	71.3	20.7	--	245.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	162.2	80.0	31.0	3.2	20.0	8.3	333.
2	154.9	72.0	33.0	3.4	15.0	7.0	307.
3	125.9	78.0	26.0	2.3	21.0	8.7	292.
4	39.8	24.0	3.9	<0.4	5.0	1.4	81.
5	30.2	22.0	2.6	<0.4	3.3	0.8	63.
AVG	110.9	59.0	21.2	2.0	14.0	5.8	233.

TABLE A.2, CONTINUED.

SITE 14

COLLECTION EFFICIENCY = 0.84

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	TON BAL
1	4-17	0.75	1.10	0.71	4.05	55.0	-0.04
2	4-17	1.85	3.16	0.25	3.86	75.0	0.00
3	4-17	5.01	3.66	0.21	3.70	110.0	-0.08
4	4-17	8.66	0.76	1.03	3.95	62.0	-0.02
5	4-17	9.42	0.05	15.24	4.22	33.0	-0.05
6	4-17	9.47	0.01	15.24	4.24	ISA	--
AVG				0.47	3.93	67.0	-0.04
	S02	S04	N02	N03	CL	PO4	AN SUM UEQ/L
1	NAP	81.0	NAP	68.0	19.0	<0.2	249.
2	NAP	80.0	97.0	35.0	<0.6	ISA	292.
3	NAP	140.0	NAP	130.0	46.0	<0.2	456.
4	NAP	78.0	NAP	65.0	18.0	<0.2	239.
5	NAP	45.0	NAP	38.0	8.2	<0.2	136.
6	NAP	42.0	NAP	35.0	7.2	<0.2	126.
AVG	--	82.8	97.0	65.7	17.7	--	268.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	89.1	60.0	18.0	2.5	23.0	12.0	240.
2	138.0	77.0	37.0	2.1	11.0	8.0	292.
3	199.5	100.0	41.0	2.2	25.0	15.0	423.
4	112.2	63.0	14.0	1.2	16.0	6.0	234.
5	60.3	43.0	6.2	<2.0	8.0	2.2	130.
6	57.5	40.0	5.7	<2.0	ISA	ISA	ISA
AVG	116.9	67.3	22.4	1.5	16.6	8.6	264.

TABLE A.2, CONTINUED.

SITE 15

COLLECTION EFFICIENCY = 0.39

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	0.34	0.56	3.03	5.61	27.0	-0.31
2	4-17	0.90	MOE	MOE	MOE	MOE	--
3	4-17	4.45	MOE	MOE	MOE	MOE	--
AVG				--	5.61	27.0	-0.31
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	72.0	NAP	72.0	16.0	<0.2	232.
2	MOE	MOE	MOE	MOE	MOE	MOE	MOE
3	MOE	MOE	MOE	MOE	MOE	MOE	MOE
AVG	--	72.0	--	72.0	16.0	--	232.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	2.5	36.0	15.0	1.9	40.0	17.0	169.
2	MOE	MOE	MOE	MOE	MOE	MOE	MOE
3	MOE	MOE	MOE	MOE	MOE	MOE	MOE
AVG	2.5	36.0	15.0	1.9	40.0	17.0	169.

TABLE A.2, CONTINUED.

SITE 16

COLLECTION EFFICIENCY = 0.42

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	TON BAL
1	4-17	0.77	0.36	4.36	4.11	43.0	-0.07
2	4-17	1.13	0.05	30.48	4.19	32.0	0.00
3	4-17	1.18	8.38	0.19	4.29	26.0	-0.09
4	4-17	9.56	0.32	3.05	4.14	38.0	-0.16
AVG				0.62	4.18	34.4	-0.07
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	<0.2	57.0	NAP	52.0	13.0	<0.2	179.
2	<0.2	35.0	NAP	34.0	12.0	<0.2	116.
3	<0.2	31.0	NAP	30.0	14.0	<0.2	106.
4	NAP	49.0	NAP	49.0	19.0	<0.2	166.
AVG	--	42.4	--	40.4	14.0	--	139.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	77.6	33.0	11.0	1.7	15.0	7.2	168.
2	64.6	23.0	6.8	1.1	6.5	3.9	116.
3	51.3	27.0	7.4	1.2	3.0	1.9	97.
4	72.4	37.0	14.0	1.4	5.6	2.9	142.
AVG	65.9	29.3	9.4	1.3	7.7	4.1	129.

TABLE A.2, CONTINUED.

SITE 21

COLLECTION EFFICIENCY = 0.40

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.26	0.43	3.79	3.70	100.0	-0.21
2	4-16	23.69	0.18	9.17	4.04	48.0	-0.14
3	4-16	23.87	0.58	0.47	ISA	ISA	--
AVG				2.99	3.84	74.0	-0.17
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	0.1	145.0	NAP	100.0	29.0	<0.2	419.
2	0.1	61.0	NAP	52.0	17.0	<0.2	191.
3	0.2	58.0	NAP	59.0	21.0	<0.2	196.
AVG	0.1	99.5	--	74.7	22.8	--	297.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	199.5	57.0	18.0	2.3	23.0	8.3	339.
2	91.2	35.0	12.0	1.1	9.0	4.4	166.
3	ISA	42.0	21.0	<0.4	ISA	ISA	ISA
AVG	145.4	45.7	15.5	1.6	16.0	6.4	253.

TABLE A.2, CONTINUED.

