



**Quality of Wet Deposition in the
Grand Calumet River Watershed,
Northwestern Indiana,
October 17, 1995–November 12, 1996**

Water-Resources Investigations Report 99-4253

*Prepared in cooperation with the
Indiana Department of Environmental Management*

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By Timothy C. Willoughby

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Conversion Factors, Vertical Datum, and Abbreviated Water-Quality Units

| Multiply | By | To obtain |
|-------------------------------------|--------------------------|--------------|
| centimeter (cm) | 0.394 | inch |
| gram (g) | 0.0353 | ounce |
| hectare (ha) | 2.471 | acre |
| kilogram (kg) | 2.205 | pound |
| kilometer (km) | 0.6214 | mile |
| square kilometer (km ²) | 0.4 | square mile |
| liter (L) | 1.057 | quart |
| meter (m) | 3.281 | foot |
| microgram (µg) | 3.530 X 10 ⁻⁸ | ounce |
| milligram (mg) | 3.530 X 10 ⁻⁵ | ounce |
| milliliter (mL) | 0.03381 | ounce, fluid |
| millimeter (mm) | 0.0394 | inch |

Temperature is given in degrees Celsius (°C) which can be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32$$

Vertical datum: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units used in this report: Chemical concentrations and temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) and micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. Loadings are reported in kilograms per hectare (kg/ha) and grams per hectare (g/ha).

Specific conductance of water is expressed in microsiemens per centimeter at 25 degrees Celsius (µS/cm). This unit is equivalent to micromhos per centimeter at 25 degrees Celsius (µmho/cm), formerly used by the U.S. Geological Survey.

Sample volumes are given in liters (L).

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By Timothy C. Willoughby

Abstract

In June 1992, a wet-deposition collection site was established at the Gary (Indiana) Regional Airport to monitor the quantity and chemical quality of wet deposition. During the first phase of sampling, 48 wet-deposition samples were collected between June 30, 1992, and August 31, 1993. A second phase of sampling began in October 1995. During the second phase of sampling, 40 wet-deposition samples were collected between October 17, 1995, and November 12, 1996. This report presents the findings for the second phase of sampling and compares those results to the first phase of sampling.

Northwestern Indiana is a heavily industrialized area. Steel production and petroleum refining are two of the area's predominant industries. High-temperature processes, such as fossil-fuel combustion and steel production, release contaminants to the atmosphere that may result in wet deposition being a major contributor to major-ion and trace-metal loadings in northwestern Indiana and Lake Michigan. Wet-deposition samples collected during the first and second phases of sampling were analyzed for pH, specific conductance, and selected major ions and trace metals.

Forty weekly wet-deposition samples were collected at the Gary (Indiana) Regional Airport during the second phase of sampling. Approximately 1.2 times as much wet deposi-

tion was collected during the second phase of sampling compared to the first phase. Statistically significant increases (at the 5-percent significance level) in concentrations of potassium, iron, lead, and zinc were determined for samples collected during the second phase of sampling when compared to the first. No statistically significant differences were determined in constituent concentrations between samples collected during warm weather (April 1 through October 31) and during cold weather (November 1 through March 31). Annual loadings for the second phase of sampling were greater than 2 times the loadings determined during the first phase of sampling for silica, iron, potassium, lead, and zinc.

Introduction

The atmosphere is an important component of the hydrologic cycle to be considered when assessing the effects of contaminants in the environment. The atmosphere is recognized as a major pathway by which contaminants are deposited to the Earth's surface, possibly in areas far removed from their source (Majewski and Capel, 1995). Wet and dry deposition may have a significant adverse effect on the quality of surface water and shallow ground water and is becoming widely acknowledged as an important contributor to the declining health of aquatic ecosystems.

Natural and anthropogenic processes emit contaminants to the atmosphere that are later deposited to the Earth's surface. The atmospheric-depositional process can be classified into two categories: those involving precipitation, called wet deposition, and those not involving precipitation, called dry deposition (Bidleman, 1988). Removal of contaminants from the atmosphere in fog, mist, and dew lies somewhere between the wet and dry processes but is more closely related to dry deposition.

The chemical composition of wet deposition is affected by the chemistry of atmospheric aerosols and airborne particles (Schroder and others, 1989). Rainout and washout are the two major processes that introduce contaminants to wet deposition. Rainout includes several processes that occur in clouds, such as nucleation, condensation, or gas dissolution. Washout is the process that scavenges the airborne particulates between the cloud base and the Earth's surface. Rainout and washout probably occur simultaneously and continuously during a wet-deposition event because most storms produce convective air-current components that add large masses of near-surface air to overlying clouds (Schroder and Hedley, 1986).

The Great Lakes compose the largest area (244,000 km²) of fresh water on Earth (Herdendorf, 1982). This important natural resource for the United States and Canada is managed under the Great Lakes Water Quality Agreement, Annex 15 (Airborne Toxic Substances), which mandates that "the parties, in cooperation with State and Provincial Governments, shall conduct research, surveillance, and monitoring and implement pollution control measures for the purpose of reducing atmospheric deposition of toxic substances, particularly persistent toxic substances, to the Great Lakes Basin Ecosystem" (International Joint Commission United States and Canada, 1978).

Northwestern Indiana is the State's highest priority area for nonpoint-source-pollution control (Indiana Nonpoint Source Task Force, 1989). Recommendations made by the Indiana Nonpoint Source Task Force are to (1) evaluate and quantify water-quality impacts of airborne pollutants in inland waters and Lake Michigan, (2) cooperate in Great Lakes air-monitoring programs, (3) initiate a statewide monitoring program for airborne toxic and acid pollutants, (4) improve integration of State air- and water-pollution-control programs, and (5) develop and implement enhanced air-pollution-control strategies. The U.S. Geological Survey (USGS), in cooperation with the Indiana Department of Environmental Management (IDEM), began a study to address some of these recommendations. As part of this study, the USGS established a wet-deposition sampling site at the Gary (Indiana) Regional Airport (referred to as the Gary airport in this report) in June 1992 to monitor the quantity and quality of wet deposition.

Purpose and Scope

This report describes the quality of wet-deposition samples collected at the Gary airport from October 17, 1995, to November 12, 1996, and analyzed for pH, specific conductance, and selected major ions and trace metals. In addition, this report:

- (1) displays truncated boxplots showing the distribution of constituent concentrations found in samples collected at the Gary airport;
- (2) statistically compares the results of major-ion concentrations found in wet deposition with results from two National Atmospheric Deposition Program/National Trends Network (NADP/NTN) sites (Indiana Dunes National Lakeshore and Huntington Reservoir) in northern Indiana. This comparison is intended to determine if the chemistry of wet-deposition samples collected at the Gary airport is unique to the collection site or if the chemistry of these samples is

consistent with sites outside the industrialized Gary area;

- (3) stastically compares the concentration of major ions and trace metals measured in wet-deposition samples collected during the first phase of sampling (June 30, 1992, to August 31, 1993) with concentrations measured in samples collected during the second phase of sampling (October 17, 1995, to November 12, 1996). This comparison is intended to determine if concentrations of major ions and trace metals are changing over time;
- (4) presents estimated weekly and annual constituent loadings determined during the second sampling phase and compares these loadings to the loadings determined for the first sampling phase; and
- (5) describes the constituent concentrations measured in 29 quality-control samples and compares these concentrations to the constituent concentrations measured in wet-deposition samples collected during the second phase of sampling.

Site Description

The wet-deposition sampling site is located in the Grand Calumet River Watershed at the Gary airport in northwestern Indiana (fig. 1). The sampling equipment, consisting of an AeroChem Metric 301 wet/dry collector and a Belfort weighing rain gage, is located 30.5 m and 40 m, respectively, north of the airport's traffic-control tower. The sampling equipment was installed at an altitude of 178 m above sea level, approximately 400 m north of Interstate 90, 3.5 km south of Lake Michigan, and 18 km west of the Lake and Porter County boundary. Access to the sampling site was by a paved single-lane road on secured airport property. The airport grounds are enclosed with a fence to limit access. Air traffic at the airport did not pass over the sampling equipment.

Study Methods

This section describes the selection of the sampling site, constituents selected and the analytical methods used to measure their concentrations, and the modifications made to the AeroChem Metric wet/dry collector for the collection of trace metals in wet deposition. This section also describes procedures used for cleaning the equipment, for processing the samples, and for statistical analysis of the results.

Sampling-Site Selection

The sampling site at the Gary airport was chosen in cooperation with IDEM prior to the start of the first phase of sampling. Several factors were considered when evaluating possible sampling locations, including: the need to minimize the possibility of local point sources affecting wet-deposition chemistry; the need for a secure location for the sampling equipment; the need for an electrical power source; and the need for an open, flat field with no obstruction projecting onto the collector or rain gage with an angle greater than 45 degrees from horizontal as recommended by the NADP/NTN. The sampling equipment was installed in accordance with NADP/NTN protocols (Bigelow, 1984).

Constituent Selection and Analysis

Calcium, magnesium, sodium, potassium, sulfate, chloride, and nitrate are constituents measured in samples collected by the NADP/NTN. These constituents also were analyzed in wet-deposition samples collected at the Gary airport to evaluate their differences from concentrations measured at the NADP/NTN sites located at the Indiana Dunes National Lakeshore and Huntington Reservoir. The Indiana Dunes National Lakeshore site is approximately 26 km east of the Gary airport, and the Huntington Reservoir site is approximately 180 km southeast of the Gary airport (fig. 2).

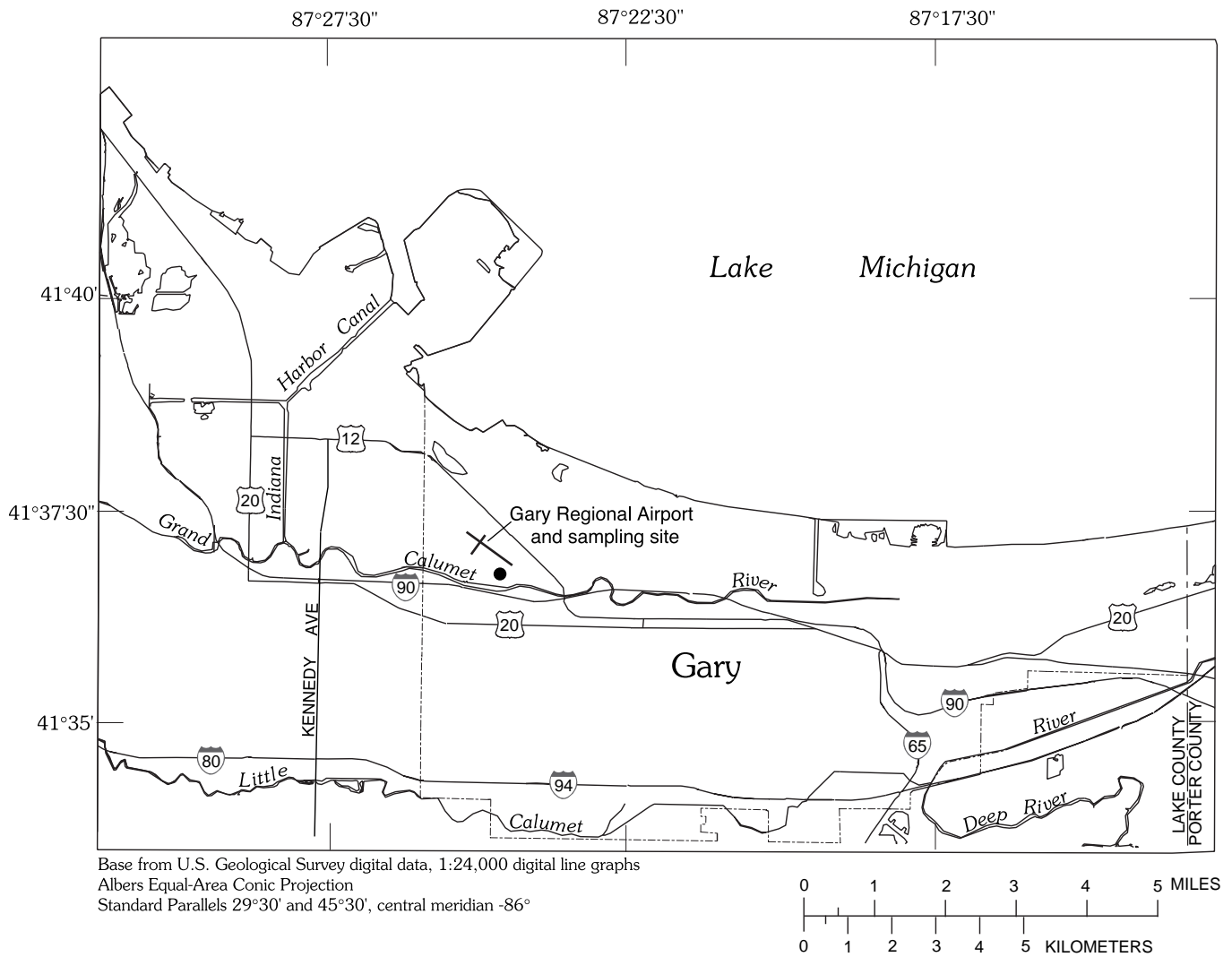


Figure 1. Location of wet-deposition sampling site at the Gary (Indiana) Regional Airport.



Base from U.S. Geological Survey, 1:100,000, 1983
 Albers Equal-Area Conic projection
 Standard parallels 29°30' and 45°30', central meridian -86°

Figure 2. Location of wet-deposition sampling site at the Gary (Indiana) Regional Airport and two National Atmospheric Deposition Program/National Trends Network sampling sites at the Indiana Dunes National Lakeshore and Huntington Reservoir.

The trace metals measured for this study were selected because they are by-products of industrial processes used in the Gary, Ind., area and because of their toxic potentials. Trace metals analyzed include cadmium, chromium, copper, lead, manganese, and zinc. Although copper, manganese, and zinc are necessary for proper cellular development of organisms, these metals may bioaccumulate, especially in aquatic organisms, and therefore can present a health risk (Amdur and others, 1993). Cadmium, chromium, and lead are not essential metals for proper cellular development, but exposure at very low concentrations may present a health risk.

All samples were submitted to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo., for analysis. The analytical procedure and the method reporting limits are listed in table 1. The analytical methods used during the first phase of sampling for major cations (calcium, magnesium, silica, sodium, and potassium), major anions (sulfate, bromide, chloride, fluoride, nitrate, and phosphate), and iron remained the same for the second phase of sampling. The analytical methods used to measure trace-metal concentrations changed between the first and second phases of sampling. During the first phase of sampling, most of the trace metals were measured by graphite furnace atomic absorption spectroscopy (GFAAS) and inductively coupled argon plasma atomic emission spectroscopy (ICAP). During the second phase of sampling, the trace metals were analyzed by inductively coupled argon plasma mass spectroscopy (ICAP/MS). The ICAP/MS method provided lower method reporting limits for many of the trace metals at a reduced cost.

All analytical techniques used for this study were standard USGS methods for the determination of inorganic substances in water. Unless otherwise noted, all of the methods are described in Fishman and Friedman (1989) and the page numbers are provided. Calcium, magnesium, sodium, silica, and iron were analyzed by ICAP (method I-1472-85, p. 24–32). Potassium was

Table 1. Constituent, method of analysis, and the method reporting limits for the 27 constituents analyzed in wet-deposition samples collected at the Gary (Indiana) Regional Airport

[ICAP, inductively coupled argon plasma atomic emission spectroscopy; mg/L, milligrams per liter; FAAS, flame atomic absorption spectroscopy; IC, ion chromatography; ICAP/MS, inductively coupled argon plasma/mass spectroscopy; µg/L, micrograms per liter]

| Constituent | Method of analysis | Method reporting limit |
|-------------|--------------------|------------------------|
| Calcium | ICAP | 0.02 mg/L |
| Magnesium | ICAP | .01 mg/L |
| Sodium | ICAP | .2 mg/L |
| Potassium | FAAS | .01 mg/L |
| Sulfate | IC | .01 mg/L |
| Bromide | IC | .01 mg/L |
| Chloride | IC | .01 mg/L |
| Fluoride | IC | .01 mg/L |
| Silica | ICAP | .01 mg/L |
| Nitrate | IC | .04 mg/L |
| Phosphate | IC | .03 mg/L |
| Aluminum | ICAP/MS | 1 µg/L |
| Antimony | ICAP/MS | 1 µg/L |
| Barium | ICAP/MS | 1 µg/L |
| Beryllium | ICAP/MS | 1 µg/L |
| Cadmium | ICAP/MS | 1 µg/L |
| Chromium | ICAP/MS | 1 µg/L |
| Cobalt | ICAP/MS | 1 µg/L |
| Copper | ICAP/MS | 1 µg/L |
| Iron | ICAP | 3 µg/L |
| Lead | ICAP/MS | 1 µg/L |
| Manganese | ICAP/MS | 1 µg/L |
| Molybdenum | ICAP/MS | 1 µg/L |
| Nickel | ICAP/MS | 1 µg/L |
| Silver | ICAP/MS | 1 µg/L |
| Uranium | ICAP/MS | 1 µg/L |
| Zinc | ICAP/MS | 1 µg/L |

measured by flame atomic absorption spectrometry (FAAS, method I-1630-85, p. 393–394). Major anions (sulfate, bromide, chloride, fluoride, nitrate, and phosphate) were analyzed by ion chromatography (IC, method I-2058-85, p. 527–530). Aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, silver, uranium (natural), and zinc were measured by ICPAP/MS (Faires, 1993). Arsenic and mercury were measured during the first phase of sampling but were not included in the second phase because none of the samples had detectable concentrations of arsenic or mercury.

Collector Modifications

The AeroChem Metric 301 wet/dry collector was modified to decrease possible sources of trace-metal contamination to the sample (fig. 3).

The bottom of the collector was enclosed with aluminum sheeting to house the collection bottle, a thermostat, and a maximum-minimum thermometer. Access to the inside of the bottom enclosure was through an aluminium door on the front of the collector. A latch and lock were used to secure the door and limit access to the collection bottle. The bottom was removed from a 13-L polyethylene bucket, and a hole was cut through the collector frame to allow a collection funnel to pass through the collector frame into the bottom enclosure. The lid and lid arms of the collector were coated with Teflon to minimize contamination from wet deposition splashing off the lid or lid arms into the collection funnel. A 31-cm-diameter high-density polyethylene funnel was installed so that the funnel rested on the 13-L polyethylene bucket. A polyethylene-covered foam pad, attached to the bottom of the collector lid,

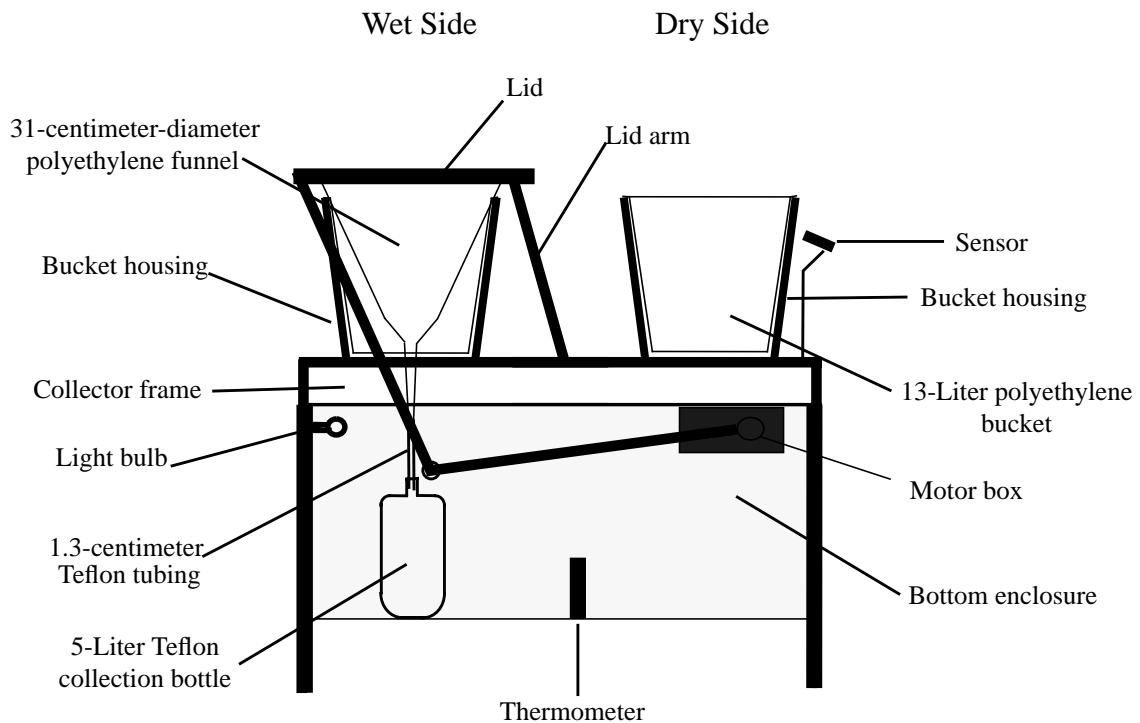


Figure 3. Modified AeroChem Metric 301 wet/dry collector.

fit tightly against the top of the funnel when the collector was closed. A tight fit between the polyethylene-covered foam pad and the top of the funnel prevented contaminants from blowing into the funnel when the sampler lid was closed. A polyethylene fitting was attached to a silicon stopper in the bottom of the funnel so that a 1.3-cm Teflon tube could be attached to the funnel. The Teflon tube then passed through a 1.3-cm hole drilled in the cap of a 5-L Teflon collection bottle. Two 100-watt light bulbs were installed as close as possible to the hole cut in the collector frame. The light bulbs were used to heat the area around the collection funnel to minimize snow and ice buildup in the funnel and were turned on by a thermostat that was set to activate at approximately 5°C.