SITE 22

COLLECTION EFFICIENCY = 0.98

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.42	0.22	3.04	3.79	89.0	-0.18
2	4-16	23.65	0.22	3.04	4.06	47.0	-0.24
3	4-16	23.87	0.22	3.04	4.04	47.0	-0.17
4	4-17	0.09	0.10	3.04	4.02	53.0	--
AVG				3.04	3.95	60.0	-0.19
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	120.0	NAP	110.0	29.0	<0.2	379.
2	NAP	64.0	NAP	56.0	22.0	<0.2	206.
3	NAP	58.0	NAP	56.0	18.0	<0.2	190.
4	NAP	63.0	NAP	67.0	24.0	<0.2	217.
AVG	--	78.4	--	73.1	23.1	--	253.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	162.2	66.0	18.0	3.0	24.0	10.0	317.
2	87.1	38.0	9.0	<1.5	10.0	4.2	162.
3	91.2	38.0	11.0	<1.5	6.8	3.3	160.
4	95.5	51.0	17.0	<1.5	15A	15A	15A
AVG	111.2	47.8	13.2	0.9	13.6	5.8	213.

TABLE A.2, CONTINUED.

SITE 23

COLLECTION EFFICIENCY = 1.02

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.76	0.21	3.09	4.28	48.0	-0.21
2	4-16	23.97	0.10	6.86	4.07	49.0	-0.16
3	4-17	0.07	0.07	9.27	4.37	26.0	-0.08
4	4-17	0.14	0.07	9.27	4.20	34.0	-0.03
5	4-17	0.21	0.07	9.27	4.19	35.0	0.03
6	4-17	0.28	0.07	9.46	4.06	48.0	0.01
7	4-17	0.35	0.06	11.03	4.13	41.0	0.17
8	4-17	0.41	0.02	11.03	4.20	35.0	--
AVG				7.20	4.18	39.9	-0.04
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	0.1	91.0	NAP	92.0	30.0	<0.2	304.
2	NAP	65.0	NAP	70.0	22.0	<0.2	222.
3	<0.2	31.0	NAP	33.0	14.0	<0.2	109.
4	NAP	38.0	NAP	40.0	14.0	<0.2	130.
5	NAP	35.0	NAP	37.0	15.0	<0.2	122.
6	NAP	53.0	NAP	56.0	22.0	<0.2	184.
7	0.1	39.0	NAP	43.0	17.0	<0.2	138.
8	NAP	34.0	NAP	37.0	35.0	<0.2	140.
AVG	0.1	49.5	--	52.2	19.9	--	171.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	52.5	62.0	30.0	6.0	30.0	18.0	246.
2	85.1	44.0	19.0	1.1	13.0	7.0	189.
3	42.7	25.0	7.9	<1.0	7.7	4.8	101.
4	63.1	34.0	12.0	<1.0	5.8	2.8	126.
5	64.6	34.0	11.0	<1.0	5.6	2.7	126.
6	87.1	58.0	19.0	<2.0	6.8	3.7	185.
7	74.1	51.0	18.0	<2.0	6.6	3.5	163.
8	63.1	43.0	16.0	<3.0	ISA	ISA	ISA
AVG	66.8	44.0	16.7	1.0	10.8	6.1	162.

TABLE A.2, CONTINUED.

SITE 24

COLLECTION EFFICIENCY = 0.94

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.96	0.28	2.55	3.95	74.0	-0.11
2	4-17	0.24	0.08	8.47	4.20	41.0	-0.09
3	4-17	0.32	0.15	4.72	4.10	44.0	-0.04
4	4-17	0.47	0.08	9.17	3.94	63.0	-0.06
5	4-17	0.54	0.04	9.17	3.83	ISA	0.09
AVG				5.07	4.01	55.5	-0.06
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	100.0	<0.1	130.0	41.0	<0.2	371.
2	NAP	52.0	0.1	67.0	23.0	<0.2	194.
3	NAP	54.0	<0.1	62.0	23.0	<0.2	193.
4	NAP	73.0	<0.1	90.0	31.0	<0.2	267.
5	NAP	76.0	<0.1	95.0	34.0	<0.2	281.
AVG	--	70.4	0.0	88.1	30.0	--	259.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	112.2	83.0	47.0	4.9	28.0	15.0	333.
2	63.1	51.0	25.0	0.8	11.0	7.7	177.
3	79.4	55.0	25.0	0.9	8.4	4.4	186.
4	114.8	70.0	38.0	1.1	8.5	5.7	252.
5	147.9	81.0	45.0	1.0	9.7	6.3	307.
AVG	98.4	66.5	35.0	1.8	13.5	8.0	245.

TABLE A.2, CONTINUED.

SITE 25

COLLECTION EFFICIENCY = ? (NO RAINGAUGE DATA)
 UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	MOE	MOE	MOE	MOE	ISA	ISA	--
AVG				--	--	--	--
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	ISA	ISA	ISA	ISA	ISA	ISA	ISA
AVG	--	--	--	--	--	--	--
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	ISA	ISA	ISA	ISA	ISA	ISA	ISA
AVG	--	--	--	--	--	--	--

TABLE A.2, CONTINUED.

SITE 26

COLLECTION EFFICIENCY = 1.08

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	0.00	0.29	2.31	3.90	94.0	0.00
2	4-17	0.29	0.15	0.75	ISA	ISA	--
AVG				1.78	3.90	94.0	0.00
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM HEQ/L
1	NAP	130.0	NAP	130.0	45.0	<0.2	435.
2	NAP	330.0	NAP	305.0	99.0	<0.2	1064.
AVG	--	158.6	--	155.0	52.7	--	525.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	125.9	140.0	51.0	8.6	32.0	23.0	435.
2	ISA	190.0	96.0	15.0	62.0	39.0	ISA
AVG	125.9	147.1	57.4	9.5	36.3	25.3	435.

TABLE A.2. CONTINUED.

SITE 27

COLLECTION EFFICIENCY = 1.23

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAR PH	COND UMHO/CM	ION BAL
1	4-17	0.42	0.04	15.00	3.91	80.0	-0.05
2	4-17	0.46	9.30	0.07	4.09	52.0	0.01
3	4-17	9.77	0.06	11.25	3.89	80.0	-0.03
4	4-17	9.83	0.01	11.25	ISA	ISA	--
AVG				0.22	3.95	70.7	-0.02
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	NAP	110.0	NAP	100.0	30.0	<0.2	350.
2	NAP	65.0	NAP	77.0	29.0	<0.2	236.
3	NAP	100.0	NAP	110.0	35.0	<0.2	345.
4	NAP	55.0	NAP	53.0	17.0	<0.2	180.
AVG	--	90.1	--	93.8	30.7	--	305.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	123.0	75.0	32.0	4.5	31.0	18.0	333.
2	81.3	67.0	35.0	3.4	16.0	10.0	239.
3	128.8	86.0	36.0	5.3	27.0	12.0	334.
4	ISA	26.0	16.0	4.8	ISA	13.0	ISA
AVG	111.0	73.8	33.5	4.4	24.7	13.3	302.

TABLE A.2, CONTINUED.

SITE 31

COLLECTION EFFICIENCY = 1.14

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.18	0.46	0.49	3.88	ISA	--
AVG				0.49	3.88	--	--
	902	904	N02	N03	CL	P04	AN SUM UEQ/L
1	NAP	150.0	NAP	130.0	41.0	<0.2	471.
AVG	--	150.0	--	130.0	41.0	--	471.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	131.8	130.0	50.0	9.1	ISA	ISA	ISA
AVG	131.8	130.0	50.0	9.1	--	--	--

TABLE A.2, CONTINUED.

SITE 32

COLLECTION EFFICIENCY = 1.40

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.77	0.34	1.93	4.39	59.0	-0.10
2	4-17	0.11	0.03	1.93	ISA	ISA	--
AVG				1.93	4.39	59.0	-0.10
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	110.0	NAP	120.0	41.0	<0.2	381.
2	ISA	ISA	ISA	ISA	ISA	ISA	ISA
AVG	--	110.0	--	120.0	41.0	--	381.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	40.7	110.0	51.0	6.3	43.0	26.0	346.
2	ISA	ISA	ISA	ISA	ISA	ISA	ISA
AVG	40.7	110.0	51.0	6.3	43.0	26.0	346.

TABLE A.2, CONTINUED.

SITE 33

COLLECTION EFFICIENCY = ? (NO RAINGAUGE DATA)
 UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	MOE	MOE	MOE	MOE	4.98	60.0	--
AVG				--	4.98	60.0	--
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	140.0	NAP	160.0	45.0	<0.2	485.
AVG	--	140.0	--	160.0	45.0	--	485.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	10.5	92.0	45.0	5.3	ISA	ISA	ISA
AVG	10.5	92.0	45.0	5.3	--	--	--

TABLE A.2, CONTINUED.

SITE 34

COLLECTION EFFICIENCY = 0.48

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.47	7.36	0.11	ISA	ISA	0.00
AVG				0.11	--	--	0.00
	S02	S04	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	ISA	ISA	ISA	ISA	ISA	ISA	0.
AVG	--	--	--	--	--	--	--
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	ISA	ISA	ISA	ISA	ISA	ISA	0.
AVG	--	--	--	--	--	--	--

TABLE A.2, CONTINUED.

SITE 35

COLLECTION EFFICIENCY = 1.05

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.25	0.12	5.32	4.55	43.0	-0.15
2	4-16	23.37	0.12	5.33	4.23	48.0	-0.15
3	4-16	23.50	9.56	0.07	4.31	57.0	-0.21
AVG				0.20	4.34	49.3	-0.17
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	83.0	NAP	87.0	24.0	<0.2	277.
2	NAP	72.0	NAP	84.0	30.0	<0.2	258.
3	NAP	97.0	NAP	120.0	41.0	<0.2	355.
AVG	--	84.0	--	97.0	31.7	--	297.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	28.2	68.0	17.0	2.8	35.0	26.0	238.
2	58.9	61.0	23.0	<1.0	22.0	18.0	223.
3	49.0	70.0	39.0	2.5	33.0	30.0	286.
AVG	45.3	66.3	26.3	1.8	30.0	24.7	249.

TABLE A.2. CONTINUED.

SITE 36

COLLECTION EFFICIENCY = 0.91

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL	
1	4-16	23.58	0.12	5.85	4.23	50.0	-0.24
2	4-16	23.71	0.28	2.55	4.05	51.0	-0.08
3	4-16	23.99	9.72	0.07	4.01	71.0	-0.17
4	4-17	9.71	0.04	17.56	4.26	38.0	-0.06
5	4-17	9.75	0.71	0.41	4.32	31.0	-0.05
AVG			0.29	4.14	50.5	-0.13	
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	110.0	0.2	73.0	21.0	<0.2	314.
2	NAP	64.0	0.1	62.0	23.0	<0.2	213.
3	NAP	110.0	0.1	130.0	40.0	<0.2	390.
4	NAP	59.0	0.3	53.0	14.0	<0.2	185.
5	NAP	44.0	0.3	38.0	8.9	<0.2	135.
AVG	--	81.9	0.2	75.6	23.1	--	263.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	58.9	53.0	16.0	9.5	44.0	11.0	247.
2	89.1	48.0	19.0	1.9	15.0	4.6	197.
3	97.7	87.0	46.0	3.7	32.0	15.0	328.
4	55.0	55.0	14.0	1.5	18.0	6.2	174.
5	47.9	44.0	7.1	0.9	11.0	3.5	129.
AVG	72.6	59.2	22.2	3.8	25.7	8.7	227.

TABLE A.2, CONTINUED.

SITE 37

COLLECTION EFFICIENCY = 0.96

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.83	0.19	3.66	3.94	ISA	-0.16
2	4-17	0.02	0.19	3.66	4.04	45.0	0.00
3	4-17	0.21	9.72	0.07	3.92	60.0	-0.01
4	4-17	9.93	0.71	0.77	3.87	77.0	-0.09
AVG				0.24	3.94	59.4	-0.06
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	120.0	0.1	90.0	20.0	<0.2	350.
2	0.2	55.0	0.1	45.0	14.0	<0.2	169.
3	0.1	62.0	0.1	78.0	29.0	<0.2	231.
4	0.1	110.0	0.1	110.0	31.0	<0.2	361.
AVG	0.1	85.4	0.1	79.1	23.1	--	273.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	114.8	81.0	19.0	2.5	28.0	13.0	299.
2	91.2	39.0	9.6	2.4	9.4	3.7	168.
3	120.2	58.0	27.0	0.8	7.2	4.2	229.
4	134.9	89.0	33.0	4.2	23.0	12.0	331.
AVG	114.2	65.5	21.5	2.4	16.6	8.0	253.