The collector was activated by a sensor unit that consists of a plate and a sensor grid. The sensor unit has two functions: (1) to activate the movement of the collector lid by activating the motor-box unit when the start and stop of precipitation is detected; and (2) to regulate two heating modes: the ambient mode to melt snow and the wet-collect mode to dry water from the sensor. The sensor grid is separated from the sensor plate by approximately 1 mm. When water bridges the gap between the sensor grid and the plate, the motor box is activated, causing the collector lid to move over the dry-side bucket; this leaves the wet side open to capture precipitation. The sensor's ambient heating mode controls the temperature of the sensor plate. If the ambient temperature drops below 4°C, a heater is activated to heat the sensor plate to a temperature greater than 4°C; this melts snow or ice, so the resulting water can bridge the sensor grid and plate. The wet-collect mode of the sensor then is activated, heating the plate to a maximum of 50°C and evaporating the water that bridges the gap between the plate and the sensor grid.

Sample Collection and Processing

Wet-deposition samples were removed from the collector every Tuesday. The Tuesday to

Tuesday sampling period was consistent with the sampling period used by the NADP/NTN (Bigelow and Dossett, 1988). The procedures used to remove the samples and install clean equipment were the same as those used during the first phase of sampling (Willoughby, 1995). A different site operator collected the samples during phase 2.

Each week a clean 5-L Teflon collection bottle, a cap for the 5-L Teflon bottle, an additional cap with a 1.3-cm hole, a funnel, a Teflon tube, approximately 1 L of deionized water (DIW) used to clean the collector, and any other supplies needed by field personnel were packed in a cooler and sealed with packing tape. The cooler was shipped to the site operator by an overnight shipping service. The cooler generally was shipped on Thursday and would arrive at the residence of the site operator on Friday. Approximately every third week, an additional clean collection bottle, funnel, Teflon tube, and a quality-control sample also were shipped to the site operator. Processing of the quality-control samples is discussed in the Field Quality Assurance section of this report.

Contamination was of concern because of the low concentrations of many of the constituents of interest in this study. Site operators took every possible precaution to minimize contamination during the removal of the samples and the installation of clean equipment in the collector. These precautions included standing downwind from the collector to prevent contaminants blowing off the site operator's clothing or body into the collection funnel or collection bottle, wearing polyethylene or vinyl gloves when working around the collector, and ensuring that the collector was not activated until the collection bottle was removed.

The following procedures were used in servicing the sampling equipment:

- (1) the site operator inspected the sampling site and equipment and noted on a field form anything out of the ordinary, the ambient conditions, and whether the collector lid was open or closed;

- (2) the collector was opened and the 5-L collection bottle containing the sample was removed;
- (3) the cap with the hole on the collection bottle was replaced with the original cap to seal the collection bottle;
- (4) the collector lid was opened, the funnel and tubing were removed, and the collector was wiped clean;
- (5) a clean funnel and tubing were installed, and the collector lid was closed;
- (6) the cap on the collection bottle was replaced with the cap that had the 1.3-cm hole, and the original cap was sealed in a polyethylene zip-lock plastic bag and placed in the enclosed bottom of the collector;
- (7) the rain-gage chart was removed from the rain gage, and the water collected in the rain gage was discarded. The site operator indicated on the rain-gage chart the date and time the chart was removed;
- (8) the site operator installed a new rain-gage chart and recorded the date and time the chart was installed; and
- (9) the rain gage was zeroed.

The site operator completed the field form, indicating the date and time the sample was removed and the clean equipment installed, the empty weight of the 5-L collection bottle, current weather conditions, and the maximum and minimum temperatures measured inside the collector housing for the previous sampling week. The maximum and minimum temperatures were recorded to ensure the sample had not been frozen. The collection bottle, all other equipment used to collect the sample and clean the collector, and the field

form were placed in a cooler and sealed with strapping tape. The cooler was shipped to the USGS office in Indianapolis by an overnight shipping service. After the cooler was received by USGS Indianapolis office personnel, the following steps were used to process the sample before it was shipped to the USGS NWQL for analyses:

- (1) sample volume was determined from the mass of the sample collected by subtracting the weight of the empty bottle from the weight of the bottle plus the sample;
- (2) 15 mL of the sample were removed and the pH was determined (this pH value will be referred to as the “field pH”);
- (3) approximately 250 mL of the raw sample were filtered through a 47-mm, 0.45-micrometer polycarbonate filter into a 250-mL high-density polyethylene bottle for laboratory determination of major anions and specific conductance;
- (4) the 5-L collection bottle then was re-weighed, and the volume of the sample remaining was computed. The remaining sample was acidified with nitric acid to 0.2 percent by volume;
- (5) 15 mL of the acidified sample were removed after shaking, and the pH was measured. If the pH were greater than 2.0, additional acid was added and this step was repeated.
- (6) the acidified sample was allowed to stand for 24 hours at 4°C to let the sample undergo a mild digestion of any particulate material; and
- (7) 250 mL of the acidified sample were filtered with a 47-mm, 0.45-micrometer polycarbonate filter into a 250-mL Teflon bottle for laboratory analysis of trace metals and major cations.

All sample handling at the USGS office in Indianapolis was done on a laboratory bench top covered with an adhesive-backed Teflon

sheet to help minimize contamination during sample preservation and filtering. The samples then were packed in ice and sent to the NWQL by overnight shipping service.

The NWQL required a minimum of 500 mL of sample for the analysis of specific conductance, major ions, and trace metals. Sample volumes less than 500 mL were not diluted to prevent decreasing concentrations of some of the constituents of interest below the method reporting limit. Therefore, a priority was established for the analysis of small-volume samples. Weekly samples with measured volumes less than 250 mL were analyzed only for field pH. Samples with volumes between 250 and 275 mL were analyzed for field pH, major cations, and trace metals. Samples with volumes between 275 and 500 mL were analyzed for specific conductance, major cations, trace metals, and major anions. Samples with volumes greater than 500 mL were analyzed for field pH, specific conductance, major cations, trace metals, and major anions. These priorities for analyses were adjusted occasionally to best utilize the sample volume collected.

Equipment Cleaning

All DIW used in this study met the American Society for Testing and Materials type 1 standard (greater than 16.7 megOhm). The equipment was cleaned at the USGS office laboratory in Indianapolis. The 5-L Teflon bottles and caps were cleaned by rinsing three times with deionized water. The bottles then were filled with a 1-percent nitric acid and DIW solution and allowed to leach for 24 hours. The bottles were rinsed three more times with DIW, filled with DIW, and leached for an additional 24 hours. The bottles were rinsed three more times with DIW, and the excess water was shaken from the bottle. The 5-L Teflon bottles were stored in sealed polyethylene bags pre-rinsed with DIW.

The funnels were rinsed three times with large amounts of DIW. Any debris attached to the sides of the funnel was removed with a polyethylene brush. A stopper was used to close the polyethylene funnel, and the funnel was filled with a 1-percent nitric-acid solution. The funnel was allowed to leach for 24 hours. The funnel then was rinsed three more times with DIW, filled with DIW, and leached for an additional 24 hours. The funnel then was rinsed a final time with large amounts of DIW. The excess water was shaken from the funnel, and the funnel was stored in a sealed polyethylene bag pre-rinsed with DIW.

The Teflon tubing and the cap used for sampling (the cap with the hole for the Teflon tube to pass through) were rinsed three times with large amounts of DIW, followed by three 100-mL rinses with a 1-percent nitric-acid solution. The Teflon tubing and the cap then were rinsed a final time with DIW and stored in sealed polyethylene bags pre-rinsed with DIW.

The 250-mL Teflon bottles used to ship the samples to the laboratory for analyses of trace metals and major cations were cleaned in the same manner as the 5-L Teflon bottles. New 250-mL high-density polyethylene bottles used to ship the samples to the laboratory for analyses of anions were cleaned by rinsing the bottles three times with DIW, filling with DIW, and leaching for 24 hours. The polyethylene bottles then were rinsed an additional three times with DIW. The 250-mL Teflon and polyethylene bottles were stored in sealed polyethylene bags pre-rinsed with DIW at the USGS office laboratory in Indianapolis.

The filters used during sample processing were cleaned immediately before use; the filters were rinsed with 50 mL of a 1-percent nitric-acid and DIW solution followed by three 50-mL rinses with DIW. The filters then were rinsed with 20 mL of the sample (if sufficient volumes were collected) before the sample was filtered into the 250-mL Teflon and polyethylene bottles.

The collector was cleaned weekly after the previous sample was removed and before a clean funnel was installed for the next week of sampling. The lid, lid arms, polyethylene lid pad, and the top of the collector frame were wiped clean with a laboratory-quality paper towel and DIW to remove dust, bird droppings, and debris that collected during the previous sampling week.

Statistical Analysis

A Kruskal-Wallis test (Conover, 1980, p. 229) was done to determine if there were statistically significant differences among the distributions of pH, specific conductance, and constituent concentrations measured at the Gary airport and two NADP/NTN sites. In applying this test, concentrations measured less than the largest reporting limit for each constituent in samples from any of the three sites were set equal to that reporting limit. The Kruskal-Wallis test gives an indication of any statistically significant differences among the distributions for each parameter measured at each site; it does not, however, indicate which site is significantly different from one or both of the other sites. To determine which pairs of sites or sampling phases were statistically different, a Tukey's test was completed on the ranks of the data (Helsel and Hirsch, 1992, p. 200). The Tukey's test is a multiple-comparison based on a "least significant range," which is the difference between any two means that must be exceeded for them to be significantly different. For this report, a 5-percent level of significance ($\alpha=0.05$) was selected for the Kruskal-Wallis and the Tukey's test.

A Wilcoxon-Mann-Whitney rank-sum test was done to determine if there were statistically significant differences between the two sampling phases or between samples collected during warm weather (April 1 through October 31) and cold weather (November 1 through March 31) for constituents that had more than 50 percent of their

concentrations measured greater than the method reporting limit. Constituent concentrations for those constituents that were measured less than the method reporting limit were set equal to the method reporting limit. For this report, a 5-percent level of significance ($\alpha=0.05$) was selected for the Wilcoxon-Mann-Whitney rank-sum test.

Quality of Wet Deposition

Forty wet-deposition samples collected during the phase 2 sampling period are included in this analysis. Five samples were lost because of the shutdown of the Federal Government in December 1995 and January 1996. One sample was lost because the collector malfunctioned, and another was lost because access to the site was blocked. No wet deposition was collected in the collection bottle for 9 weeks. During one week, the sample volume exceeded the volume of the collection bottle (5 L), but the data for that sample were included in the analysis.

Weekly wet-deposition amounts were measured from the continuous monitoring rain-gage charts and compared to the wet-deposition amounts computed from the volume of sample collected. Catch efficiencies were computed by dividing the wet-deposition amounts computed from the sample volume by the wet-deposition amounts measured from the rain-gage charts. Thirty-four samples were used to compute the catch efficiencies; the sample that overflowed the collection bottle was not used in the calculation. On several occasions during the study, the clock on the rain gage stopped during the sampling period or the rain gage failed to operate properly. Samples that were collected on weeks when the clock stopped or when the rain gage did not operate properly were not included in the determination of the catch efficiency. A median catch efficiency of 104.5 percent was computed. Figure 4 shows truncated boxplots of the wet-deposition amounts

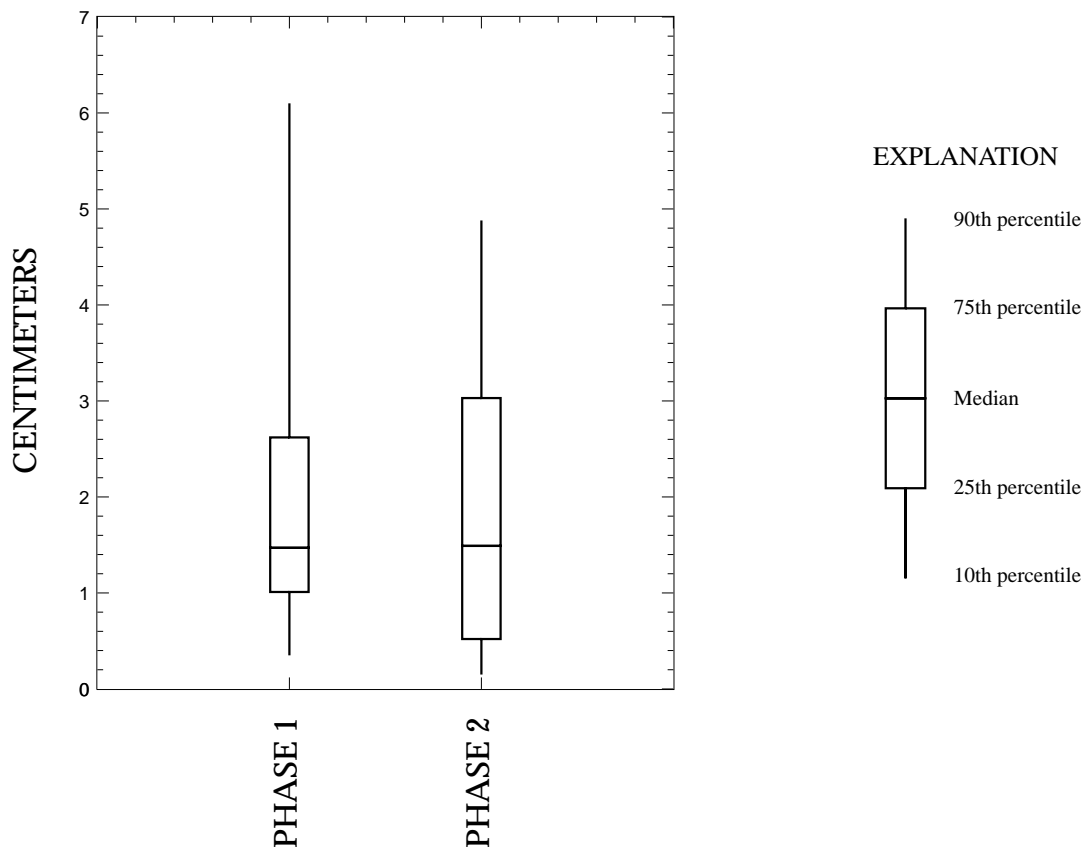


Figure 4. Distribution of weekly wet-deposition computed from samples collected at the Gary (Indiana) Regional Airport. Phase 1 samples were collected from June 30, 1992, to August 31, 1993. Phase 2 samples were collected from October 17, 1995, to November 12, 1996.

computed from the sample volumes collected during both sampling phases.

Sample volumes varied during the study period, and not all of the water-quality characteristics could be measured in small-volume samples. Of the 40 weekly samples, 29 were analyzed for all parameters (table 5, at the back of the report); 7 samples were analyzed for field pH, major cations, and trace metals (major anions were not measured); and 4 samples were measured only for field pH.

Constituent Concentrations

No concentrations greater than the method reporting limit were detected for bromide, antimony, beryllium, cadmium, cobalt, silver, and uranium. Table 2 lists the number of samples analyzed for each constituent; the number of times the constituent was detected at concentrations greater than the method reporting limit; and the concentrations at the 25th, 50th, and 75th percentiles for samples collected during phase 2.

Table 2. Water-quality characteristics analyzed in wet-deposition samples collected at the Gary (Indiana) Regional Airport

[$\mu\text{S/cm}$, microsiemens per centimeter at 25 degrees Celsius; NA, not applicable; mg/L, milligrams per liter; < , less than the method reporting limit; $\mu\text{g/L}$, micrograms per liter]

| Property or constituent | Number of samples analyzed | Number of samples in which the concentration exceeded the method reporting limit | Value or concentration at indicated percentile | | | Method reporting units |
|-------------------------|----------------------------|--|--|------|------|------------------------|
| | | | 25th | 50th | 75th | |
| Specific conductance | 29 | 29 | 18.7 | 22.7 | 28.5 | $\mu\text{S/cm}$ |
| Field pH | 40 | NA | 4.44 | 4.60 | 5.79 | units |
| Calcium | 36 | 36 | .61 | .91 | 1.80 | mg/L |
| Magnesium | 36 | 36 | .09 | .16 | .22 | mg/L |
| Sodium | 36 | 8 | <.2 | <.2 | .2 | mg/L |
| Potassium | 36 | 35 | .03 | .07 | 1.0 | mg/L |
| Sulfate | 29 | 29 | 2.4 | 3.2 | 4.3 | mg/L |
| Bromide | 29 | 0 | <.01 | <.01 | <.01 | mg/L |
| Chloride | 29 | 27 | .11 | .23 | .42 | mg/L |
| Fluoride | 29 | 24 | .02 | .03 | .06 | mg/L |
| Silica | 36 | 36 | .15 | .24 | 40 | mg/L |
| Nitrate | 28 | 28 | 1.66 | 1.93 | 2.53 | mg/L |
| Phosphate | 29 | 3 | <.03 | <.03 | <.03 | mg/L |
| Aluminum | 36 | 36 | 48 | 70 | 124 | $\mu\text{g/L}$ |
| Antimony | 36 | 0 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Barium | 36 | 36 | 2 | 3 | 5 | $\mu\text{g/L}$ |
| Beryllium | 36 | 0 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Cadmium | 36 | 0 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Chromium | 36 | 1 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Cobalt | 36 | 0 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Copper | 36 | 28 | 1 | 2 | 3 | $\mu\text{g/L}$ |
| Iron | 36 | 36 | 33 | 49 | 94 | $\mu\text{g/L}$ |
| Lead | 36 | 33 | 2 | 3 | 5 | $\mu\text{g/L}$ |
| Manganese | 36 | 36 | 8 | 12 | 20 | $\mu\text{g/L}$ |
| Molybdenum | 36 | 1 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Nickel | 36 | 1 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Silver | 36 | 0 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Uranium | 36 | 0 | <1 | <1 | <1 | $\mu\text{g/L}$ |
| Zinc | 36 | 36 | 8 | 13 | 18 | $\mu\text{g/L}$ |

Truncated boxplots showing the distributions of major ions and trace metals in wet-deposition samples collected at the Gary airport in which more than 50 percent of the concentrations reported were greater than the method reporting limit are shown in figures 5 and 6. Selected major-ion concentrations measured in wet-deposition samples collected at the Gary airport were compared to concentrations measured in samples collected at NADP/NTN sites located at the Indiana Dunes National Lakeshore and Huntington Reservoir. Figure 7 displays truncated boxplots of concentrations measured at the NADP/NTN sites. Statistically significant differences were determined for calcium ($p < 0.001$), magnesium ($p < 0.001$), potassium ($p < 0.001$), and sulfate ($p = 0.020$), where p is the significance level attained by the data. All three sites were significantly different from each other for calcium and magnesium. The median calcium and magnesium concentrations decreased as the distance from the Gary airport increased. Potassium concentrations measured at the Gary airport were not significantly different than the concentrations measured at the Indiana Dunes National Lakeshore; however, potassium concentrations measured at the Gary airport and the Indiana Dunes National Lakeshore were significantly different than the concentrations measured at Huntington Reservoir. Sulfate concentrations measured at the Gary airport were significantly different than the concentrations measured at the Indiana Dunes National Lakeshore and Huntington Reservoir; however, there were not significant differences in sulfate concentrations measured at the Indiana Dunes National Lakeshore and Huntington Reservoir.