TABLE A.2, CONTINUED.

SITE 41

COLLECTION EFFICIENCY = ? (NO RAINGAUGE DATA)
 UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAT	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	MOE	MOE	MOE	3.70	140.0	--
AVG	--	--	--	3.70	140.0	--
	SO2	SO4	NO2	NO3	CL	PO4
						AN SUM UEQ/L
1	NAP	240.0	NAP	160.0	36.0	<0.2
AVG	--	240.0	--	160.0	36.0	--
	FREE H	NH4	NA	K	CA	MG
						CAT SUM UEQ/L
1	199.5	120.0	28.0	9.8	ISA	ISA
AVG	199.5	120.0	28.0	9.8	--	--

TABLE A.2, CONTINUED.

SITE 42

COLLECTION EFFICIENCY = 0.91

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.51	0.66	1.09	4.07	53.0	-0.08
2	4-16	23.17	9.25	0.08	3.92	77.0	-0.05
AVG				0.15	3.99	65.0	-0.07
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	72.0	ISA	74.0	22.0	<0.2	240.
2	NAP	110.0	NAP	94.0	28.0	<0.2	342.
AVG	--	91.0	--	84.0	25.0	--	291.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	85.1	55.0	15.0	2.0	23.0	9.2	222.
2	120.2	88.0	28.0	3.7	27.0	15.0	324.
AVG	102.7	71.5	21.5	2.9	25.0	12.1	273.

TABLE A.2, CONTINUED.

SITE 43

COLLECTION EFFICIENCY = 0.61

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	8.11	0.65	1.69	4.43	30.0	-0.14
AVG				1.69	4.43	30.0	-0.14
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	53.0	NAP	53.0	9.6	<0.2	169.
AVG	--	53.0	--	53.0	9.6	--	169.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	37.2	19.0	7.5	0.6	28.0	13.0	146.
AVG	37.2	19.0	7.5	0.6	28.0	13.0	146.

TABLE A.2, CONTINUED.

SITE 44

COLLECTION EFFICIENCY = 0.87

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.81	10.24	0.07	ISA	ISA	0.00
AVG				0.07	--	--	0.00
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	ISA	ISA	ISA	ISA	ISA	ISA	0.
AVG	--	--	--	--	--	--	--
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	ISA	ISA	ISA	ISA	ISA	ISA	0.
AVG	--	--	--	--	--	--	--

TABLE A.2, CONTINUED.

SITE 45

COLLECTION EFFICIENCY = 1.27

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	23.00	9.66	0.07	6.44	44.0	0.01
2	4-17	8.66	0.48	0.52	4.42	ISA	-0.10
AVG				0.09	4.97	44.0	-0.02
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	0.2	92.0	NAP	83.0	22.0	<0.2	289.
2	NAP	80.0	NAP	69.0	14.0	<0.2	243.
AVG	0.2	88.7	--	79.2	19.8	--	276.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	0.4	65.0	19.0	3.6	55.0	47.0	292.
2	38.0	49.0	15.0	3.5	34.0	23.0	220.
AVG	10.7	60.6	17.9	3.6	49.2	40.4	272.

TABLE A.2, CONTINUED.

SITE 46

COLLECTION EFFICIENCY = ? (NO RAINGAUGE DATA)
 UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	MOE	MOE	MOE	MOE	4.44	ISA	-0.32
AVG	--	--	--	--	4.44	--	-0.32
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	NAP	160.0	NAP	140.0	31.0	<0.2	491.
AVG	--	160.0	--	140.0	31.0	--	491.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	36.3	110.0	28.0	3.7	55.0	33.0	354.
AVG	36.3	110.0	28.0	3.7	55.0	33.0	354.

TABLE A.2, CONTINUED.

SITE 51

COLLECTION EFFICIENCY = 0.88

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	8.36	0.16	4.57	5.99	46.0	-0.35
2	4-17	8.52	0.52	1.44	4.44	22.0	-0.24
3	4-17	9.04	0.15	5.12	4.38	22.0	-0.07
AVG				2.71	4.58	30.0	-0.22
	SD2	SD4	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	130.0	NAP	120.0	25.0	<0.2	405.
2	NAP	39.0	NAP	26.0	4.1	<0.2	108.
3	NAP	29.0	NAP	18.0	4.4	<0.2	80.
AVG	--	66.0	--	54.7	11.2	--	198.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	1.0	67.0	17.0	3.3	57.0	41.0	284.
2	36.3	6.6	2.0	0.4	12.0	8.0	85.
3	41.7	8.5	1.6	<0.4	7.1	4.6	75.
AVG	26.3	27.4	6.9	1.2	25.4	17.9	148.

TABLE A.2, CONTINUED.

SITE 52

COLLECTION EFFICIENCY = 1.04

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	7.73	0.21	3.17	4.21	50.0	-0.14
2	4-17	7.94	0.62	1.06	4.10	38.0	-0.05
3	4-17	8.57	0.08	1.59	ISA	ISA	--
AVG				1.59	4.15	44.0	-0.10
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UMOL/L
1	<0.2	94.0	NAP	74.0	12.0	<0.2	274.
2	<0.2	44.0	NAP	32.0	6.4	<0.2	126.
3	NAP	45.0	NAP	33.0	10.0	<0.2	133.
AVG	--	67.0	--	51.3	9.3	--	195.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UMOL/L
1	61.7	58.0	12.0	4.6	36.0	15.0	238.
2	79.4	14.0	2.4	0.6	8.1	3.7	120.
3	ISA	25.0	4.3	0.8	ISA	ISA	ISA
AVG	70.5	35.1	7.0	2.5	22.0	9.4	179.

TABLE A.2, CONTINUED.

SITE 53

COLLECTION EFFICIENCY = 0.76

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.80	9.37	0.09	4.59	38.0	-0.05
2	4-17	8.17	0.64	1.19	4.23	28.0	-0.12
AVG				0.16	4.38	33.3	-0.08
	S02	S04	N02	N03	CL	PD4	AN SUM UEQ/L
1	NAP	83.0	NAP	49.0	16.0	<0.2	231.
2	NAP	35.0	NAP	23.0	6.4	<0.2	99.
AVG	--	60.5	--	36.8	11.5	--	169.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	25.7	67.0	14.0	4.7	34.0	20.0	219.
2	58.9	3.9	2.3	<0.4	7.8	3.9	88.
AVG	41.2	37.5	8.5	2.5	21.7	12.5	158.

TABLE A.2, CONTINUED.

SITE 54

COLLECTION EFFICIENCY = 1.77

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL	
1	4-16	22.67	9.49	4.52	41.0	-0.08	
2	4-17	8.16	0.56	4.27	30.0	-0.06	
AVG			0.12	4.39	36.0	-0.07	
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	83.0	NAP	74.0	17.0	<0.2	257.
2	NAP	40.0	NAP	29.0	5.7	<0.2	115.
AVG	--	63.5	--	53.5	11.9	--	192.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	30.2	71.0	17.0	4.3	33.0	24.0	236.
2	53.7	12.0	2.7	<0.4	12.0	7.7	108.
AVG	40.9	44.2	10.5	2.3	23.5	16.6	178.

TABLE A.2, CONTINUED.

SITE 55

COLLECTION EFFICIENCY = 1.37

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	TON BAL
1	4-16	22.88	9.43	0.07	5.28	31.0	-0.15
2	4-17	8.32	0.50	1.32	4.31	36.0	-0.11
3	4-17	8.82	0.26	1.98	4.13	41.0	-0.04
AVG				0.18	4.40	35.6	-0.11
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	0.2	59.0	NAP	93.0	20.0	<0.2	231.
2	<0.2	82.0	NAP	74.0	18.0	<0.2	256.
3	0.1	55.0	NAP	46.0	8.5	<0.2	165.
AVG	0.1	66.2	--	73.0	16.1	--	221.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	5.2	32.0	14.0	5.2	40.0	31.0	198.
2	49.0	51.0	20.0	2.6	32.0	21.0	229.
3	74.1	31.0	5.6	3.1	14.0	8.5	159.
AVG	40.2	38.6	13.8	3.7	29.9	21.1	198.

TABLE A.2, CONTINUED.

SITE 56

COLLECTION EFFICIENCY = 1.10

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT)		DT	R-RATE	LAB PH	COND	ION BAL
	DAY	HR	HR	MM/HR		UMHO/CM	
1	4-16	23.05	0.11	1.68	4.42	ISA	0.01
2	4-16	23.16	10.37	0.06	4.01	60.0	-0.11
3	4-17	9.53	0.04	6.71	4.00	54.0	-0.12
AVG				0.11	4.05	58.2	-0.09
	S02	S04	NO2	NO3	CL	P04	AN SUM
							UEQ/L
1	NAP	86.0	NAP	68.0	13.0	ISA	253.
2	NAP	100.0	NAP	77.0	17.0	<0.2	294.
3	NAP	86.0	NAP	75.0	13.0	ISA	260.
AVG	--	94.3	--	75.1	15.4	--	279.
	FREE H	NH4	NA	K	CA	MG	CAT SUM
							UEQ/L
1	38.0	91.0	13.0	4.9	33.0	21.0	255.
2	97.7	61.0	18.0	2.2	27.0	15.0	263.
3	100.0	64.0	12.0	<1.0	19.0	8.2	230.
AVG	88.7	66.6	15.7	2.1	26.0	14.3	254.

TABLE A.2, CONTINUED.

SITE 57

COLLECTION EFFICIENCY = ? (NO RAINGAUGE DATA)
 UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	MOE	MOE	MOE	MOE	4.07	58.0	-0.06
AVG	--	--	--	--	4.07	58.0	-0.06
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	NAP	96.0	NAP	69.0	15.0	<0.2	276.
AVG	--	96.0	--	69.0	15.0	--	276.
	FREE H	NH4	NA	K	CA	HG	CAT SUM UEQ/L
1	85.1	70.0	24.0	1.6	25.0	14.0	259.
AVG	85.1	70.0	24.0	1.6	25.0	14.0	259.

TABLE A.2, CONTINUED.

SITE 58

COLLECTION EFFICIENCY = 1.65

UNITS ARE $\mu\text{MOL/L}$ UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND $\mu\text{MHO/CM}$	ION BAL
1	4-17	9.69	0.04	14.68	4.20	51.0	-0.06
2	4-17	9.73	0.03	14.68	4.36	37.0	-0.04
AVG				14.68	4.26	45.3	-0.06
	S02	S04	N02	N03	CL	P04	AN SUM UEG/L
1	NAP	87.0	NAP	68.0	14.0	<0.2	256.
2	NAP	54.0	NAP	56.0	20.0	<0.2	184.
AVG	--	73.4	--	63.1	16.5	--	226.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEG/L
1	63.1	96.0	17.0	1.4	23.0	8.4	240.
2	43.7	62.0	17.0	2.7	20.0	5.4	176.
AVG	55.1	82.0	17.0	1.9	21.8	7.2	214.

TABLE A.2, CONTINUED.