Truncated boxplots for concentrations of constituents for which more than 50 percent of the concentrations measured were greater than the method reporting limit in samples collected during warm weather (April 1 to October 31) and cold weather (November 1 to March 31) are displayed in figures 8 and 9. All of the samples were included from both phases of sampling. None of the median concentrations of the constituents analyzed (calcium, magnesium, potassium, sulfate,

chloride, fluoride, silica, nitrate, barium, copper, iron, lead, manganese, or zinc) were significantly different between warm and cold sampling periods.

Comparison of Concentrations to Previous Sampling Phase

Truncated boxplots for concentrations of constituents for which more than 50 percent of the concentrations measured were greater than the method reporting limit in samples collected during the two phases of sampling are displayed in figures 10 and 11. Statistically significant greater concentrations were observed during the second phase of sampling when compared to the first phase for potassium ($p = 0.026$), iron ($p = 0.039$), lead ($p = 0.013$), and zinc ($p < 0.001$), where p is the significance level attained by the data.

Constituent Loadings

Constituent concentrations were not measured for all weeks during which wet deposition occurred if insufficient volumes were collected; therefore, a method to estimate those concentrations was developed. Median constituent concentrations were determined from samples collected during warm weather (April 1 through October 31) and cold weather (November 1 through March 31) for the second phase of sampling. Although, median constituent concentrations in samples collected during warm weather were not significantly different than median constituent concentrations in samples collected during cold weather, they frequently were different. The median constituent concentrations were substituted for missing values from samples collected during the same periods that had insufficient volumes for analysis of all of the constituents listed in table 1. The weekly and annual loadings are therefore referred to as “estimated” values. If a constituent concentration was measured less than the method reporting limit, a range for that constituent’s weekly loading was estimated. To estimate this

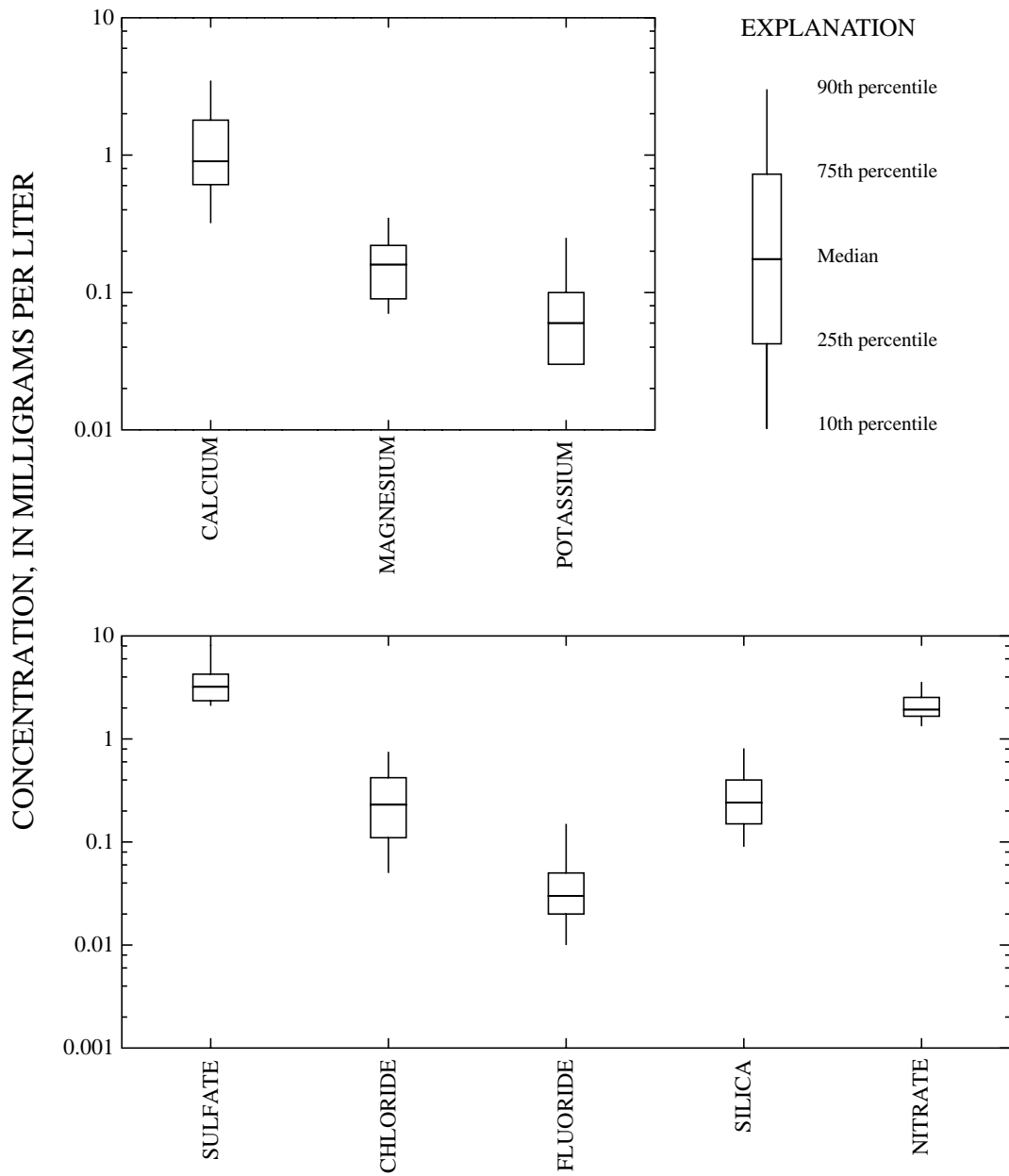


Figure 5. Distribution of concentrations for major ions measured in wet-deposition samples collected at the Gary (Indiana) Regional Airport.

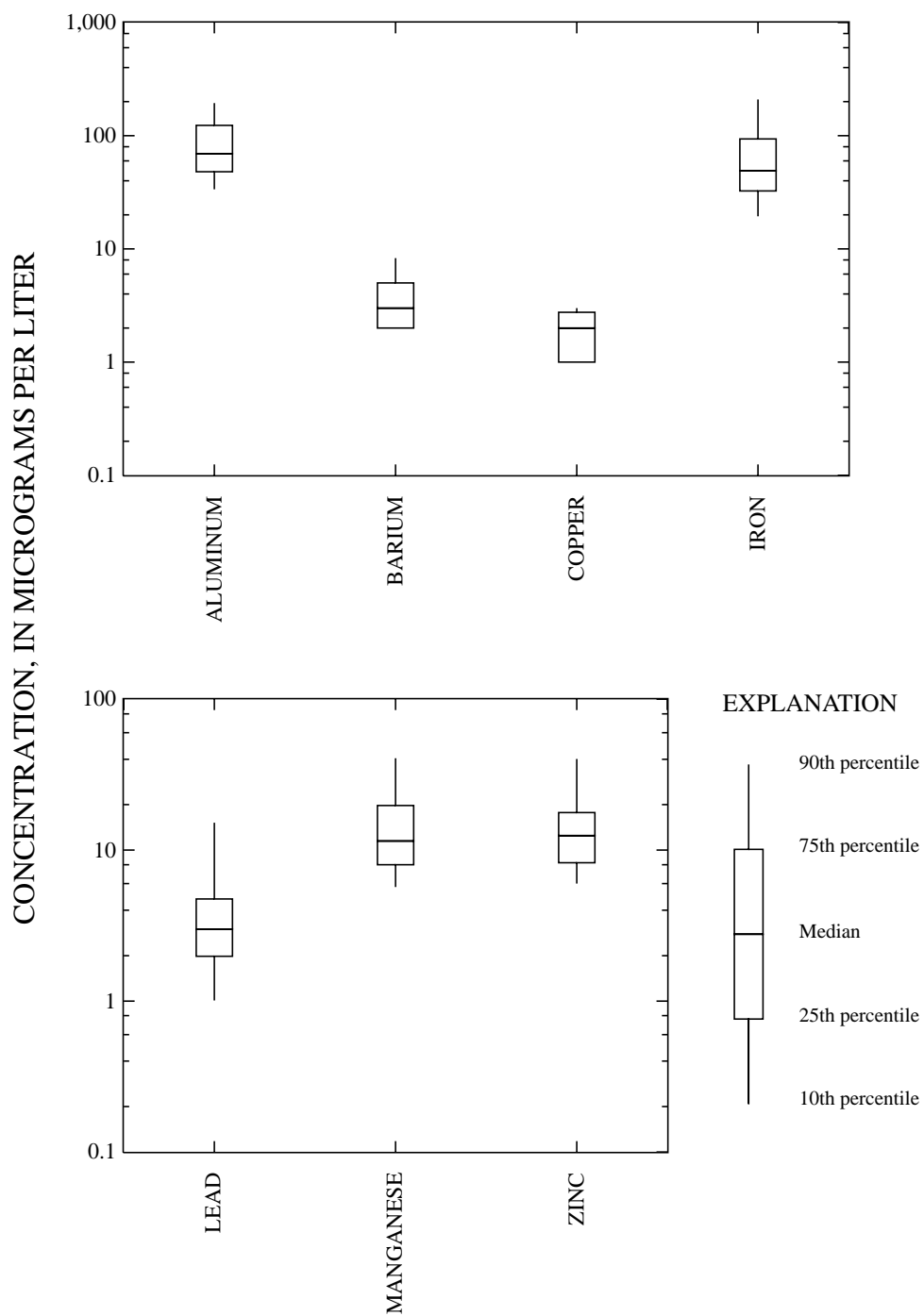


Figure 6. Distribution of concentrations for trace metals measured in wet-deposition samples at the Gary (Indiana) Regional Airport.

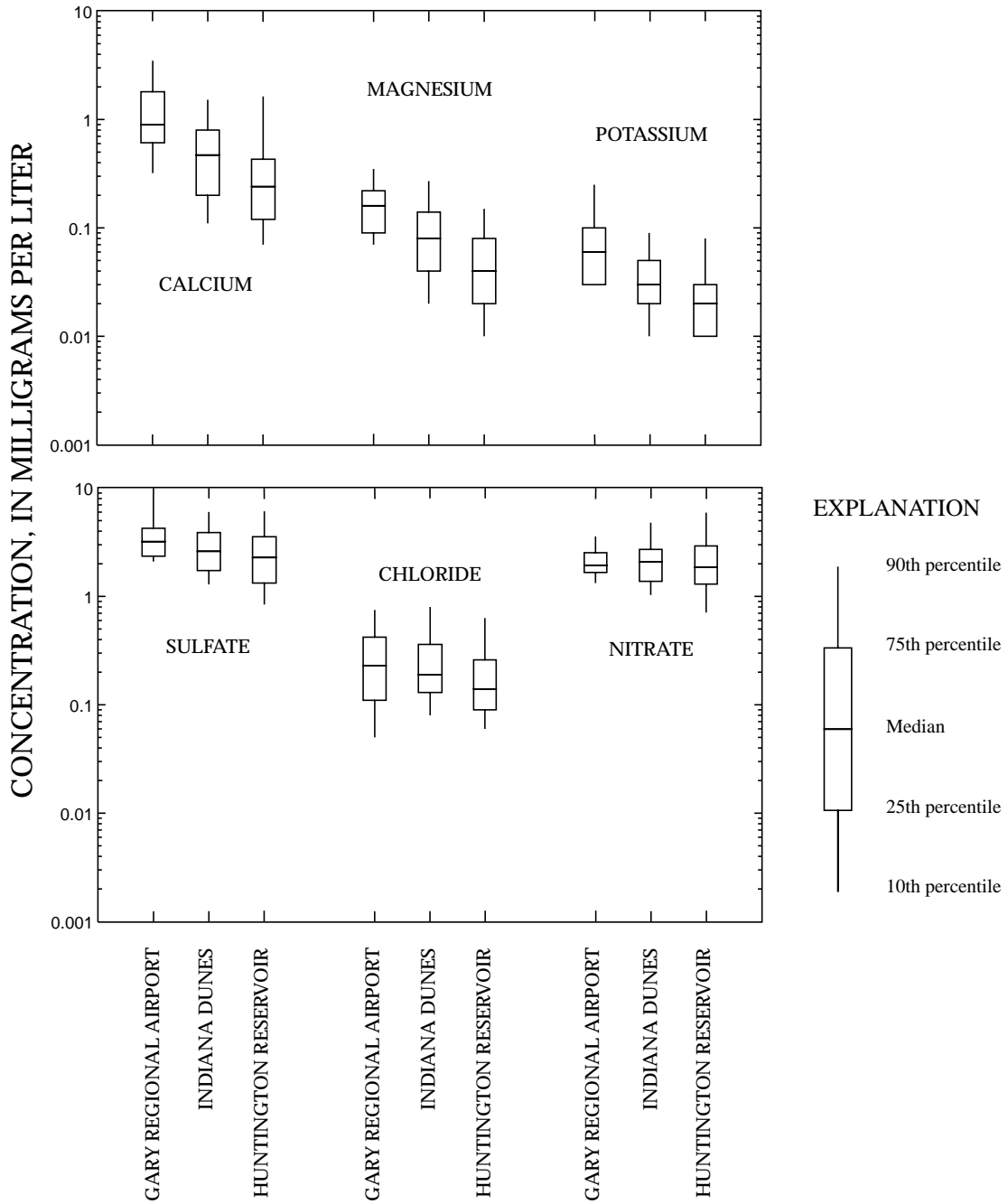


Figure 7. Distribution of concentrations of major ions analyzed in samples collected at the Gary (Indiana) Regional Airport and at National Atmospheric Deposition Program/National Trends Network sites at the Indiana Dunes National Lakeshore and Huntington Reservoir.

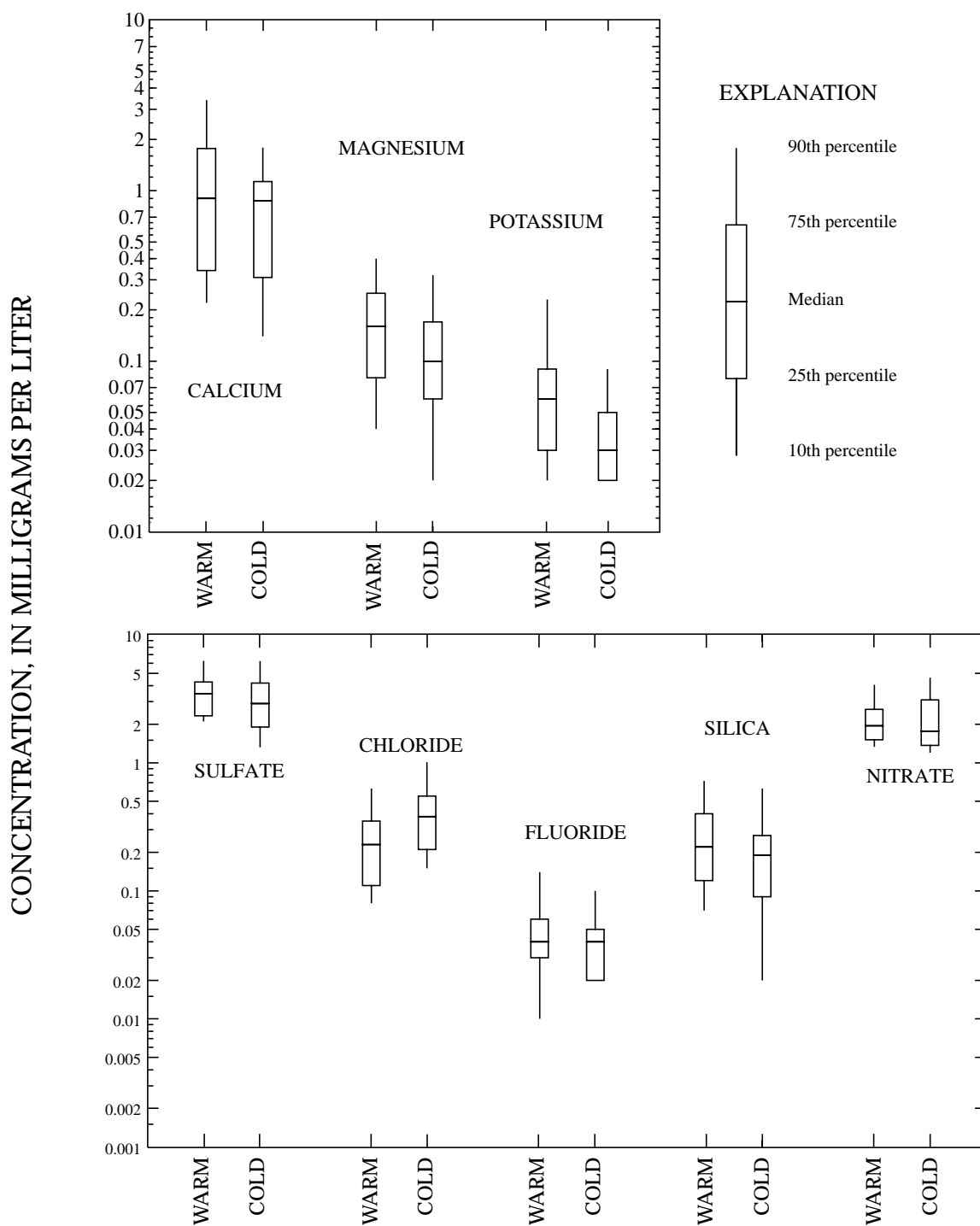


Figure 8. Distribution of concentrations of major ions analyzed in samples collected at the Gary (Indiana) Regional Airport during warm weather (April 1 to October 31) and cold weather (November 1 to March 31).