SITE 61

COLLECTION EFFICIENCY = 0.90

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	21.84	10.02	0.07	4.06	58.0	-0.11
2	4-17	7.86	0.44	1.68	4.64	14.0	-0.07
3	4-17	8.30	0.22	3.26	4.15	40.0	-0.03
4	4-17	8.52	0.09	3.26	4.22	ISA	-0.09
5	4-17	8.61	0.02	3.26	ISA	ISA	--
AVG				0.24	4.22	37.3	-0.07
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	94.0	NAP	58.0	12.0	<0.2	258.
2	NAP	17.0	NAP	15.0	6.6	<0.2	56.
3	NAP	50.0	NAP	33.0	7.8	ISA	141.
4	NAP	49.0	NAP	36.0	8.7	<0.2	143.
5	NAP	57.0	NAP	41.0	13.0	<0.2	168.
AVG	--	53.2	--	35.6	8.9	--	151.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	87.1	50.0	12.0	4.4	28.0	11.0	231.
2	22.9	17.0	1.7	<1.0	3.7	1.3	52.
3	70.8	42.0	5.9	<1.0	6.5	2.4	136.
4	60.3	22.0	6.0	<1.0	13.0	8.2	131.
5	ISA	24.0	9.9	7.5	ISA	ISA	ISA
AVG	60.3	34.4	6.6	1.5	12.8	5.3	139.

TABLE A.2, CONTINUED.

SITE 62

COLLECTION EFFICIENCY = 1.14

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT)		DT	R-RATE	LAB PH	COND	ION BAL
	DAY	HR	HR	MM/HR		UMHO/CM	
1	4-16	22.94	9.39	0.07	4.67	33.0	-0.16
2	4-17	8.33	0.05	14.09	4.12	45.0	-0.07
3	4-17	8.38	0.03	14.09	4.17	ISA	-0.01
AVG				0.18	4.27	39.0	-0.09
	S02	S04	NO2	NO3	CL	PO4	AN SUM
							UEQ/L
1	0.1	73.0	NAP	57.0	9.3	<0.2	212.
2	0.1	62.0	NAP	42.0	8.5	<0.2	175.
3	0.2	46.0	NAP	30.0	5.7	<0.2	128.
AVG	0.1	62.3	--	44.8	8.1	--	178.
	FREE H	NH4	NA	K	CA	MG	CAT SUM
							UEQ/L
1	21.4	41.0	6.7	1.7	35.0	20.0	181.
2	75.9	44.0	5.3	<1.0	12.0	6.8	163.
3	67.6	36.0	4.4	<1.0	6.2	2.7	126.
AVG	53.2	40.9	5.6	0.6	19.3	10.8	161.

TABLE A.2, CONTINUED.

SITE 63

COLLECTION EFFICIENCY = 0.95

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.45	9.49	0.07	4.50	40.0	-0.13
2	4-17	7.94	0.60	1.15	4.37	28.0	-0.11
3	4-17	8.54	0.47	1.47	4.05	48.0	-0.05
AVG				0.20	4.26	38.7	-0.10
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	85.0	NAP	67.0	11.0	<0.2	248.
2	NAP	45.0	NAP	29.0	4.9	<0.2	124.
3	NAP	62.0	NAP	52.0	9.5	<0.2	186.
AVG	--	64.0	--	49.3	8.5	--	186.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	31.6	48.0	13.0	6.7	36.0	23.0	217.
2	42.7	25.0	2.4	<1.0	12.0	8.7	111.
3	89.1	47.0	7.1	<1.0	11.0	5.6	176.
AVG	54.5	40.0	7.5	2.2	19.7	12.4	168.

TABLE A.2, CONTINUED.

SITE 64

COLLECTION EFFICIENCY = 0.99

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.23	6.70	0.10	4.60	33.0	-0.09
2	4-17	4.93	3.75	0.18	4.07	51.0	-0.07
3	4-17	8.68	0.02	30.38	4.34	25.0	0.03
4	4-17	8.70	0.02	30.38	4.40	19.0	0.11
5	4-17	8.73	0.02	30.38	4.35	22.0	0.07
6	4-17	8.75	0.02	23.08	4.27	31.0	0.00
AVG				0.36	4.31	30.1	0.01
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	0.1	66.0	NAP	58.0	12.0	<0.2	202.
2	0.1	70.0	NAP	54.0	12.0	<0.2	206.
3	0.1	30.0	NAP	23.0	4.2	<0.2	87.
4	0.1	20.0	NAP	13.0	3.2	<0.2	56.
5	0.1	25.0	NAP	19.0	4.8	<0.2	74.
6	NAP	42.0	NAP	36.0	7.5	<0.2	128.
AVG	0.1	42.2	--	33.7	7.3	--	125.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	25.1	59.0	13.0	2.7	26.0	16.0	184.
2	85.1	56.0	7.4	<1.0	14.0	7.5	192.
3	45.7	23.0	4.9	<1.0	5.3	2.9	90.
4	39.8	14.0	1.6	<1.0	2.6	1.0	63.
5	44.7	24.0	3.1	<1.0	2.9	1.0	80.
6	53.7	38.0	5.0	<1.0	10.0	5.4	128.
AVG	48.8	35.5	5.9	0.5	10.1	5.6	122.

TABLE A.2, CONTINUED.

SITE 65

COLLECTION EFFICIENCY = 0.90

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL	
1	4-16	22.02	6.88	0.11	4.29	50.0	-0.13
2	4-17	4.90	3.85	0.19	3.99	57.0	-0.06
3	4-17	8.75	0.25	2.93	4.17	35.0	-0.01
4	4-17	9.01	0.67	0.55	4.20	35.0	-0.03
AVG			0.22	4.14	45.6	-0.06	
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	94.0	NAP	83.0	16.0	<0.2	287.
2	NAP	74.0	NAP	61.0	10.0	<0.2	219.
3	NAP	42.0	NAP	39.0	5.8	<0.2	129.
4	NAP	45.0	NAP	41.0	6.6	<0.2	138.
AVG	--	66.4	--	58.1	10.0	--	201.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	51.3	77.0	14.0	1.9	32.0	22.0	252.
2	102.3	70.0	7.7	<1.0	8.7	4.4	206.
3	67.6	41.0	4.1	<1.0	5.2	2.3	128.
4	63.1	45.0	4.2	<1.0	7.2	3.7	134.
AVG	72.2	60.1	8.0	0.5	14.1	8.7	187.