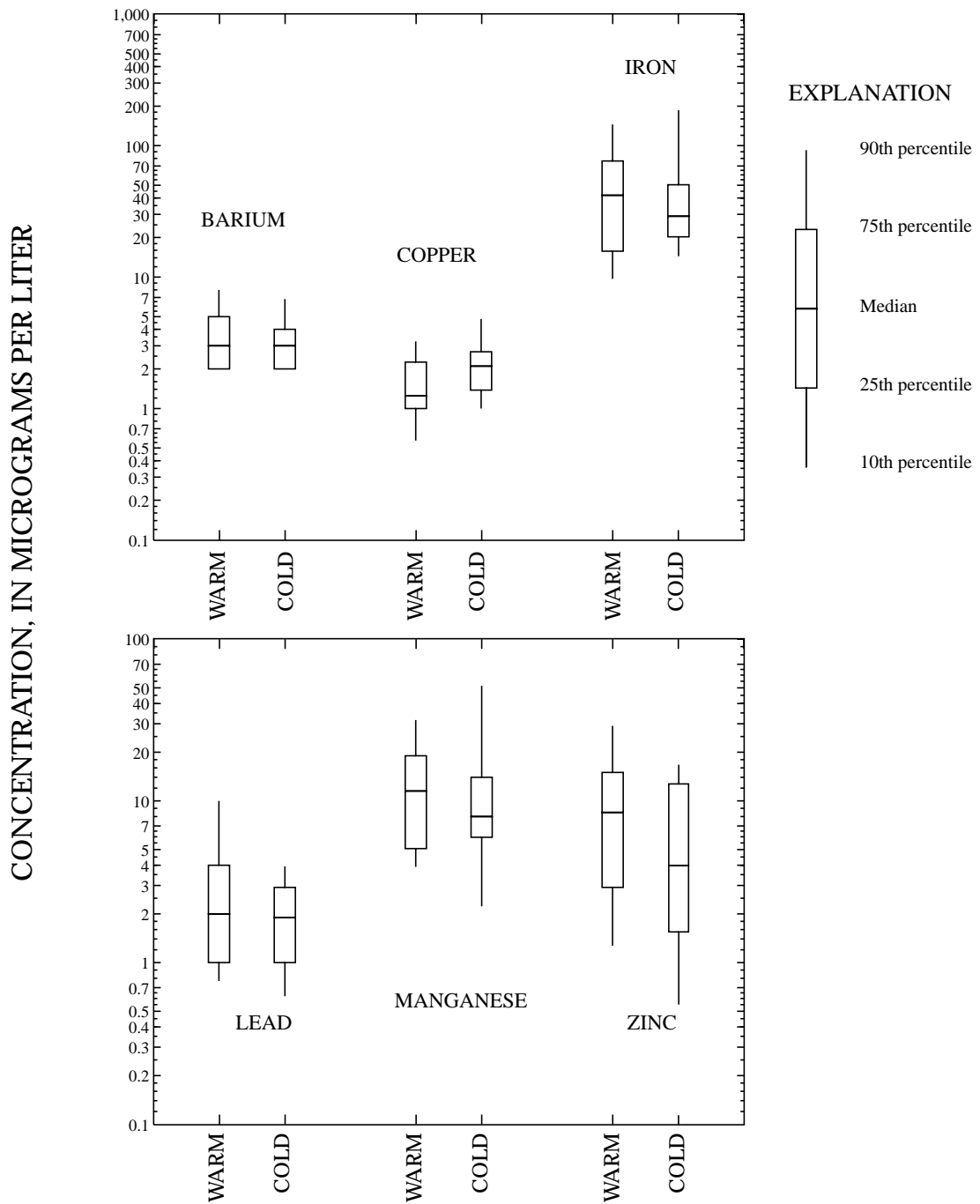


Figure 9. Distribution of concentrations of trace metals analyzed in samples collected at the Gary (Indiana) Regional Airport during warm weather (April 1 to October 31) and cold weather (November 1 to March 31).

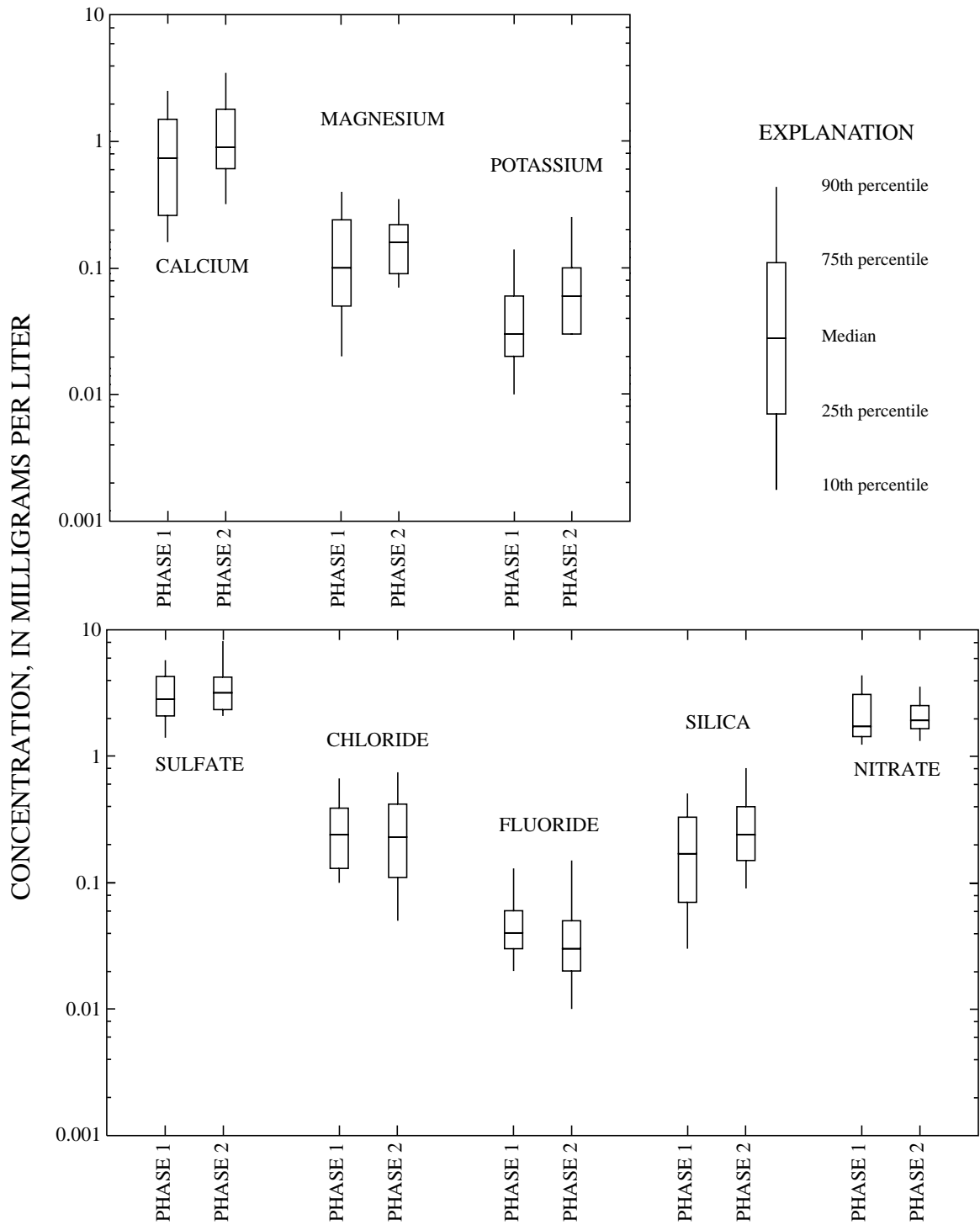


Figure 10. Distribution of concentrations of major ions analyzed in samples collected at the Gary (Indiana) Regional Airport. Phase 1 samples were collected from June 30, 1992, to August 31, 1993. Phase 2 samples were collected from October 17, 1995, to November 12, 1996.

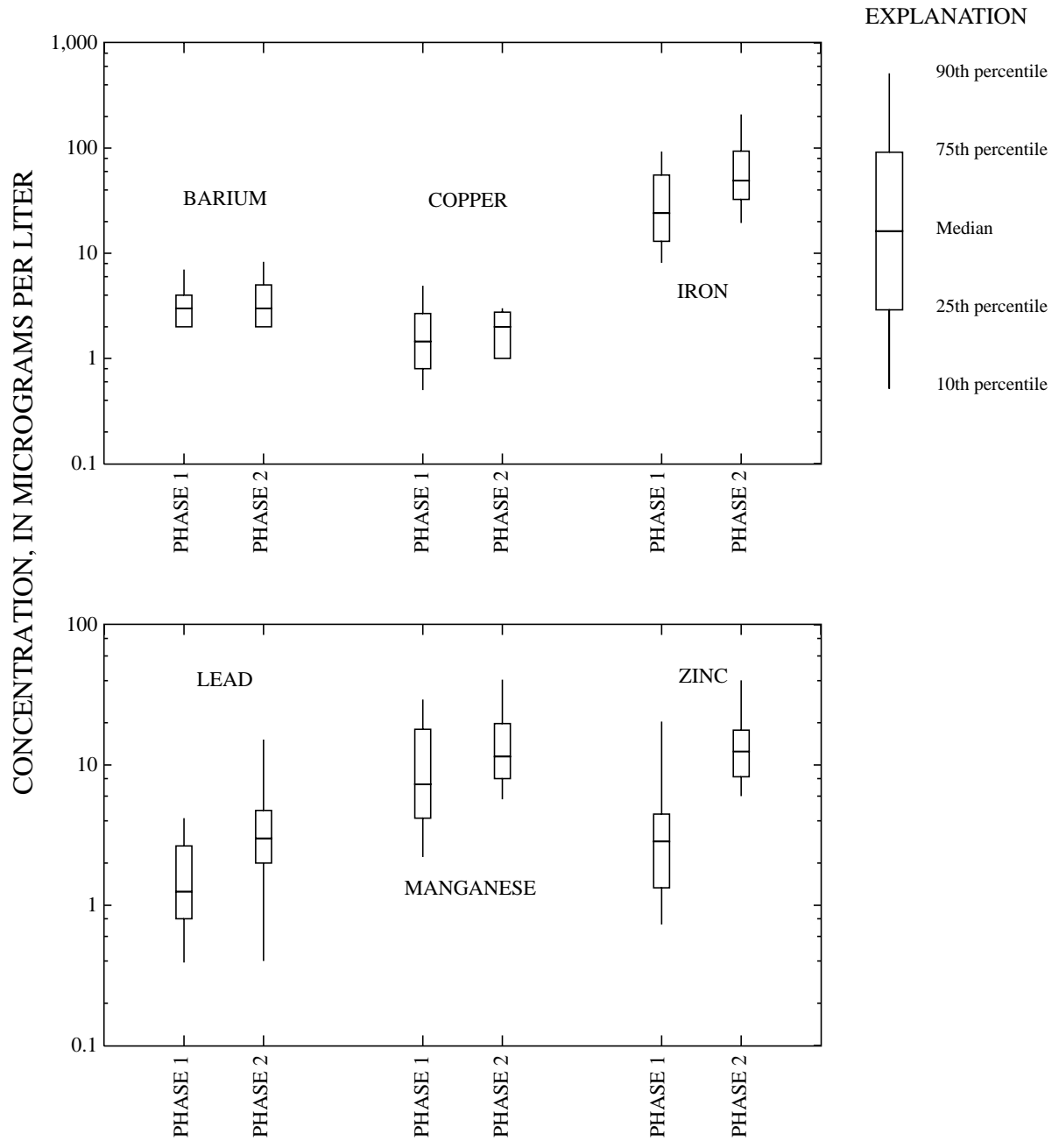


Figure 11. Distribution of concentrations of trace metals analyzed in samples collected at the Gary (Indiana) Regional Airport. Phase 1 samples were collected from June 30, 1992, to August 31, 1993. Phase 2 samples were collected from October 17, 1995, to November 12, 1996.

range, zero was substituted for the estimated minimum weekly loading and the method reporting limit was substituted for the constituent concentration to estimate the maximum weekly loading. Weekly loadings were calculated directly when the measured constituent concentration was greater than the method reporting limit. Major-ion and trace-metal loadings are presented in figures 12 and 13. Bars indicate that the concentration was less than the method reporting limit and, therefore, a range for the weekly loading is presented.

Estimated annual constituent loadings (table 3) were calculated from the sum of the weekly loadings. Weekly loadings for 37 samples collected during the 1-year period beginning October 17, 1995, at the Gary airport were used to calculate a range for the estimated annual loadings. The minimum annual loading was calculated by summing the minimum weekly loadings, and the maximum annual loading was calculated by summing the maximum weekly loadings. If a single value was calculated for the weekly loading, that value was included in the calculations of the minimum and maximum annual loading. If all of the 37 values for a constituent were measured greater than the method reporting limit, a single value was calculated and is reported as the minimum and maximum estimated annual loading.

Comparison of Annual Loadings to Previous Sampling Phase

The annual loadings for the second phase of sampling were compared with those from the first phase (figs. 14 and 15). The total precipitation collected during the second phase of sampling was approximately 1.2 times greater than that during the first phase. If the constituent concentrations had remained the same, it would be expected that the loadings for the second phase would be approximately 1.2 times greater than those during the first

Table 3. Estimated annual loadings determined from wet-deposition samples collected at the Gary (Indiana) Regional Airport for 1 year, beginning October 17, 1995

[kg/ha, kilograms per hectare; g/ha, grams per hectare]

| Constituent | Estimated annual loading | Reporting units |
|-------------|--------------------------|-----------------|
| Calcium | 9.5 | kg/ha |
| Magnesium | 1.26 | kg/ha |
| Sodium | .38 to 1.7 | kg/ha |
| Potassium | .84 | kg/ha |
| Sulfate | 27 | kg/ha |
| Bromide | less than 08 | kg/ha |
| Chloride | 2.1 | kg/ha |
| Fluoride | .31 to .33 | kg/ha |
| Silica | 2.3 | kg/ha |
| Nitrate | 18 | kg/ha |
| Phosphate | .20 to .42 | kg/ha |
| Aluminium | 820 | g/ha |
| Antimony | less than 8.0 | g/ha |
| Barium | 32 | g/ha |
| Beryllium | less than 8.0 | g/ha |
| Cadmium | less than 8.0 | g/ha |
| Chromium | .56 to 8.3 | g/ha |
| Cobalt | less than 8.0 | g/ha |
| Copper | 12 to 14 | g/ha |
| Iron | 700 | g/ha |
| Lead | 40 | g/ha |
| Manganese | 130 | g/ha |
| Molybdenum | .28 to 8.0 | g/ha |
| Nickel | .08 to 8.0 | g/ha |
| Silver | less than 8.0 | g/ha |
| Uranium | less than 8.0 | g/ha |
| Zinc | 130 | g/ha |

phase. Analyses of data, however, show that the phase 2 loadings of calcium, magnesium, sulfate, chloride, fluoride, nitrate, barium, copper, and manganese were up to 2 times greater than the phase 1 loadings; those for silica and iron were 2 to 3 times greater; those for potassium and lead were 3 to 4 times greater; and the loading for zinc was more than 5 times greater. The increase in the possible range computed for chromium (fig. 15) was a result of the change in the method reporting limit between the two sampling phases and the number of samples in which chromium was detected at concentrations less than the method reporting limit during both phases. The method reporting limit for chromium for the first phase of sampling was 5 µg/L; the method reporting limit for the second phase was 1 µg/L.

Quality-Assurance Procedures

Two types of quality-control samples were submitted to the NWQL to evaluate the precision and accuracy of results reported for wet-deposition samples collected at the Gary airport. Laboratory quality-control samples, consisting of blanks and standard reference water samples (table 6, at the back of the report), were used to evaluate the quality of the DIW and nitric acid used in preparing quality-control solutions, cleaning equipment, and acidifying samples. Field quality-control samples, consisting of funnel rinses, system blanks, and split samples (table 7, at the back of the report), were used to evaluate possible contaminations resulting from cleaning, transporting, and installing the clean equipment in the collector and evaluating the possible contamination resulting from the funnel, tubing, and collection bottle remaining in the collector for the 1-week sampling period. All quality-control sample-processing procedures remained the same for field quality-control samples, and all parameters and analytical techniques remained the same

for the laboratory and field quality-control samples as those used for the wet-deposition samples.

Laboratory Quality Assurance

Four DIW laboratory blanks were submitted periodically during the study to determine if the DIW or nitric acid used to prepare quality-control solutions and clean equipment were possible sources of contamination. None of the constituents measured in the blanks, except silica (0.04 mg/L), had median concentrations greater than the method reporting limit. The concentrations measured for silica ranged from 0.03 to 0.05 mg/L for the four DIW blank samples. The median concentration for silica was 4 times the reporting limit and is equivalent to 17 percent the median concentration determined in the wet-deposition samples (table 5, at the back of the report). The results of analyses of the DIW laboratory blanks indicate that, except for silica, no significant source of contamination was present in the DIW or nitric acid used for preparing acidified DIW funnel rinses, acidified DIW system blanks, and cleaning the equipment.

Two USGS standard reference water samples (SRWS) with known most probable values (J.W. Farrar, U.S. Geological Survey, written commun., 1996) also were submitted on four separate occasions to the laboratory for analysis. SRWS's are prepared by the Standard Reference Water Sample Project of the USGS and are used as quality-control samples for the NWQL and to evaluate laboratories used by the USGS. For this study, two SRWS solutions were selected to include as many of the constituents as possible and to simulate, as closely as possible, the concentrations measured in the wet-deposition samples collected at the Gary airport. To evaluate the accuracy of results reported by the NWQL for wet-deposition samples collected at the Gary airport, four samples were prepared from each of the two SRWS solutions and submitted periodically for analysis.

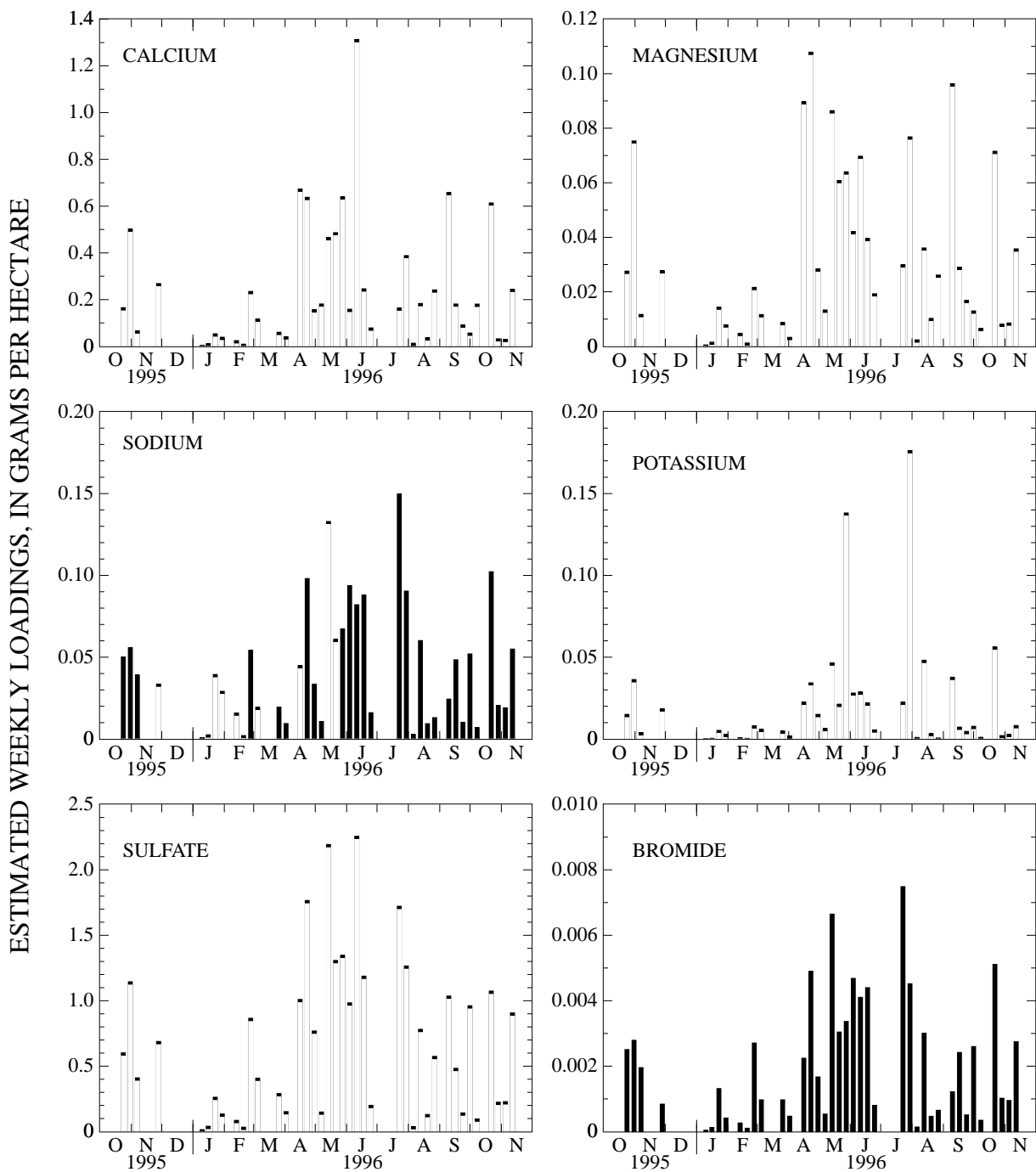


Figure 12. Estimated weekly major-ion loadings determined from wet-deposition samples collected at the Gary (Indiana) Regional Airport. Bars indicate a possible range for the weekly loadings and were estimated when a measured constituent concentration was measured less than the method reporting limit. The minimum value for a range is zero; the maximum value was computed by substituting the method reporting limit for the constituent concentration.

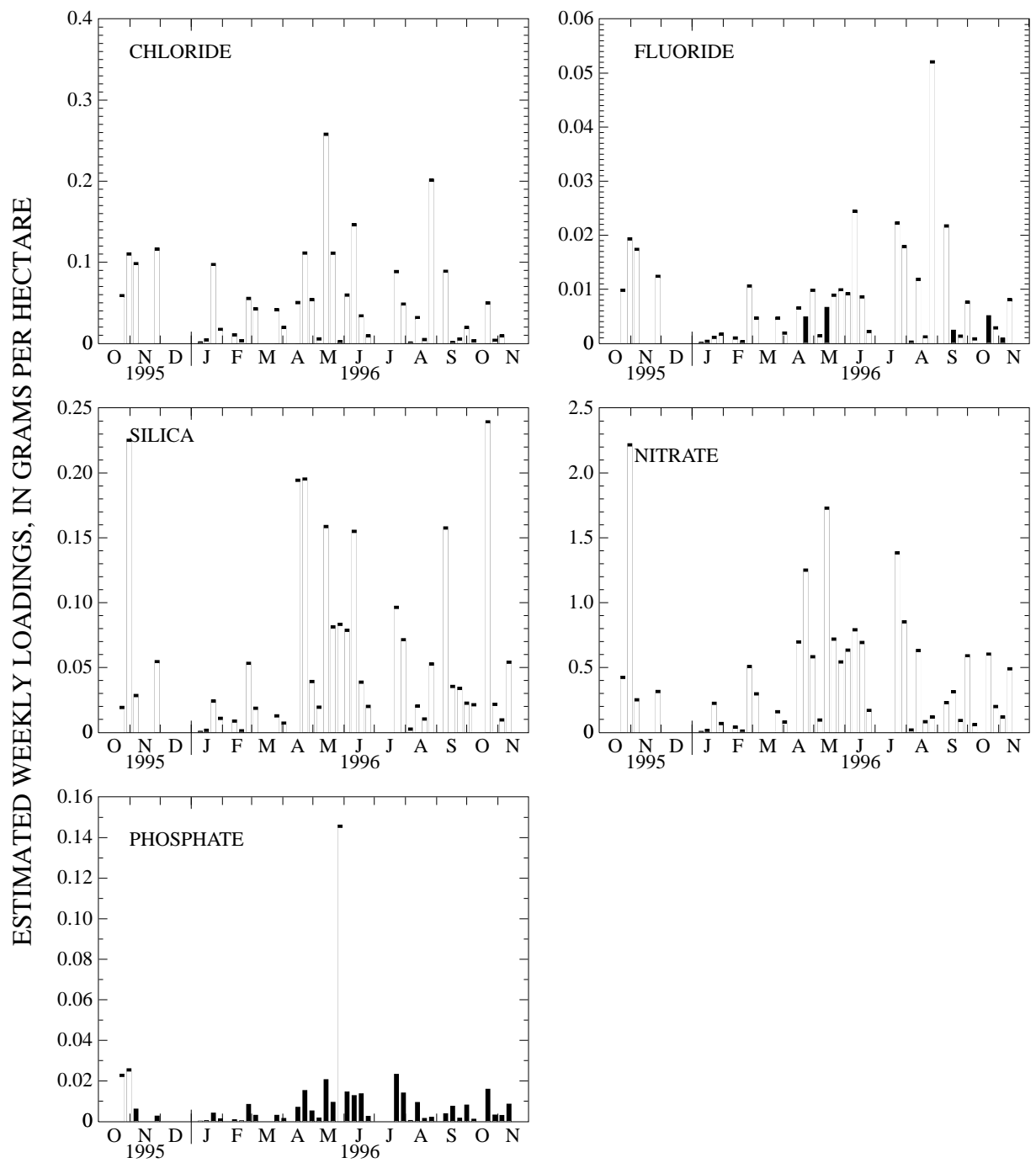


Figure 12. Estimated weekly major-ion loadings determined from wet-deposition samples collected at the Gary (Indiana) Regional Airport—Continued.

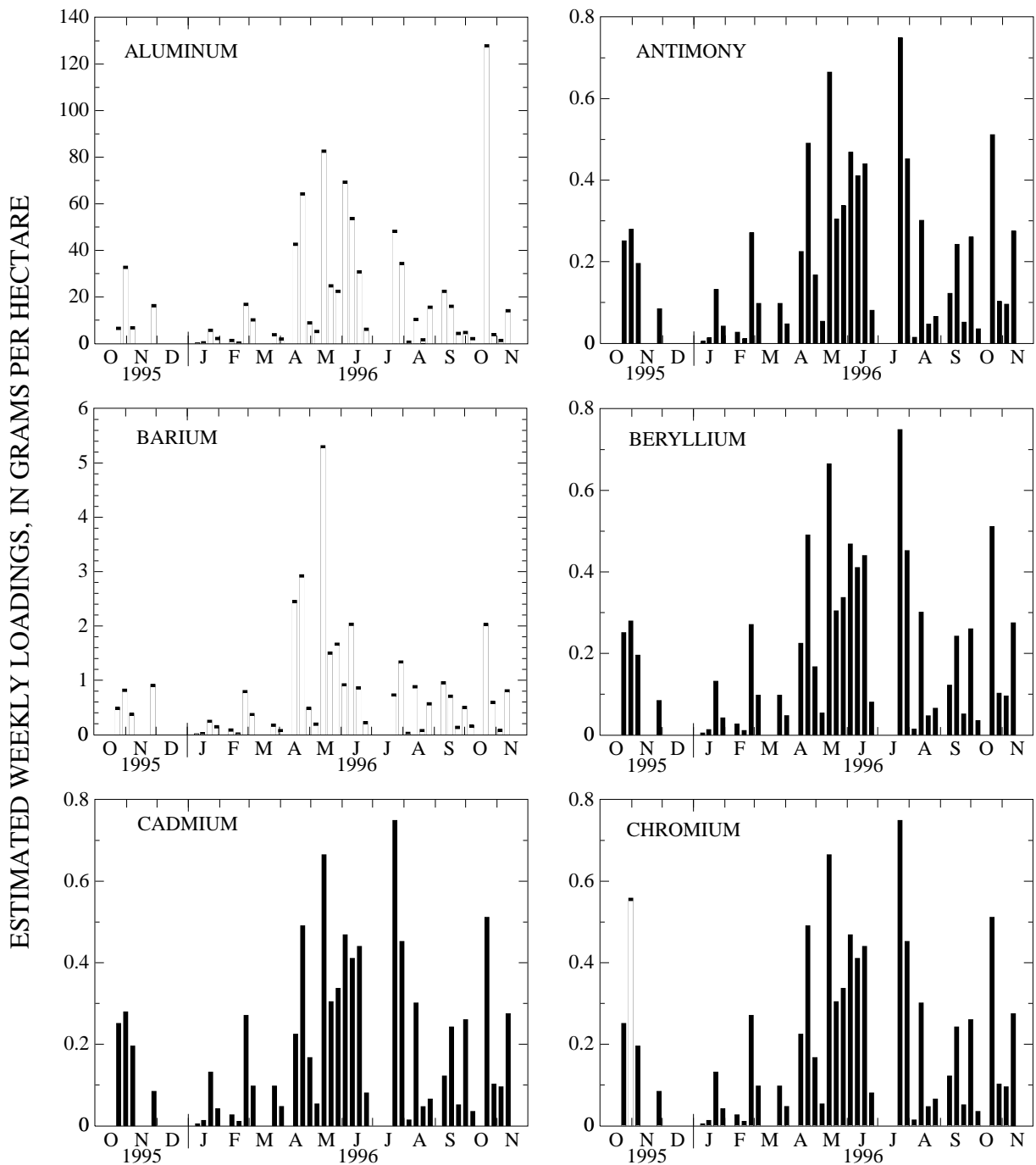


Figure 13. Estimated weekly trace-metal loadings determined from wet-deposition samples collected at the Gary (Indiana) Regional Airport. Bars indicate a possible range for the weekly loading and were estimated when the measured constituent concentration was less than the method reporting limit. The minimum value for a range is zero; the maximum value was computed by substituting the method reporting limit for the constituent concentration.

ESTIMATED WEEKLY LOADINGS, IN GRAMS PER HECTARE

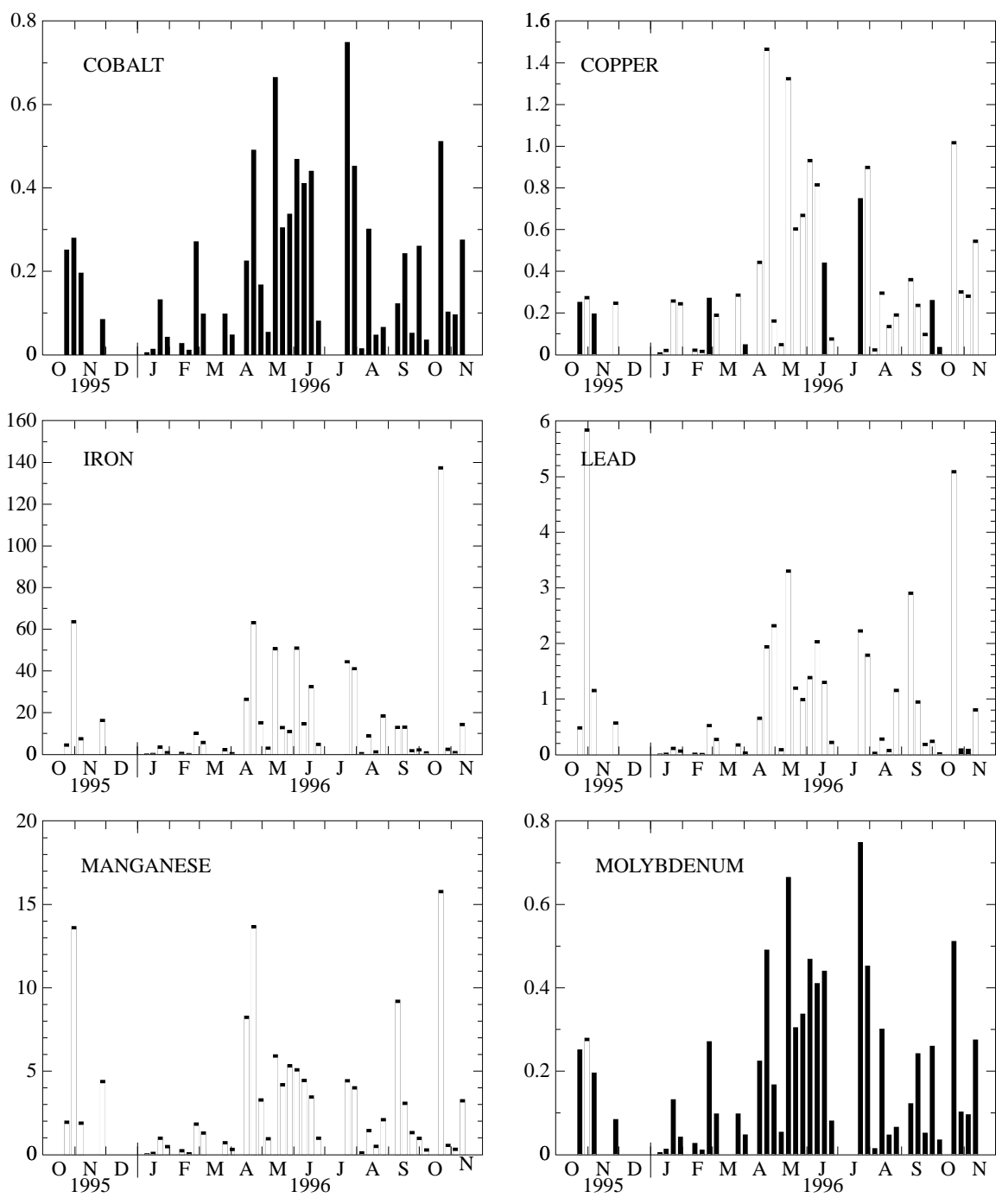


Figure 13. Estimated weekly trace-metal loadings determined from wet-deposition samples collected at the Gary (Indiana) Regional Airport—Continued.

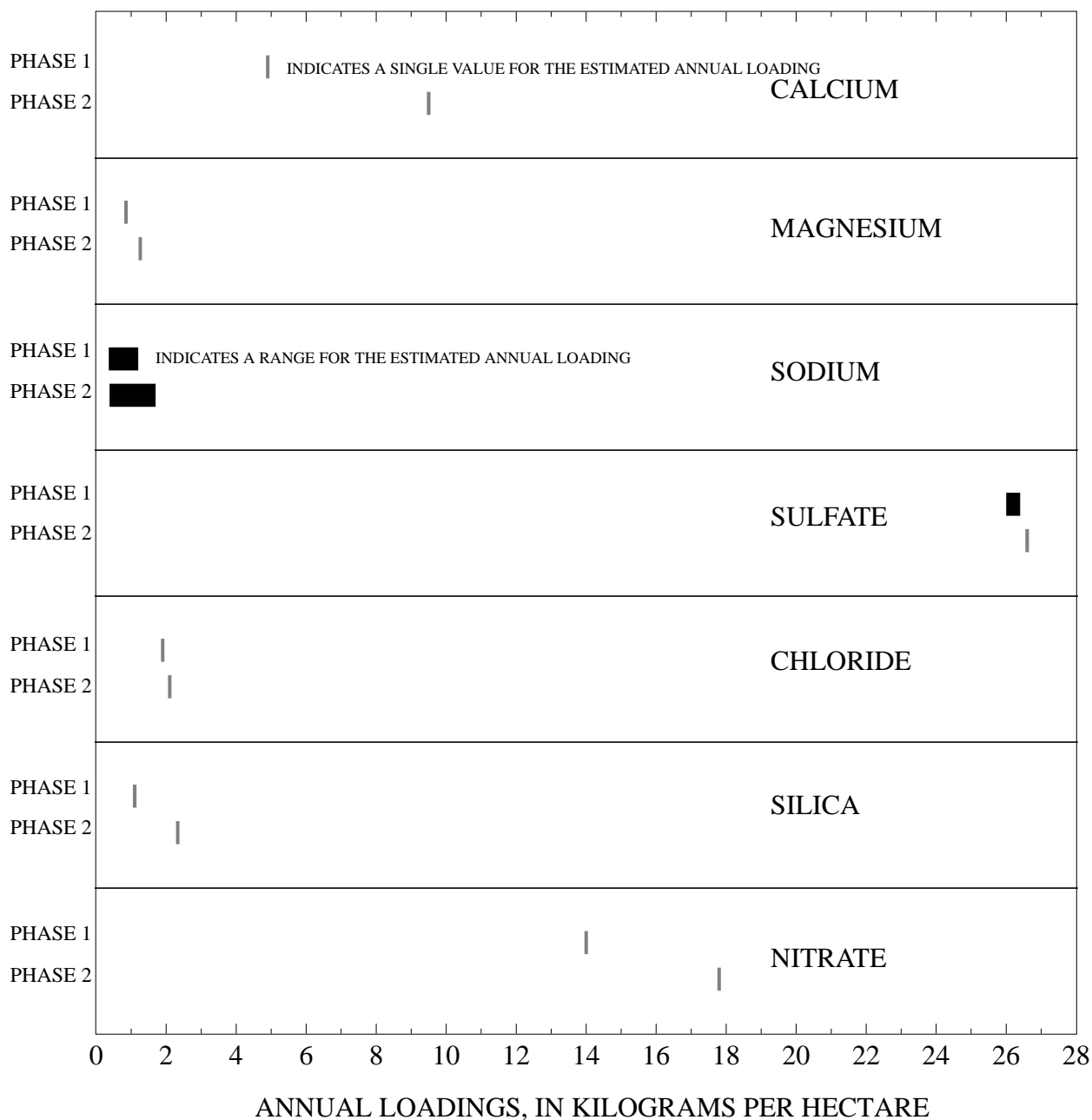


Figure 14. Estimated annual loadings for major ions from samples collected at the Gary (Indiana) Regional Airport during phase 1 (June 30, 1992, to August 31, 1993) and phase 2 (October 17, 1995, to November 12, 1996).

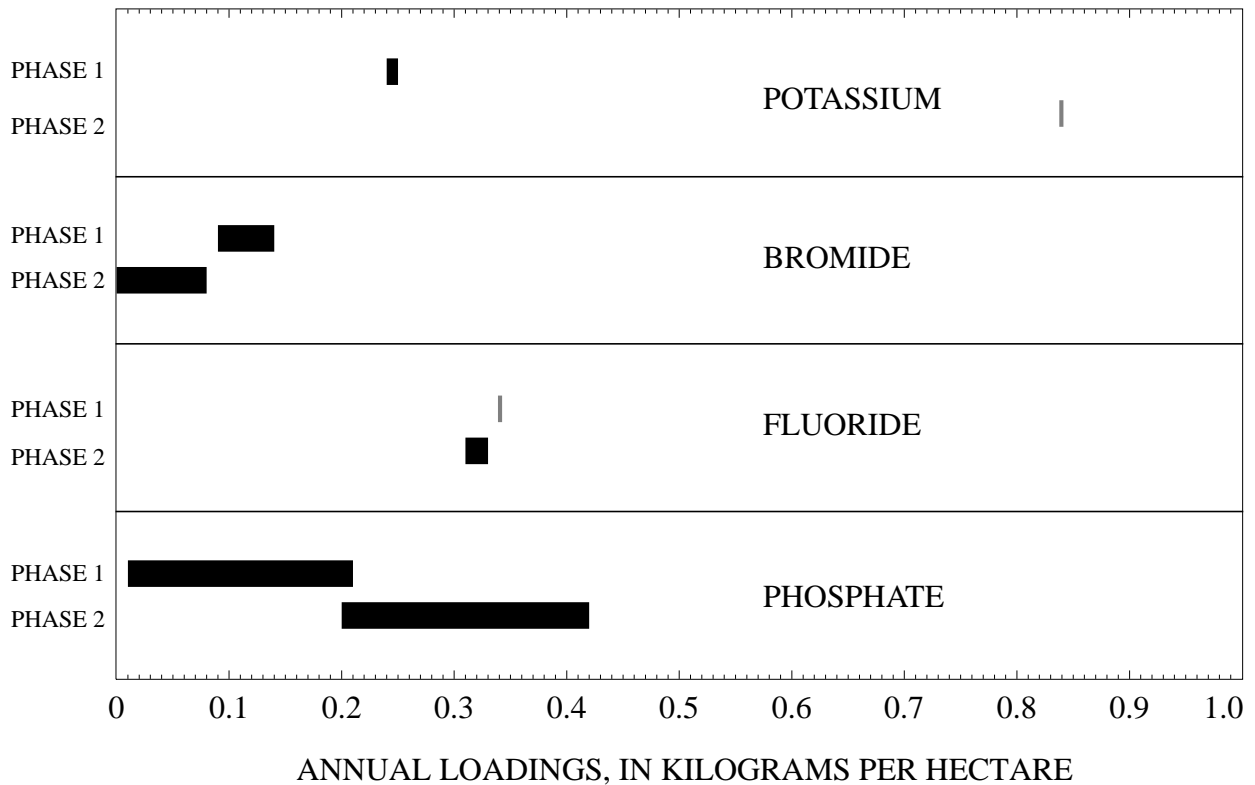


Figure 14. Estimated annual loadings for major ions from samples collected at the Gary (Indiana) Regional Airport during phase 1 (June 30, 1992, to August 31, 1993) and phase 2 (October 17, 1995, to November 12, 1996—Continued).