TABLE A.2, CONTINUED.

SITE 66

COLLECTION EFFICIENCY = 0.94

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.56	10.34	0.07	4.07	63.0	-0.09
2	4-17	8.90	0.20	3.55	4.24	32.0	-0.07
3	4-17	9.10	0.07	10.43	4.32	25.0	0.00
4	4-17	9.17	0.07	10.43	4.07	46.0	-0.02
AVG				0.26	4.16	41.5	-0.05
	302	304	ND2	ND3	CL	P04	AN SUM UEQ/L
1	NAP	97.0	NAP	91.0	27.0	<0.2	312.
2	NAP	45.0	NAP	32.0	4.4	<0.2	126.
3	NAP	32.0	NAP	23.0	4.2	<0.2	91.
4	NAP	56.0	NAP	50.0	7.6	<0.2	170.
AVG	--	57.5	--	49.0	10.8	--	175.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	85.1	90.0	28.0	1.1	26.0	14.0	284.
2	57.5	33.0	5.0	<1.0	7.5	3.7	118.
3	47.9	27.0	2.6	<1.0	4.6	2.1	91.
4	85.1	55.0	5.1	<1.0	7.4	3.1	166.
AVG	68.9	51.2	10.2	0.3	11.4	5.7	165.

TABLE A.2, CONTINUED.

SITE 67

COLLECTION EFFICIENCY = 0.95

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	22.57	0.03	21.76	4.04	50.0	-0.02
2	4-16	22.60	0.03	21.76	4.29	28.0	-0.02
3	4-16	22.63	10.47	0.07	4.20	40.0	0.04
4	4-17	9.10	0.08	8.29	4.30	26.0	0.03
5	4-17	9.18	0.08	8.29	4.11	41.0	0.08
6	4-17	9.27	0.08	8.29	4.11	40.0	0.10
7	4-17	9.35	0.08	8.29	4.04	48.0	0.11
8	4-17	9.43	0.06	8.29	4.22	31.0	0.12
AVG				0.49	4.15	38.2	0.05
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	<0.2	62.0	NAP	44.0	14.0	<0.2	182.
2	0.2	32.0	NAP	30.0	11.0	<0.2	105.
3	0.1	53.0	NAP	41.0	12.0	<0.2	159.
4	<0.2	32.0	NAP	22.0	3.4	<0.2	89.
5	0.1	42.0	NAP	40.0	4.9	<0.2	129.
6	0.1	39.0	NAP	40.0	4.5	<0.2	123.
7	0.1	48.0	NAP	50.0	5.3	<0.2	151.
8	0.1	32.0	NAP	29.0	3.8	<0.2	97.
AVG	0.1	42.8	--	37.2	7.5	--	130.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	91.2	35.0	5.4	<1.0	16.0	7.2	178.
2	51.3	27.0	7.0	<1.0	5.9	3.0	103.
3	63.1	46.0	11.0	<1.0	14.0	9.1	166.
4	50.1	24.0	3.1	<1.0	5.1	2.3	92.
5	77.6	47.0	3.4	<1.0	4.1	1.7	140.
6	77.6	48.0	2.7	<1.0	2.8	0.9	136.
7	91.2	68.0	3.3	<1.0	2.4	0.9	169.
8	60.3	37.0	3.6	<1.0	3.2	0.9	109.
AVG	70.6	41.6	5.0	--	6.8	3.3	137.

TABLE A.2, CONTINUED.

SITE 71

COLLECTION EFFICIENCY = 1.05

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	21.50	9.99	0.07	4.04	61.0	-0.01
2	4-17	7.49	0.51	0.80	4.01	52.0	0.07
AVG				0.10	4.03	57.6	0.02
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	0.1	84.0	NAP	70.0	14.0	<0.2	252.
2	NAP	57.0	NAP	45.0	8.4	<0.2	167.
AVG	0.1	73.7	--	60.4	11.9	--	220.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	91.2	59.0	13.0	2.7	31.0	11.0	250.
2	97.7	24.0	8.5	<2.0	16.0	8.4	179.
AVG	93.7	45.6	11.3	1.7	25.3	10.0	223.

TABLE A.2, CONTINUED.

SITE 72

COLLECTION EFFICIENCY = 0.79

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	21.09	14.64	0.06	4.13	52.0	0.00
2	4-17	11.74	0.07	6.08	4.43	31.0	+0.18
AVG				0.09	4.21	44.9	-0.07
	S02	S04	N02	N03	CL	P04	AN SUM UEQ/L
1	NAP	76.0	NAP	71.0	12.0	<0.2	235.
2	NAP	54.0	NAP	66.0	8.8	<0.2	183.
AVG	--	68.5	--	69.3	10.9	--	217.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	74.1	67.0	12.0	2.7	27.0	12.0	234.
2	37.2	39.0	9.7	1.2	23.0	9.6	152.
AVG	61.6	57.5	11.2	2.2	25.6	11.2	206.

TABLE A.2, CONTINUED.

SITE 73

COLLECTION EFFICIENCY = 0.47

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	21.94	11.60	0.12	4.35	28.0	-0.13
2	4-17	9.54	MOE	MOE	ISA	ISA	--
AVG				--	4.35	28.0	-0.13
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	42.0	NAP	39.0	13.0	<0.2	136.
2	NAP	57.0	NAP	57.0	10.0	<0.2	181.
AVG	--	42.0	--	39.0	13.0	<0.2	136.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	44.7	31.0	12.0	<1.0	10.0	5.8	119.
2	ISA	37.0	10.0	1.3	17.0	8.4	ISA
AVG	44.7	31.0	12.0	<1.0	10.0	5.8	119.