Four SRWS P23 samples were submitted to evaluate the accuracy of major anions and four SRWS T123 samples were submitted to evaluate the accuracy of major cations and trace metals. The SRWS's were rebottled at the USGS laboratory in Indianapolis and submitted to the laboratory in the same manner as the wet-deposition samples. Table 4 lists the most probable value (MPV), F-pseudosigma (eq. 1), and the median concentration determined from samples collected during phase 2. F-pseudosigma is analogous to a standard deviation.

$$F - pseudosigma = \frac{P75 - P25}{1.349} \quad (1)$$

where

P75 is the 75th percentile; and

P25 is the 25th percentile.

Median concentrations for each constituent were compared to the reported MPV. All of the constituents measured for the two SRWS solutions were within the reported MPV plus or minus the

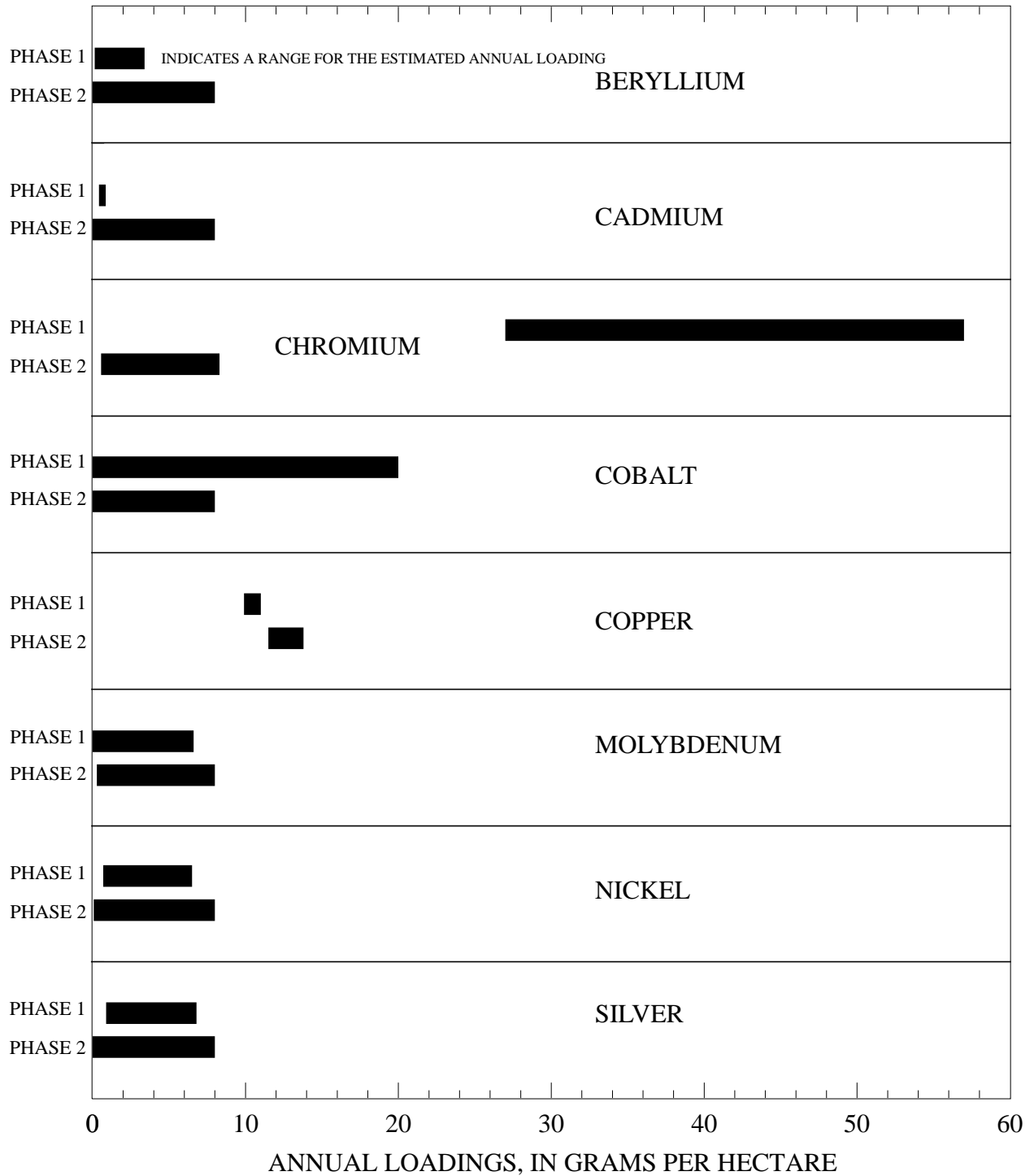


Figure 15. Estimated annual loadings for trace metals from samples collected at the Gary (Indiana) Regional Airport during phase 1 (June 30, 1992, to August 31, 1993) and phase 2 (October 17, 1995, to November 12, 1996).

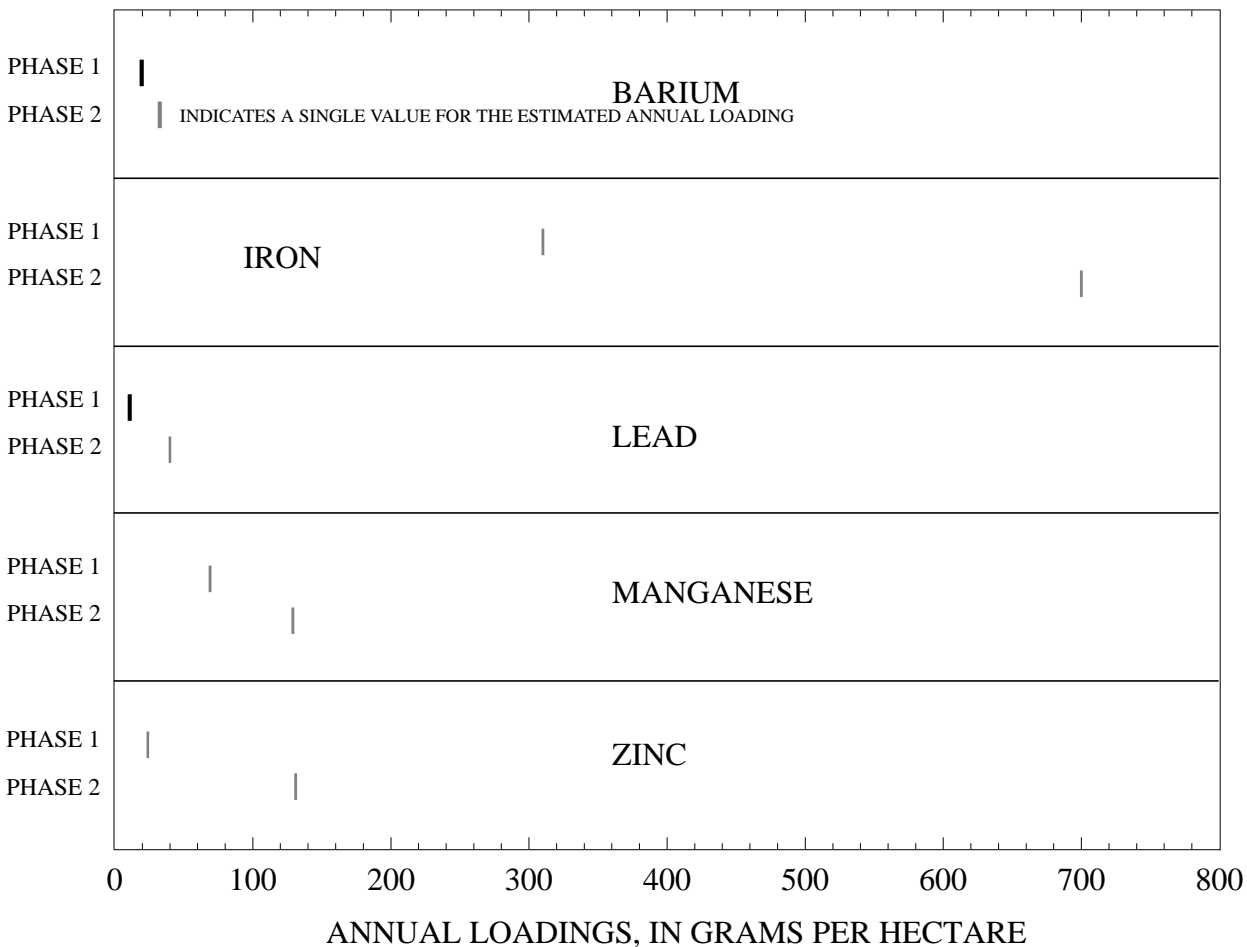


Figure 15. Estimated annual loadings for trace metals from samples collected at the Gary (Indiana) Regional Airport during phase 1 (June 30, 1992, to August 31, 1993) and phase 2 (October 17, 1995, to November 12, 1996)—Continued.

F-pseudosigma, with the exception of fluoride and phosphate. The median concentration computed for fluoride was 0.14 mg/L, which is 0.02 mg/L greater than the reported MPV. The median concentration for phosphate was 0.24, which is 0.17 mg/L less than the reported MPV. Bromide, nitrate, and uranium also were measured; however, they did not have MPV's.

Field Quality Assurance

Three types of field quality-control samples were processed periodically during the study: (1) split samples, (2) funnel rinses, and (3) system blanks (table 7, at the back of the report). Four wet-deposition samples with volumes greater than 1,000 mL were split. Each split from the sample

Table 4. Median concentrations measured for the standard reference water samples T123 and P23

[SRWS, standard reference water sample; mg/L, milligrams per liter; NR, not reported; NA, not applicable; <, less than the method reporting limit; µg/L, micrograms per liter]

| Constituent | Most probable value | F-pseudosigma | SRWS | Median concentration | Reporting unit |
|-------------|---------------------|---------------|------|----------------------|----------------|
| Calcium | 9.10 | 0.6 | T123 | 9.00 | mg/L |
| Magnesium | 1.80 | .13 | T123 | 1.80 | mg/L |
| Sodium | 19.3 | 1.0 | T123 | 19.0 | mg/L |
| Potassium | 1.16 | .10 | T123 | 1.10 | mg/L |
| Sulfate | 1.28 | .20 | P23 | 1.30 | mg/L |
| Bromide | NR | NR | NA | <.01 | mg/L |
| Chloride | .31 | .21 | P23 | .22 | mg/L |
| Fluoride | .12 | .01 | P23 | .14 | mg/L |
| Silica | 6.08 | .6 | T123 | 6.00 | mg/L |
| Nitrate | NR | NR | NA | .29 | mg/L |
| Phosphate | .41 | .02 | P23 | .24 | mg/L |
| Aluminum | 10 | 12 | T123 | 8 | µg/L |
| Antimony | 7 | 1.5 | T123 | 7 | µg/L |
| Barium | 8 | 1 | T123 | 7 | µg/L |
| Beryllium | 8 | .8 | T123 | 8 | µg/L |
| Cadmium | 6 | .9 | T123 | 6 | µg/L |
| Cobalt | 5 | .9 | T123 | 5 | µg/L |
| Copper | 10 | 1 | T123 | 10 | µg/L |
| Iron | 58 | 5 | T123 | 56 | µg/L |
| Lead | 10 | 2 | T123 | 10 | µg/L |
| Manganese | 14 | 1 | T123 | 13 | µg/L |
| Molybdenum | 9 | 1 | T123 | 9 | µg/L |
| Nickel | 4 | 1 | T123 | 4 | µg/L |
| Silver | 1 | 1 | T123 | 1 | µg/L |
| Uranium | NR | NR | NA | 8 | µg/L |
| Zinc | 6 | 4 | T123 | 5 | µg/L |

was processed independently and submitted to the laboratory to evaluate the precision of laboratory results. The concentrations measured for the split samples were subtracted from the environmental samples, and a median difference was computed for each constituent. For all of the constituents listed in table 1, the median difference between the split sample and the investigative sample was 0, with the following exceptions: nitrate (-0.04 mg/L), potassium (-0.01 mg/L), aluminum (-1.0 µg/L), and zinc (0.5 µg/L). The median difference between the split samples for nitrate, aluminum, and zinc was within 5 percent and for potassium within 15 percent of the median concentration for all samples collected during the second phase of sampling.

The funnel rinses and system blanks were prepared by diluting Ultrex nitric acid with DIW to a target pH of 4.5. The target pH of 4.5 was the median pH determined from wet-deposition samples collected during the first phase of sampling. Six acidified DIW funnel rinses were processed during phase 2 to evaluate possible contamination resulting from cleaning equipment, shipping clean equipment to the Gary airport, installing equipment in the collector, and processing the sample prior to shipping it to the NWQL. Funnel rinses were processed immediately after installation of clean equipment in the collector. The rinses were completed by passing 750 mL of the pH 4.5 solution through the funnel, with as much of the inside of the funnel surface as possible exposed to the solution; the solution was collected in a collection bottle. The collection bottle was removed and processed in the same manner as the investigative samples. Median concentrations for the six acidified DIW funnel rinses were determined. Median concentrations greater than the method reporting limit were observed for calcium (0.03 mg/L), chloride (0.02 mg/L), silica (0.06 mg/L), aluminum (12 mg/L), iron (4 mg/L), and zinc (4 mg/L).

Nine system blanks were processed during the study on weeks when there was no wet deposition. System blanks were processed in the same

manner as funnel rinses, except they were done at the end of the sampling week before installation of clean equipment in the collector. Of the constituents measured, median concentrations for calcium (0.10 mg/L), magnesium (0.02 mg/L), sulfate (0.09 mg/L), chloride (0.08 mg/L), silica (0.08 mg/L), aluminum (12 mg/L), iron (8 mg/L), and zinc (3 mg/L) were greater than the method reporting limit. All of these concentrations were greater than the median concentrations determined for the funnel rinses, with the exception of zinc, indicating that contamination of the wet-deposition samples increased during the period that the funnel, Teflon tubing, and Teflon collection bottle remained in the collector.

A comparison was made between the method reporting limit, acidified DIW funnel rinses, system blanks, and the wet-deposition samples collected at the Gary airport (fig. 16). Median concentrations were compared to evaluate the differences between concentrations observed in field quality-control samples when compared to the wet-deposition samples. Concentrations in the field quality-control samples were less than 20 percent of the median concentration computed in the wet-deposition samples for calcium (11 percent), magnesium (13 percent), sulfate (3 percent), aluminum (17 percent), and iron (16 percent). Concentrations in the field quality-control samples were greater than 30 percent of the median concentration computed in the wet-deposition samples for chloride (35 percent), silica (33 percent), and zinc (31 percent).

Summary

The USGS began collecting wet-deposition samples at the Gary (Indiana) Regional Airport in June 1992 to evaluate the quantity and quality of wet deposition in the Grand Calumet River Watershed. Two phases of sampling have been completed—the first phase was conducted from

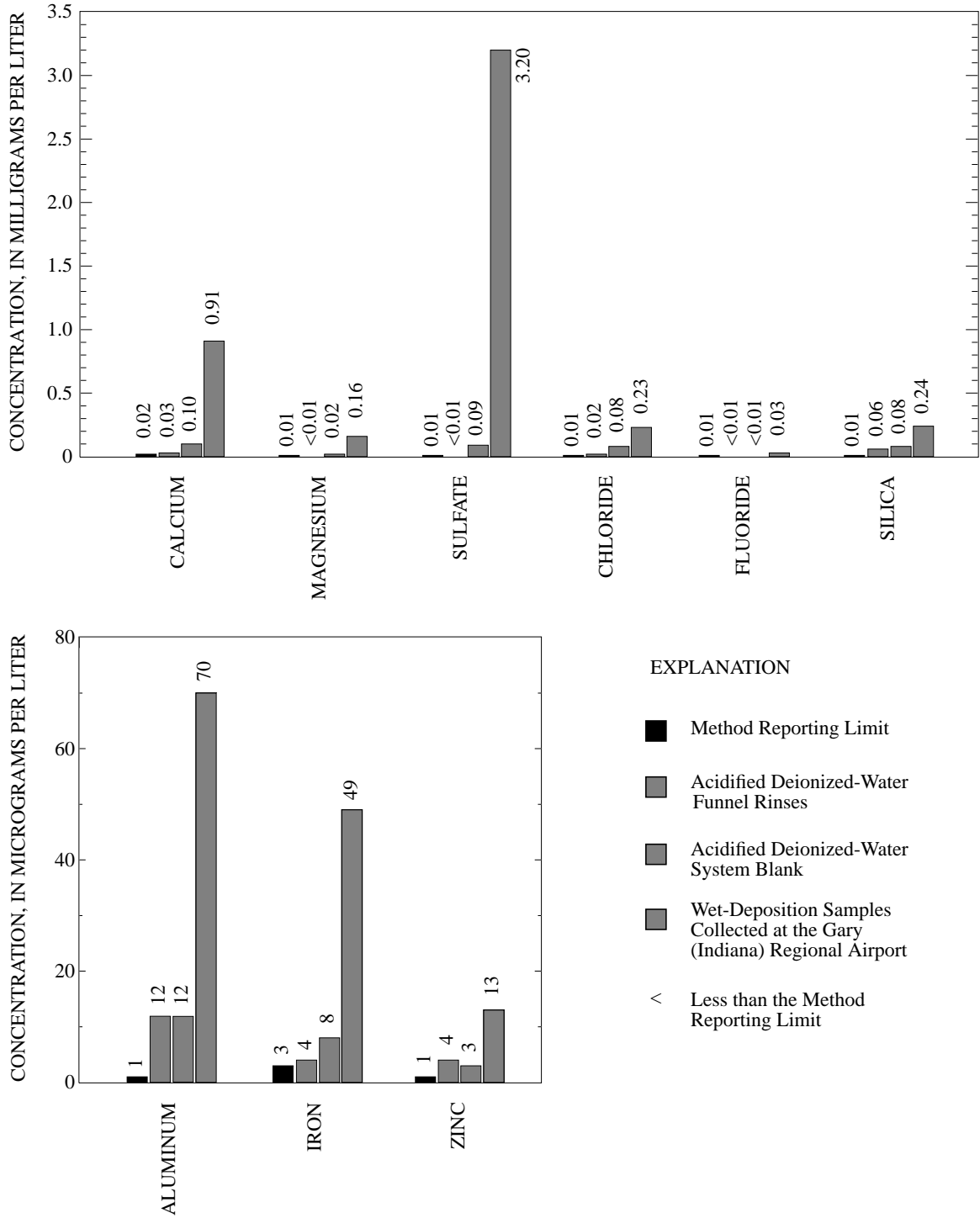


Figure 16. Median constituent concentrations for the acidified deionized-water funnel rinses, the acidified deionized-water system blanks, and the wet-deposition samples and the method reporting limits.

June 30, 1992, to August 31, 1993, and the second phase was conducted from October 17, 1995, to November 12, 1996. Forty-eight weekly wet-deposition samples were collected during the first phase of sampling, and 40 weekly wet-deposition samples were collected during the second phase of sampling that had sufficient volumes for at least some of the analyses.

The median constituent concentrations determined in samples collected during the second phase of sampling were compared to the median concentrations determined in samples collected during the first phase of sampling. At a 5-percent significance level, significant increases in sample concentrations were observed for potassium, iron, lead, and zinc for samples collected during the second phase of sampling.

Results from both phases of sampling were combined to determine if there were differences in concentrations between samples collected during warm weather (April 1 through October 31) and cold weather (November 1 through March 31). No statistically significant differences were observed at the 5-percent significance level.

Annual loadings were computed for each constituent. The volume of water collected during phase 2 was 1.2 times greater than the volume collected during phase 1. Constituent loadings for the second phase of sampling, however, were more than 2 times the loadings computed for the first phase of sampling for potassium, silica, iron, lead, and zinc.

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SUPPLEMENTAL DATA

Table 5. Reported concentrations for wet-deposition samples collected at the Gary (Indiana) Regional Airport

[ICAP, sample analyzed by inductively coupled argon plasma atomic emission spectroscopy; FAAS, sample analyzed by flame atomic absorption spectroscopy; IC, sample analyzed by ion chromatography; ICAP/MS, sample analyzed by inductively coupled argon plasma mass spectroscopy; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; mg/L , milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; --, not analyzed; <, concentration reported less than the method reporting limit]

| Date on | Time on (24-hour time) | Date off | Time off | Volume (liters) | Specific conductance ($\mu\text{S}/\text{cm}$) | Field pH (standard units) | Calcium (ICAP) (mg/L) | Magnesium (ICAP) (mg/L) | Sodium (ICAP) (mg/L) | Potassium (FAAS) (mg/L) | Sulfate (IC) (mg/L) | Chloride (IC) (mg/L) | Fluoride (IC) (mg/L) | Bromide (IC) (mg/L) | Silica (ICAP) (mg/L) |
|----------|------------------------|----------|----------|-----------------|--|---------------------------|-----------------------|-------------------------|----------------------|-------------------------|---------------------|----------------------|----------------------|---------------------|----------------------|
| 10/17/95 | 1545 | 10/24/95 | 1515 | 1.868 | 14.6 | 5.03 | 0.66 | 0.11 | <0.2 | 0.06 | 2.4 | 0.24 | 0.04 | <0.01 | 0.08 |
| 10/24/95 | 1530 | 10/31/95 | 0935 | 2.079 | 47.3 | 4.23 | 1.80 | .27 | <.2 | .13 | 4.1 | .40 | .07 | <.01 | .81 |
| 10/31/95 | 0945 | 11/07/95 | 0945 | 1.456 | 23.4 | 4.38 | .34 | .06 | <.2 | .02 | 2.1 | .51 | .09 | <.01 | .15 |
| 11/21/95 | 1415 | 11/28/95 | 1300 | .626 | 41.9 | 5.87 | 3.20 | .33 | .4 | .22 | 8.2 | 1.40 | .15 | <.01 | .66 |
| 01/02/96 | 1100 | 01/10/96 | 1225 | .033 | -- | 4.16 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 01/10/96 | 1245 | 01/16/96 | 1030 | .094 | -- | 4.42 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 01/16/96 | 1035 | 01/23/96 | 1030 | .979 | 20.3 | 4.61 | .41 | .11 | .3 | .04 | 2.0 | .75 | .01 | <.01 | .19 |
| 01/23/96 | 1100 | 01/30/96 | 1045 | .310 | -- | 4.39 | .94 | .19 | .7 | .07 | -- | -- | -- | -- | .28 |
| 02/06/96 | 1115 | 02/13/96 | 1040 | .198 | -- | 5.54 | .92 | .18 | .6 | .03 | -- | -- | -- | -- | .36 |
| 02/13/96 | 1050 | 02/20/96 | 1030 | .078 | -- | 6.64 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 02/20/96 | 1100 | 02/27/96 | 1045 | 2.016 | 18.1 | 4.82 | .87 | .08 | <.2 | .03 | 3.2 | .21 | .04 | <.01 | .20 |
| 02/27/96 | 1100 | 03/05/96 | 1052 | .725 | 29.4 | 4.51 | 1.20 | .12 | .2 | .06 | 4.2 | .45 | .05 | <.01 | .20 |
| 03/20/96 | 1220 | 03/26/96 | 1030 | .723 | 26.5 | 4.40 | .62 | .09 | <.2 | .05 | 3.0 | .44 | .05 | <.01 | .14 |
| 03/26/96 | 1040 | 04/02/96 | 1030 | .351 | -- | 4.13 | .88 | .07 | <.2 | .04 | -- | -- | -- | -- | .17 |
| 04/09/96 | 1055 | 04/16/96 | 1045 | 1.672 | 27.1 | 6.64 | 3.00 | .40 | .2 | .10 | 4.5 | .23 | .03 | <.01 | .87 |
| 04/16/96 | 1050 | 04/23/96 | 1040 | 3.653 | 19.6 | 6.07 | 1.30 | .22 | <.2 | .07 | 3.6 | .23 | <.01 | <.01 | .40 |
| 04/23/96 | 1045 | 04/30/96 | 1140 | 1.244 | 29.8 | 4.56 | .94 | .17 | <.2 | .09 | 4.6 | .33 | .06 | <.01 | .24 |
| 04/30/96 | 1200 | 05/07/96 | 1055 | .398 | -- | 6.43 | 3.40 | .25 | <.2 | .12 | -- | -- | -- | -- | .38 |
| 05/07/96 | 1120 | 05/14/96 | 0915 | 4.952 | 24.7 | 4.54 | .70 | .13 | .2 | .07 | 3.3 | .39 | <.01 | <.01 | .24 |
| 05/14/96 | 0930 | 05/21/96 | 1330 | 2.266 | 20.5 | 5.42 | 1.60 | .20 | .2 | .07 | 4.3 | .37 | .03 | <.01 | .27 |

Table 5. Reported concentrations for wet-deposition samples collected at the Gary (Indiana) Regional Airport—Continued

| Date on | Time on (24-hour time) | Date off | Time off | Volume (liters) | Specific conductance (μS/cm) | Field pH (standard units) | Calcium (ICAP) (mg/L) | Magnesium (ICAP) (mg/L) | Sodium (ICAP) (mg/L) | Potassium (FAAS) (mg/L) | Sulfate (IC) (mg/L) | Chloride (IC) (mg/L) | Fluoride (IC) (mg/L) | Bromide (IC) (mg/L) | Silica (ICAP) (mg/L) |
|----------|------------------------|----------|----------|-----------------|------------------------------|---------------------------|-----------------------|-------------------------|----------------------|-------------------------|---------------------|----------------------|----------------------|---------------------|----------------------|
| | | | | | | | | | | | | | | | |
| 05/28/96 | 1105 | 06/04/96 | 1101 | 3.489 | 16.0 | 4.62 | .34 | .09 | <.2 | .06 | 2.1 | .13 | .02 | <.01 | .17 |
| 06/04/96 | 1100 | 06/11/96 | 1100 | 3.056 | 26.3 | 4.49 | 3.20 | .17 | <.2 | .07 | 5.5 | .36 | .06 | <.01 | .38 |
| 06/11/96 | 1115 | 06/18/96 | 1015 | 3.277 | 20.7 | 4.56 | .56 | .09 | <.2 | .05 | 2.7 | .08 | .02 | <.01 | .09 |
| 06/18/96 | 1030 | 06/25/96 | 1140 | .598 | 18.6 | 4.86 | .98 | .24 | <.2 | .07 | 2.5 | .13 | .03 | <.01 | .26 |
| 07/16/96 | 1115 | 07/23/96 | 0915 | 5.577 | 23.6 | 4.34 | .22 | .04 | <.2 | .03 | 2.3 | .12 | .03 | <.01 | .13 |
| 07/23/96 | 0930 | 07/30/96 | 0915 | 3.367 | 22.1 | 4.57 | .86 | .17 | <.2 | .39 | 2.8 | .11 | .04 | <.01 | .16 |
| 07/30/96 | 0920 | 08/06/96 | 0930 | .105 | -- | 5.24 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 08/06/96 | 0940 | 08/13/96 | 1020 | 2.241 | 19.2 | 4.65 | .61 | .12 | <.2 | .16 | 2.6 | .11 | .04 | <.01 | .07 |
| 08/13/96 | 1025 | 08/20/96 | 1230 | .347 | -- | 4.53 | .79 | .22 | <.2 | .07 | -- | -- | -- | -- | .24 |
| 08/20/96 | 1250 | 08/27/96 | 1030 | .487 | 40.6 | 4.52 | 3.70 | .40 | <.2 | <.01 | 8.8 | 3.10 | .80 | <.01 | .82 |
| 09/03/96 | 0950 | 09/10/96 | 1045 | .908 | 46.7 | 6.51 | 5.40 | .79 | <.2 | .31 | 8.5 | .74 | .18 | <.01 | 1.30 |
| 09/10/96 | 1050 | 09/17/96 | 1105 | 1.803 | 11.6 | 5.90 | .75 | .12 | <.2 | .03 | 2.0 | <.01 | <.01 | <.01 | .15 |
| 09/17/96 | 1115 | 09/24/96 | 1115 | .381 | -- | 4.55 | 1.80 | .33 | <.2 | .09 | -- | -- | -- | -- | .68 |
| 09/24/96 | 1115 | 10/01/96 | 1130 | 1.936 | 36.9 | 4.19 | .22 | .05 | <.2 | .03 | 3.7 | .08 | .03 | <.01 | .09 |
| 10/01/96 | 1200 | 10/08/96 | 1115 | .259 | -- | 6.84 | 5.20 | .19 | <.2 | .03 | -- | -- | -- | -- | .64 |
| 10/08/96 | 1120 | 10/22/96 | 1130 | 3.808 | 18.1 | 6.06 | 1.20 | .14 | <.2 | .11 | 2.1 | .10 | <.01 | <.01 | .47 |
| 10/22/96 | 1130 | 10/29/96 | 1130 | .760 | 22.7 | 4.42 | .32 | .08 | <.2 | .02 | 2.2 | .05 | .03 | <.01 | .22 |
| 10/29/96 | 1135 | 11/05/96 | 1215 | .710 | 13.6 | 4.58 | .32 | .09 | <.2 | .03 | 2.4 | .11 | <.01 | <.01 | .11 |
| 11/05/96 | 1220 | 11/12/96 | 1125 | 2.048 | 18.7 | 5.14 | .89 | .13 | <.2 | .03 | 3.3 | .32 | .03 | <.01 | .20 |

Reported Concentrations 39

Table 5. Reported concentrations for wet-deposition samples collected at the Gary (Indiana) Regional Airport—Continued

| Date on | Date off | Nitrate (IC) (mg/L) | Phosphate (IC) (mg/L) | Aluminum (ICAP/MS) (µg/L) | Anti-mony (ICAP/MS) (µg/L) | Barium (ICAP/MS) (µg/L) | Beryllium (ICAP/MS) (µg/L) | Cadmium (ICAP/MS) (µg/L) | Chromium (ICAP/MS) (µg/L) | Cobalt (ICAP/MS) (µg/L) | Copper (ICAP/MS) (µg/L) | Iron (ICAP) (µg/L) | Lead (ICAP/MS) (µg/L) | Manganese (ICAP/MS) (mg/L) | Molybdenum (ICAP/MS) (µg/L) | Nickel (ICAP/MS) (µg/L) | Silver (ICAP/MS) (µg/L) | Uranium (natural) (ICAP/MS) (µg/L) | Zinc (ICAP/MS) (µg/L) |
|----------|----------|---------------------|-----------------------|---------------------------|----------------------------|-------------------------|----------------------------|--------------------------|---------------------------|-------------------------|-------------------------|--------------------|-----------------------|----------------------------|-----------------------------|-------------------------|-------------------------|------------------------------------|-----------------------|
| 10/17/95 | 10/24/95 | 1.73 | 0.09 | 28 | <1 | 2 | <1 | <1 | <1 | <1 | <1 | 20 | 2 | 8 | <1 | <1 | <1 | <1 | 14 |
| 10/24/95 | 10/31/95 | 7.97 | .09 | 119 | <1 | 3 | <1 | <1 | 2 | <1 | 1 | 230 | 21 | 49 | 1 | <1 | <1 | <1 | 39 |
| 10/31/95 | 11/07/95 | 1.33 | <.03 | 37 | <1 | 2 | <1 | <1 | <1 | <1 | <1 | 41 | 6 | 10 | <1 | <1 | <1 | <1 | 15 |
| 11/21/95 | 11/28/95 | 3.85 | <.03 | 199 | <1 | 11 | <1 | <1 | <1 | <1 | 3 | 200 | 7 | 53 | <1 | 1 | <1 | <1 | 43 |
| 01/02/96 | 01/10/96 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 01/10/96 | 01/16/96 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 01/16/96 | 01/23/96 | 1.77 | <.03 | 47 | <1 | 2 | <1 | <1 | <1 | <1 | 2 | 30 | 1 | 8 | <1 | <1 | <1 | <1 | 15 |
| 01/23/96 | 01/30/96 | -- | -- | 63 | <1 | 4 | <1 | <1 | <1 | <1 | 6 | 32 | 2 | 13 | <1 | <1 | <1 | <1 | 14 |
| 02/06/96 | 02/13/96 | -- | -- | 67 | <1 | 4 | <1 | <1 | <1 | <1 | 1 | 35 | <1 | 11 | <1 | <1 | <1 | <1 | 10 |
| 02/13/96 | 02/20/96 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 02/20/96 | 02/27/96 | 1.90 | <.03 | 64 | <1 | 3 | <1 | <1 | <1 | <1 | <1 | 39 | 2 | 7 | <1 | <1 | <1 | <1 | 8 |
| 02/27/96 | 03/05/96 | 3.15 | <.03 | 109 | <1 | 4 | <1 | <1 | <1 | <1 | 2 | 64 | 3 | 14 | <1 | <1 | <1 | <1 | 12 |
| 03/20/96 | 03/26/96 | 1.73 | <.03 | 44 | <1 | 2 | <1 | <1 | <1 | <1 | 3 | 28 | 2 | 8 | <1 | <1 | <1 | <1 | 13 |
| 03/26/96 | 04/02/96 | -- | -- | 51 | <1 | 2 | <1 | <1 | <1 | <1 | <1 | 18 | 1 | 8 | <1 | <1 | <1 | <1 | 7 |
| 04/09/96 | 04/16/96 | 3.15 | <.03 | 192 | <1 | 11 | <1 | <1 | <1 | <1 | 2 | 120 | 3 | 37 | <1 | <1 | <1 | <1 | 15 |
| 04/16/96 | 04/23/96 | 2.57 | <.03 | 132 | <1 | 6 | <1 | <1 | <1 | <1 | 3 | 130 | 4 | 28 | <1 | <1 | <1 | <1 | 12 |
| 04/23/96 | 04/30/96 | 3.54 | <.03 | 56 | <1 | 3 | <1 | <1 | <1 | <1 | 1 | 94 | 14 | 20 | <1 | <1 | <1 | <1 | 18 |
| 04/30/96 | 05/07/96 | -- | -- | 106 | <1 | 4 | <1 | <1 | <1 | <1 | 1 | 65 | 2 | 19 | <1 | <1 | <1 | <1 | 11 |
| 05/07/96 | 05/14/96 | 2.61 | <.03 | 125 | <1 | 8 | <1 | <1 | <1 | <1 | 2 | 77 | 5 | 9 | <1 | <1 | <1 | <1 | 18 |
| 05/14/96 | 05/21/96 | 2.39 | <.03 | 83 | <1 | 5 | <1 | <1 | <1 | <1 | 2 | 44 | 4 | 14 | <1 | <1 | <1 | <1 | 10 |

Table 5. Reported concentrations for wet-deposition samples collected at the Gary (Indiana) Regional Airport—Continued

| Date on | Date off | Nitrate (IC) (mg/L) | Phosphate (IC) (mg/L) | Aluminum (ICAP/MS) (µg/L) | Anti-mony (ICAP/MS) (µg/L) | Barium (ICAP/MS) (µg/L) | Beryllium (ICAP/MS) (µg/L) | Cadmium (ICAP/MS) (µg/L) | Chromium (ICAP/MS) (µg/L) | Cobalt (ICAP/MS) (µg/L) | Copper (ICAP/MS) (µg/L) | Iron (ICAP) (µg/L) | Lead (ICAP/MS) (µg/L) | Manganese (ICAP/MS) (mg/L) | Molybdenum (ICAP/MS) (µg/L) | Nickel (ICAP/MS) (µg/L) | Silver (ICAP/MS) (µg/L) | Uranium (natural) (ICAP/MS) (µg/L) | Zinc (ICAP/MS) (µg/L) |
|----------|----------|---------------------|-----------------------|---------------------------|----------------------------|-------------------------|----------------------------|--------------------------|---------------------------|-------------------------|-------------------------|--------------------|-----------------------|----------------------------|-----------------------------|-------------------------|-------------------------|------------------------------------|-----------------------|
| 05/21/96 | 05/28/96 | 1.64 | 0.43 | 68 | <1 | 5 | <1 | <1 | <1 | <1 | 2 | 34 | 3 | 16 | <1 | <1 | <1 | <1 | 54 |
| 05/28/96 | 6/04/96 | 1.37 | <.03 | 149 | <1 | 2 | <1 | <1 | <1 | <1 | 2 | 110 | 3 | 11 | <1 | <1 | <1 | <1 | 8 |
| 06/04/96 | 06/11/96 | 1.95 | <.03 | 132 | <1 | 5 | <1 | <1 | <1 | <1 | 2 | 37 | 5 | 11 | <1 | <1 | <1 | <1 | 20 |
| 06/11/96 | 06/18/96 | 1.59 | <.03 | 71 | <1 | 2 | <1 | <1 | <1 | <1 | <1 | 75 | 3 | 8 | <1 | <1 | <1 | <1 | 11 |
| 06/18/96 | 06/25/96 | 2.21 | <.03 | 82 | <1 | 3 | <1 | <1 | <1 | <1 | 1 | 66 | 3 | 13 | <1 | <1 | <1 | <1 | 11 |
| 07/16/96 | 07/23/96 | 1.86 | <.03 | 65 | <1 | 1 | <1 | <1 | <1 | <1 | <1 | 60 | 3 | 6 | <1 | <1 | <1 | <1 | 6 |
| 07/23/96 | 07/30/96 | 1.90 | <.03 | 77 | <1 | 3 | <1 | <1 | <1 | <1 | 2 | 92 | 4 | 9 | <1 | <1 | <1 | <1 | 15 |
| 07/30/96 | 08/06/96 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 08/06/96 | 08/13/96 | 2.13 | <.03 | 36 | <1 | 3 | <1 | <1 | <1 | <1 | 1 | 31 | 1 | 5 | <1 | <1 | <1 | <1 | 6 |
| 08/13/96 | 08/20/96 | -- | -- | 44 | <1 | 2 | <1 | <1 | <1 | <1 | 3 | 36 | 2 | 12 | <1 | <1 | <1 | <1 | 14 |
| 08/20/96 | 08/27/96 | -- | <.03 | 246 | <1 | 9 | <1 | <1 | <1 | <1 | 3 | 290 | 18 | 33 | <1 | <1 | <1 | <1 | 34 |
| 09/03/96 | 09/10/96 | 1.95 | <.03 | 188 | <1 | 8 | <1 | <1 | <1 | <1 | 3 | 110 | 24 | 76 | <1 | <1 | <1 | <1 | 100 |
| 09/10/96 | 09/17/96 | 1.33 | <.03 | 68 | <1 | 3 | <1 | <1 | <1 | <1 | 1 | 56 | 4 | 13 | <1 | <1 | <1 | <1 | 10 |
| 09/17/96 | 09/24/96 | -- | -- | 94 | <1 | 3 | <1 | <1 | <1 | <1 | 2 | 44 | 4 | 27 | <1 | <1 | <1 | <1 | 25 |
| 09/24/96 | 10/01/96 | 2.30 | <.03 | 20 | <1 | 2 | <1 | <1 | <1 | <1 | <1 | 10 | 1 | 4 | <1 | <1 | <1 | <1 | 5 |
| 10/01/96 | 10/08/96 | -- | -- | 74 | <1 | 5 | <1 | <1 | <1 | <1 | <1 | 35 | 1 | 10 | <1 | <1 | <1 | <1 | 6 |
| 10/08/96 | 10/22/96 | 1.20 | <.03 | 251 | <1 | 4 | <1 | <1 | <1 | <1 | 2 | 270 | 10 | 31 | <1 | <1 | <1 | <1 | 9 |
| 10/22/96 | 10/29/96 | 2.04 | <.03 | 42 | <1 | 6 | <1 | <1 | <1 | <1 | 3 | 29 | <1 | 6 | <1 | <1 | <1 | <1 | 8 |
| 10/29/96 | 11/05/96 | 1.33 | <.03 | 19 | <1 | 1 | <1 | <1 | <1 | <1 | 3 | 14 | <1 | 4 | <1 | <1 | <1 | <1 | 5 |
| 11/05/96 | 11/12/96 | 1.82 | <.03 | 53 | <1 | 3 | <1 | <1 | <1 | <1 | 2 | 54 | 3 | 12 | <1 | <1 | <1 | <1 | 17 |