TABLE A.2, CONTINUED.

SITE 74

COLLECTION EFFICIENCY = 1.34

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	CONC UMHO/CM	ION BAL
1	4-17	8.23	3.16	0.21	6.20	39.0	-0.08
2	4-17	11.40	0.58	1.13	4.43	36.0	-0.10
3	4-17	11.98	0.23	0.74	4.47	30.0	-0.02
AVG				0.37	4.69	36.6	-0.08
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	0.1	89.0	NAP	84.0	15.0	<0.2	277.
2	0.1	68.0	NAP	71.0	10.0	<0.2	217.
3	NAP	48.0	NAP	55.0	7.6	<0.2	159.
AVG	0.1	75.0	--	74.9	11.9	--	237.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	0.6	130.0	11.0	8.6	33.0	20.0	256.
2	37.2	49.0	6.9	2.4	32.0	18.0	195.
3	33.9	43.0	6.2	2.4	27.0	8.0	155.
AVG	20.6	84.2	8.6	5.1	31.9	17.7	218.

TABLE A.2, CONTINUED.

SITE 75

COLLECTION EFFICIENCY = 1.08

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START DAY	(GMT) HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-16	21.85	0.19	3.46	4.11	57.0	-0.05
2	4-16	22.04	10.89	0.06	3.89	74.0	-0.02
3	4-17	8.93	0.33	2.00	4.38	26.0	-0.08
4	4-17	9.26	0.24	2.74	4.01	51.0	0.03
5	4-17	9.50	3.18	0.21	4.87	9.6	0.01
6	4-17	12.68	0.01	65.64	4.35	31.0	0.03
7	4-17	12.69	0.01	65.64	4.49	19.0	0.06
8	4-17	12.70	0.01	65.64	4.52	17.0	0.05
AVG				0.34	4.22	36.7	0.00
	SO2	SO4	NO2	NO3	CL	PO4	AN SUM UEQ/L
1	NAP	96.0	NAP	75.0	22.0	<0.2	289.
2	NAP	96.0	NAP	73.0	27.0	<0.2	292.
3	NAP	45.0	NAP	37.0	8.8	<0.2	136.
4	NAP	67.0	NAP	55.0	9.9	ISA	199.
5	NAP	15.0	NAP	14.0	5.3	<0.2	49.
6	NAP	46.0	NAP	46.0	6.5	<0.2	145.
7	NAP	27.0	NAP	24.0	3.6	<0.2	82.
8	NAP	23.0	NAP	21.0	3.4	<0.2	70.
AVG	--	53.6	--	44.5	11.3	--	163.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	77.6	86.0	24.0	5.1	26.0	15.0	275.
2	128.8	68.0	22.0	6.3	21.0	9.0	285.
3	41.7	49.0	7.3	1.8	8.8	4.2	126.
4	97.7	73.0	9.5	1.6	8.2	2.9	204.
5	13.5	22.0	3.5	<2.0	4.1	1.4	50.
6	44.7	62.0	5.2	1.8	14.0	3.7	149.
7	32.4	33.0	3.1	1.0	7.3	1.5	87.
8	30.2	27.0	2.3	<1.0	6.2	1.1	74.
AVG	60.0	54.0	10.1	2.3	12.3	5.1	161.

TABLE A.2, CONTINUED.

SITE 76

COLLECTION EFFICIENCY = 1.05

UNITS ARE UMOL/L UNLESS NOTED

STAGE	START (GMT) DAY	HR	DT HR	R-RATE MM/HR	LAB PH	COND UMHO/CM	ION BAL
1	4-17	8.54	0.25	2.66	6.60	75.0	0.28
2	4-17	8.79	0.25	2.66	4.26	33.0	-0.05
3	4-17	9.04	0.21	3.19	4.25	30.0	-0.17
4	4-17	9.24	0.21	3.20	4.13	36.0	0.00
5	4-17	9.45	0.02	43.97	4.71	9.5	0.09
6	4-17	9.46	0.01	79.95	4.22	30.0	-0.06
7	4-17	9.47	0.01	79.95	4.34	23.0	-0.01
8	4-17	9.48	0.01	79.94	4.42	19.0	-0.03
9	4-17	9.49	3.55	0.91	ISA	ISA	0.00
AVG				1.89	4.36	31.9	0.00
	S02	S04	NO2	NO3	CL	P04	AN SUM UEQ/L
1	NAP	160.0	NAP	18.0	27.0	4.3	378.
2	NAP	53.0	NAP	38.0	7.7	<0.2	152.
3	NAP	50.0	NAP	37.0	6.9	<0.2	144.
4	NAP	42.0	NAP	33.0	5.5	<0.2	123.
5	NAP	9.7	NAP	8.5	2.7	<0.2	31.
6	NAP	38.0	NAP	29.0	5.4	<0.2	110.
7	NAP	30.0	NAP	21.0	3.7	<0.2	85.
8	NAP	25.0	NAP	17.0	3.8	<0.2	71.
9	ISA	ISA	ISA	ISA	ISA	ISA	0.
AVG	--	51.0	--	25.2	7.8	0.5	85.
	FREE H	NH4	NA	K	CA	MG	CAT SUM UEQ/L
1	0.3	330.0	32.0	23.0	37.0	21.0	501.
2	55.0	47.0	6.2	2.4	11.0	5.7	144.
3	56.2	49.0	3.2	1.4	4.3	1.6	122.
4	74.1	32.0	3.9	1.0	3.8	1.8	122.
5	19.5	10.0	0.8	<0.4	1.1	0.4	33.
6	60.3	30.0	3.3	<1.0	4.0	1.4	104.
7	45.7	25.0	2.5	1.3	3.4	1.2	84.
8	38.0	20.0	2.2	<1.0	3.1	1.1	69.
9	ISA	ISA	ISA	ISA	ISA	ISA	0.
AVG	43.6	67.9	6.8	3.6	8.5	4.3	91.

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