Reported Concentrations 41

Table 6. Reported concentrations for laboratory quality-control samples

[ICAP, sample analyzed by inductively coupled argon plasma atomic emission spectroscopy; FAAS, sample analyzed by flame atomic absorption spectroscopy; IC, sample analyzed by ion chromatography; ICAP/MS, sample analyzed by inductively coupled argon plasma mass spectroscopy; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; --, not analyzed; SRWS, standard reference water sample; < , concentration reported less than the method reporting limit]

| Date | Sample type | Specific conductance ($\mu\text{S}/\text{cm}$) | pH (standard units) | Calcium (ICAP) (mg/L) | Magnesium (ICAP) (mg/L) | Sodium (ICAP) (mg/L) | Potassium (FAAS) (mg/L) | Sulfate (IC) (mg/L) | Chloride (IC) (mg/L) | Fluoride (IC) (mg/L) | Bromide (IC) (mg/L) | Silica (ICAP) (mg/L) | Nitrate (IC) (mg/L) | Phosphate (IC) (mg/L) |
|----------|-------------|--|---------------------|-----------------------|-------------------------|----------------------|-------------------------|---------------------|----------------------|----------------------|---------------------|----------------------|---------------------|-----------------------|
| 03/13/96 | Blank | 0.9 | 5.50 | <0.02 | <0.01 | <0.2 | <0.01 | <0.01 | <0.01 | 0.05 | <0.01 | 0.03 | <0.04 | <0.03 |
| 03/13/96 | SRWS (T123) | -- | -- | 9.00 | 1.80 | 19.0 | 1.20 | -- | -- | -- | -- | -- | -- | -- |
| 03/13/96 | SRWS (P23) | 13.7 | 6.40 | -- | -- | -- | -- | 1.40 | .26 | .13 | <.01 | 6.20 | 1.15 | .34 |
| 08/08/96 | Blank | .6 | 6.21 | <.02 | <.01 | <.2 | <.01 | <.01 | <.01 | <.01 | <.01 | .05 | <.04 | <.03 |
| 08/08/96 | SRWS (T123) | -- | -- | 9.00 | 1.80 | 19.0 | 1.10 | -- | -- | -- | -- | -- | -- | -- |
| 08/08/96 | SRWS (P23) | 13.8 | 6.41 | -- | -- | -- | -- | 1.30 | .21 | .14 | <.01 | 6.00 | <.04 | .15 |
| 09/12/96 | Blank | .6 | 6.32 | <.02 | <.01 | <.2 | <.01 | <.01 | <.01 | <.01 | <.01 | .05 | <.04 | <.03 |
| 09/12/96 | SRWS (T123) | -- | -- | 9.00 | 1.80 | 19.0 | 1.10 | -- | -- | -- | -- | -- | -- | -- |
| 09/12/96 | SRWS (P23) | 13.5 | 6.41 | -- | -- | -- | -- | 1.30 | .21 | .14 | <.01 | 6.00 | <.04 | .22 |
| 02/28/97 | Blank | <1.0 | 6.06 | <.02 | <.01 | <.2 | .31 | <.01 | <.01 | <.01 | <.01 | .03 | <.04 | <.03 |
| 02/28/97 | SRWS (T123) | -- | -- | <.02 | <.01 | <.2 | 1.00 | -- | -- | -- | -- | -- | -- | -- |
| 02/28/97 | SRWS (P23) | 14.0 | 6.40 | -- | -- | -- | -- | 1.30 | .23 | .13 | <.01 | .03 | .62 | .28 |

Table 6. Reported concentrations for laboratory quality-control samples—Continued

| Date | Sample type | Aluminum (ICAP/ MS) (µg/L) | Antimony (ICAP/ MS) (µg/L) | Barium (ICAP/ MS) (µg/L) | Beryllium (ICAP/ MS) (µg/L) | Cadmium (ICAP/ MS) (µg/L) | Chromium (ICAP/ MS) (µg/L) | Cobalt (ICAP/ MS) (µg/L) | Copper (ICAP/ MS) (µg/L) | Iron (ICAP) (µg/L) | Lead (ICAP/ MS) (µg/L) | Manga- nese (ICAP/ MS) (µg/L) | Molyb- denum (ICAP/ MS) (µg/L) |
|----------|-------------|-------------------------------------|-------------------------------------|-----------------------------------|--------------------------------------|------------------------------------|-------------------------------------|-----------------------------------|-----------------------------------|--------------------------|---------------------------------|---|--|
| 03/13/96 | Blank | 2 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | 4 | <1 | <1 | <1 |
| 03/13/96 | SRWS (T123) | 8 | 7 | 7 | 9 | 6 | 10 | 5 | 10 | 59 | 9 | 13 | 9 |
| 03/13/96 | SRWS (P23) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 08/08/96 | Blank | 3 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <3 | <1 | <1 | <1 |
| 08/08/96 | SRWS (T123) | 8 | 7 | 7 | 8 | 6 | 10 | 5 | 11 | 56 | 10 | 13 | 9 |
| 08/08/96 | SRWS (P23) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 09/12/96 | Blank | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <3 | <1 | <1 | <1 |
| 09/12/96 | SRWS (T123) | 8 | 7 | 8 | 8 | 6 | 10 | 5 | 10 | 55 | 10 | 13 | 9 |
| 09/12/96 | SRWS (P23) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 02/28/97 | Blank | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <3 | <1 | <1 | <1 |
| 02/28/97 | SRWS (T123) | 7 | 7 | 7 | 8 | 6 | 10 | 5 | 10 | <3 | 10 | <1 | 8 |
| 02/28/97 | SRWS (P23) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Table 6. Reported concentrations for laboratory quality-control samples—Continued

| Date | Sample type | Nickel (ICAP/ MS) (µg/L) | Silver (ICAP/ MS) (µg/L) | Uranium (natural) (ICAP/ MS) (µg/L) | Zinc (ICAP/ MS) (µg/L) |
|----------|-------------|-----------------------------------|-----------------------------------|---|---------------------------------|
| 03/13/96 | Blank | <1 | <1 | <1 | <1 |
| 03/13/96 | SRWS (T123) | 4 | 2 | <1 | 5 |
| 03/13/96 | SRWS (P23) | -- | -- | -- | -- |
| 08/08/96 | Blank | <1 | <1 | <1 | <1 |
| 08/08/96 | SRWS (T123) | 4 | 1 | <1 | 5 |
| 08/08/96 | SRWS (P23) | -- | -- | -- | -- |
| 09/12/96 | Blank | <1 | <1 | <1 | <1 |
| 09/12/96 | SRWS (T123) | 4 | 1 | <1 | 5 |
| 09/12/96 | SRWS (P23) | -- | -- | -- | -- |
| 02/28/97 | Blank | <1 | <1 | <1 | <1 |
| 02/28/97 | SRWS (T123) | 4 | 1 | <1 | 4 |
| 02/28/97 | SRWS (P23) | -- | -- | -- | -- |

Table 7. Reported concentrations for field quality-control samples processed at the Gary (Indiana) Regional Airport

[ICAP, sample analyzed by inductively coupled argon plasma atomic emission spectroscopy; FAAS, sample analyzed by flame atomic absorption spectroscopy; IC, sample analyzed by ion chromatography; ICAP/MS, sample analyzed by inductively coupled argon plasma mass spectroscopy; $\mu\text{S}/\text{cm}$, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; $\mu\text{g}/\text{L}$, micrograms per liter; --, not analyzed; DIW, deionized water; <, concentration reported less than the method reporting limit]

| Date on | Time on (24-hour time) | Date off | Time off | Sample type | Sample matrix | Specific conductance ($\mu\text{S}/\text{cm}$) | pH (standard units) | Calcium (ICAP) (mg/L) | Magnesium (ICAP) (mg/L) | Sodium (ICAP) (mg/L) | Potassium (FAAS) (mg/L) | Sulfate (IC) (mg/L) |
|----------|------------------------|----------|----------|--------------|---------------|--|---------------------|-----------------------|-------------------------|----------------------|-------------------------|---------------------|
| 10/17/95 | 1530 | 10/17/95 | 1531 | Funnel Rinse | Acidified DIW | 18.9 | 4.46 | 0.05 | 0.01 | <0.2 | <0.01 | <0.01 |
| 10/24/95 | 1531 | 10/31/95 | 0936 | Split | Natural | 46.8 | 4.23 | 1.80 | .27 | <.2 | .21 | 4.10 |
| 11/28/95 | 1400 | 12/05/95 | 1200 | System Blank | Acidified DIW | 16.6 | 4.44 | .06 | .01 | <.2 | <.01 | .07 |
| 12/05/95 | 1200 | 12/05/95 | 1201 | Funnel Rinse | Acidified DIW | 29.2 | 4.21 | .03 | <.01 | <.2 | <.01 | <.01 |
| 12/05/95 | 1215 | 12/12/95 | 1000 | System Blank | Acidified DIW | 12.6 | 4.97 | .52 | .17 | .5 | .02 | .30 |
| 01/23/96 | 1050 | 01/23/96 | 1051 | Funnel Rinse | Acidified DIW | 15.5 | 4.48 | .03 | <.01 | <.2 | <.01 | <.01 |
| 01/30/96 | 1050 | 02/06/96 | 1105 | System Blank | Acidified DIW | 15.9 | 4.43 | .04 | .01 | <.2 | <.01 | <.01 |
| 03/05/96 | 1000 | 03/12/96 | 1030 | System Blank | Acidified DIW | 15.1 | 4.50 | .11 | .02 | <.2 | <.01 | .09 |
| 03/12/96 | 1045 | 03/19/96 | 1210 | System Blank | Acidified DIW | 21.7 | 4.55 | .47 | .07 | <.2 | .02 | .34 |
| 04/02/96 | 1040 | 04/09/96 | 1030 | System Blank | Acidified DIW | 14.3 | 4.47 | .10 | .02 | <.2 | <.01 | .15 |
| 04/09/96 | 1056 | 04/16/96 | 1046 | Split | Natural | 26.9 | 6.64 | 3.00 | .41 | .2 | .10 | 4.7 |
| 06/25/96 | 1130 | 06/25/96 | 1131 | Funnel Rinse | Acidified DIW | 13.5 | 4.14 | <.02 | <.01 | <.2 | <.01 | <.01 |
| 07/02/96 | 0900 | 07/09/96 | 0901 | System Blank | Acidified DIW | 13.2 | 4.54 | <.02 | <.01 | <.2 | <.01 | <.01 |
| 07/09/96 | 0930 | 07/16/96 | 1115 | System Blank | Acidified DIW | 13.1 | 4.55 | .17 | .04 | <.2 | .01 | .26 |
| 08/06/96 | 0941 | 08/13/96 | 1021 | Split | Natural | 19.4 | 4.65 | .61 | .12 | <.2 | .02 | 2.6 |
| 08/20/96 | 1240 | 08/20/96 | 1241 | Funnel Rinse | Acidified DIW | 13.2 | 4.53 | <.02 | <.01 | <.2 | <.01 | <.01 |
| 08/27/96 | 0940 | 09/03/96 | 0941 | System Blank | Acidified DIW | 22.1 | 4.47 | <.02 | <.01 | <.2 | <.01 | <.01 |
| 11/05/96 | 1221 | 11/12/96 | 1126 | Split | Natural | 18.9 | 5.14 | .88 | .13 | <.2 | .05 | 3.3 |
| 02/28/97 | 1200 | 02/28/97 | 1201 | Funnel Rinse | Acidified DIW | 8.0 | 4.53 | <.02 | <.01 | <.2 | .04 | <.01 |

Table 7. Reported concentrations for field quality-control samples processed at the Gary (Indiana) Regional Airport—Continued

| Date | Sample type | Sample matrix | Chloride (IC) (mg/L) | Fluoride (IC) (mg/L) | Bromide (IC) (mg/L) | Silica (ICAP) (mg/L) | Nitrate (IC) (mg/L) | Phosphate (IC) (mg/L) | Aluminum (ICP/MS) (µg/L) | Antimony (ICP/MS) (µg/L) | Barium (ICP/MS) (µg/L) | Beryllium (ICP/MS) (µg/L) | Cadmium (ICP/MS) (µg/L) |
|----------|--------------|---------------|----------------------|----------------------|---------------------|----------------------|---------------------|-----------------------|--------------------------|--------------------------|------------------------|---------------------------|-------------------------|
| 10/17/95 | Funnel Rinse | Acidified DIW | 0.03 | <0.01 | <0.01 | 0.07 | 3.41 | <0.03 | 32 | <1 | <1 | <1 | <1 |
| 10/24/95 | Split | Natural | .40 | .08 | <.01 | .82 | 7.97 | .09 | 120 | <1 | 3 | <1 | <1 |
| 11/28/95 | System Blank | Acidified DIW | .14 | <.01 | <.01 | .06 | 2.66 | <.03 | 9 | <1 | <1 | <1 | <1 |
| 12/05/95 | Funnel Rinse | Acidified DIW | 1.30 | .01 | <.01 | .06 | 2.48 | <.03 | 18 | <1 | <1 | <1 | <1 |
| 12/05/95 | System Blank | Acidified DIW | .85 | <.01 | <.01 | .17 | 2.48 | <.03 | 45 | <1 | 2 | <1 | <1 |
| 01/23/96 | Funnel Rinse | Acidified DIW | .07 | .02 | <.01 | .03 | 2.35 | <.03 | 5 | <1 | <1 | <1 | <1 |
| 01/30/96 | System Blank | Acidified DIW | .13 | <.01 | <.01 | .06 | 2.39 | <.03 | 12 | <1 | <1 | <1 | <1 |
| 03/05/96 | System Blank | Acidified DIW | .08 | <.01 | <.01 | .08 | 2.43 | <.03 | 14 | <1 | <1 | <1 | <1 |
| 03/12/96 | System Blank | Acidified DIW | .09 | <.01 | <.01 | .23 | 4.43 | <.03 | 69 | <1 | <1 | <1 | <1 |
| 04/02/96 | System Blank | Acidified DIW | .02 | <.01 | <.01 | .09 | 2.30 | <.03 | 11 | <1 | <1 | <1 | <1 |
| 04/09/96 | Split | Natural | .21 | .03 | <.01 | .87 | 3.19 | <.03 | 191 | <1 | 11 | <1 | <1 |
| 06/25/96 | Funnel Rinse | Acidified DIW | <.01 | <.01 | <.01 | .03 | 2.04 | <.03 | 4 | <1 | <1 | <1 | <1 |
| 07/02/96 | System Blank | Acidified DIW | <.01 | <.01 | <.01 | .03 | 1.99 | <.03 | <1 | <1 | <1 | <1 | <1 |
| 07/09/96 | System Blank | Acidified DIW | <.01 | .03 | <.01 | .11 | 2.17 | <.03 | 21 | <1 | <1 | <1 | <1 |
| 08/06/96 | Split | Natural | .11 | .04 | <.01 | .11 | 2.17 | <.03 | 37 | <1 | 3 | <1 | <1 |
| 08/20/96 | Funnel Rinse | Acidified DIW | <.01 | .02 | <.01 | .09 | 2.21 | <.03 | 18 | <1 | <1 | <1 | <1 |
| 08/27/96 | System Blank | Acidified DIW | <.01 | <.01 | <.01 | .08 | 3.54 | <.03 | 12 | <1 | <1 | <1 | <1 |
| 11/05/96 | Split | Natural | .32 | .03 | <.01 | .19 | 1.86 | <.03 | 54 | <1 | 3 | <1 | <1 |
| 02/28/97 | Funnel Rinse | Acidified DIW | <.01 | <.01 | <.01 | .05 | 2.04 | <.03 | <1 | <1 | <1 | <1 | <1 |

Table 7. Reported concentrations for field quality-control samples processed at the Gary (Indiana) Regional Airport–Continued

| Date | Sample type | Sample matrix | Chromium (ICP/ MS) (µg/L) | Cobalt (ICP/ MS) (µg/L) | Copper (ICP/ MS) (µg/L) | Iron (ICAP) (µg/L) | Lead (ICP/ MS) (µg/L) | Manga- nese (ICP/ MS) (µg/L) | Molyb- denum (ICP/ MS) (µg/L) | Nickel (ICP/ MS) (µg/L) | Silver (ICP/ MS) (µg/L) | Uranium (natural) (ICP/ MS) (µg/L) | Zinc (ICP/ MS) (µg/L) |
|----------|--------------|---------------|------------------------------------|----------------------------------|----------------------------------|--------------------------|--------------------------------|--|---|----------------------------------|----------------------------------|--|--------------------------------|
| 10/17/95 | Funnel Rinse | Acidified DIW | 1 | <1 | <1 | 19 | <1 | 3 | <1 | <1 | <1 | <1 | 17 |
| 10/24/95 | Split | Natural | 2 | <1 | 1 | 230 | 20 | 48 | 1 | <1 | <1 | <1 | 37 |
| 11/28/95 | System Blank | Acidified DIW | <1 | <1 | <1 | 7 | <1 | <1 | <1 | <1 | <1 | <1 | 10 |
| 12/05/95 | Funnel Rinse | Acidified DIW | <1 | <1 | 1 | 42 | <1 | 1 | <1 | <1 | <1 | <1 | 14 |
| 12/05/95 | System Blank | Acidified DIW | <1 | <1 | 3 | 37 | 3 | 8 | <1 | <1 | <1 | <1 | 11 |
| 01/23/96 | Funnel Rinse | Acidified DIW | <1 | <1 | 1 | 5 | <1 | <1 | <1 | <1 | <1 | <1 | 5 |
| 01/30/96 | System Blank | Acidified DIW | <1 | <1 | <1 | 8 | <1 | <1 | <1 | <1 | <1 | <1 | 13 |
| 03/05/96 | System Blank | Acidified DIW | <1 | <1 | <1 | 12 | <1 | <1 | <1 | <1 | <1 | <1 | 3 |
| 03/12/96 | System Blank | Acidified DIW | <1 | <1 | <1 | 34 | 1 | 7 | <1 | <1 | <1 | <1 | 7 |
| 04/02/96 | System Blank | Acidified DIW | <1 | <1 | <1 | 8 | <1 | 1 | <1 | <1 | <1 | <1 | 3 |
| 04/09/96 | Split | Natural | <1 | <1 | 2 | 120 | 3 | 38 | <1 | <1 | <1 | <1 | 14 |
| 06/25/96 | Funnel Rinse | Acidified DIW | <1 | <1 | <1 | <3 | <1 | <1 | <1 | <1 | <1 | <1 | 2 |
| 07/02/96 | System Blank | Acidified DIW | <1 | <1 | <1 | <3 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 07/09/96 | System Blank | Acidified DIW | <1 | <1 | <1 | 10 | <1 | 2 | <1 | <1 | <1 | <1 | <1 |
| 08/06/96 | Split | Natural | <1 | <1 | 1 | 31 | 1 | 5 | <1 | <1 | <1 | <1 | 6 |
| 08/20/96 | Funnel Rinse | Acidified DIW | <1 | <1 | <1 | <3 | <1 | <1 | <1 | <1 | <1 | <1 | 2 |
| 08/27/96 | System Blank | System Blank | <1 | <1 | <1 | 4 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 11/05/96 | Split | Natural | <1 | <1 | 2 | 53 | 3 | 12 | <1 | <1 | <1 | <1 | 18 |
| 02/28/97 | Funnel Rinse | Acidified DIW | <1 | <1 | <1 | <3 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |