SURFACE-WATER QUALITY OF THE CEDAR RIVER BASIN, IOWA-MINNESOTA, WITH EMPHASIS ON THE OCCURRENCE AND TRANSPORT OF HERBICIDES, MAY 1984 THROUGH NOVEMBER 1985

By Paul J. Squillace and Richard A. Engberg

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CONVERSION FACTORS

For readers who prefer to use metric (International System) units, conversion factors for inch-pound units used in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
feet (ft)	0.3048	meter
mile (mi)	1.609	kilometer
acre	4.047	square meter
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile [$(ft^3/s)/mi^2$]		
million gallons per year (Mgal/yr)	0.0001200	cubic meter per second
pound (lb)	0.4536	kilogram
ton, short	0.9072	megagram

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ABSTRACT

The surface-water quality in the Cedar River basin was evaluated by analyzing the occurrence, distribution, and transport of common inorganic constituents and selected trace inorganic and organic constituents, with emphasis on herbicides. The surface-water quality of the Cedar River basin was monitored from May 1984 through November 1985. Depth integrated surface-water samples generally were collected monthly at six stations for a considerable range of river discharge. Samples were analyzed for concentrations of common inorganic constituents in the dissolved phase and for concentrations of primary nutrients, trace elements, organic carbon, and herbicides in the dissolved and the dissolved plus suspended phases.

Water in the Cedar River was determined to be a calcium bicarbonate type; suspended-sediment concentrations ranged from 3 to 676 milligrams per liter. Concentrations of dissolved fluoride, dissolved nitrite plus nitrate, dissolved arsenic, dissolved lead, and dissolved mercury were less than those of the U.S. Environmental Protection Agency's drinking-water standards for public water supplies.

Generally, herbicides were detected only in the dissolved phase, which indicates that herbicides are not being adsorbed on the suspended sediment. However, the lack of detection of adsorbed herbicides also may indicate a need for re-examination of traditionally acceptable methods of treating water samples at the sampling site, separating sediment and water, and extracting organic compounds from sediment. The largest concentrations of several dissolved herbicides were detected after application on agricultural areas in the spring and early summer in both wet and dry periods. However, dissolved atrazine concentrations also increased in the winter during periods of high streamflow resulting from snow melt. The maximum concentration of dissolved herbicides detected at all sampling sites during the study were: alachlor, 21 micrograms per liter; atrazine, 16 micrograms per liter; cyanazine, 8.7 micrograms per liter; metolachlor, 11.0 micrograms per liter; and metribuzin, 3.0 micrograms per liter.

Herbicides can be transported from agricultural areas to the river by overland flow, drainage from agricultural areas conveyed by tile drains, and ground water. Hydrograph separation for 10 locations in the Cedar River basin indicates that the ground-water contribution varies within the basin and probably ranges from 56 to 80 percent of the annual river discharge. The predominance of ground-water contribution, the persistent detection of dissolved atrazine even during base flow, and the variety of dissolved herbicides detected in the river during the dry spring of 1985 indicate that some herbicides are being transported to the river by ground water. Atrazine transported to the Cedar River was estimated to be about 1.4 to 4.0 percent of that applied, depending on the assumed application rate. The large river discharge in June 1984, which was predominantly overland flow, contained about 70 percent of the atrazine transported to the river during 1984.

INTRODUCTION

The water quality of rivers is dynamic and is affected by natural factors, such as topography and geology. Furthermore, human activity factors, such as land use, water use, and population distribution within river basins, also can affect the water quality. The Cedar River basin, an area of 7,819 mi^2 in northeastern Iowa and southern Minnesota, generally typifies most river basins in Iowa. Land use in the basin is principally agricultural, but the basin contains several metropolitan areas, including two cities with more than 100,000 persons. These metropolitan areas are sources of municipal and industrial wastewater that enters the river. Likewise, agricultural chemicals, such as herbicides and fertilizers, can be transported from agricultural areas to the Cedar River. These chemicals can be transported by overland flow (water moving over the surface of the land), discharge from agricultural areas conveyed by tile drains, and ground water. Some of the chemical constituents may be transported in the dissolved phase or in the suspended phase (particulate or adsorbed on suspended sediment). The origin of this suspended sediment may be stream beds, stream banks, or the land surface.

Because of the increased concern of Iowans about trace constituents in rivers, the U.S. Geological Survey, in cooperation with the University of Iowa Hygienic Laboratory, began a study of the surface-water quality in the Cedar River basin in 1984. This study included analyses of surface-water samples for principal inorganic constituents in the dissolved phase as well as for selected nutrients, trace elements, and organic compounds, primarily herbicides, in the dissolved and the dissolved plus suspended phases.

Purpose and Scope

This report describes the results of a study to evaluate the water quality in the Cedar River by analyzing the occurrence, distribution, and transportation of selected trace inorganic and organic constituents, with an emphasis on herbicides. Transportation of these constituents partially was evaluated by comparing quantities of these constituents transported in solution to those transported in the suspended phase. Samples were collected at selected sites in the Cedar River basin during a 19-month period over a considerable range of river discharges.

Description of Study Area

The bedrock underlying the Cedar River basin consists of dolomite, limestone, and lesser quantities of shale, which generally are covered by a layer of glacial drift (fig. 1). Bedrock predominately consist of Devonian limestone and dolomite; however, small quantities of Silurian dolomitic rock also are present. Nearly all of the basin is covered by glacial drift. Some headwater reaches of the primary tributaries are in the Wisconsin Cary drift, also known as the Des Moines Lobe. The glacial drift ranges in thickness from 0 to 400 ft; the glacial drift is thickest in buried valleys (D.R. Soller, U.S. Geological Survey, written commun., 1986). Glacial drift is less than 50 ft thick in most of the basin north of Waterloo (D.R. Soller, written commun., 1986).

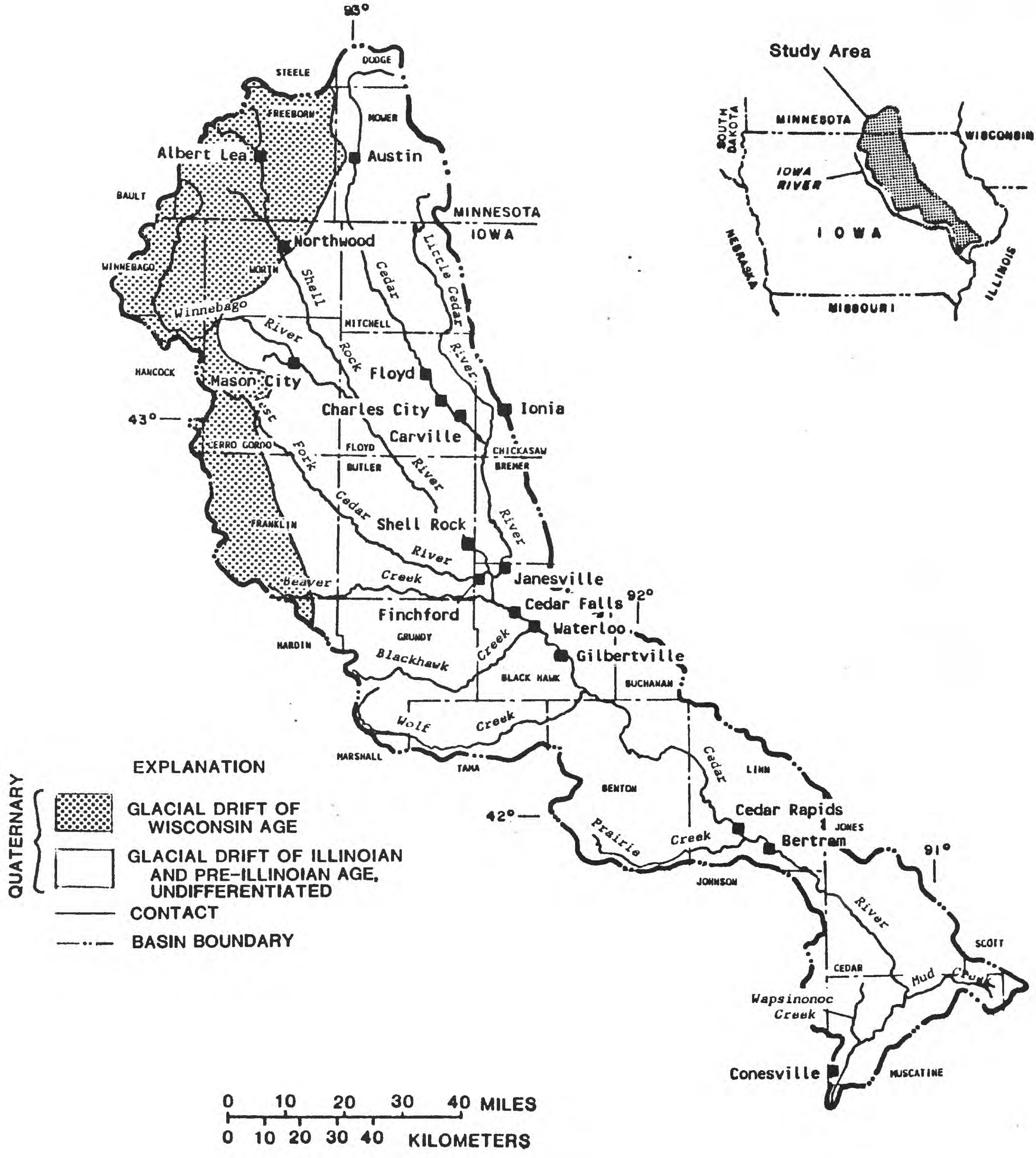


Figure 1.--Glacial drift in the study area (modified from Anderson, 1983, p. 221 and 225).

Acknowledgments

Water samples for this investigation were analyzed by the University of Iowa Hygienic Laboratory in Iowa City and Des Moines, Iowa. Our thanks to their staff for their efforts, cooperation, and support.

PRECIPITATION

Normal annual precipitation in the basin ranges from 30 to 33 in., but can vary considerably (Waite, 1969, p. 4). The southern part of the Cedar River basin normally receives the greatest annual precipitation.

SURFACE-WATER HYDROLOGY

The Cedar River is the largest tributary to the Iowa River. The average discharge of the Cedar River near the junction with the Iowa River is about 4,800 ft^3/s and actually exceeds the average discharge of the Iowa River, 2,900 ft^3/s, near the junction (Miller and others, 1984, p. 63 and p. 76). The total drainage area for the Cedar River is 7,819 mi^2 and extends into southern Minnesota (fig. 2). The primary tributaries of the Cedar River are in the northwestern one-half of the basin. Downstream from Cedar Falls, only five tributaries have drainage areas that exceed 200 mi^2 and none exceed 400 mi^2 (Schwob, 1963, p. 2).

The quantity of runoff that is produced from a single storm varies substantially with topography in the Cedar River basin. Upstream from Northwood, in the flat area within the Cary drift, runoff can be as much as 30 $(ft^3/s)/mi^2$. In the rest of the Cedar River basin, runoff can be as much as 129 $(ft^3/s)/mi^2$ (Lara, 1987). Flood runoff predominantly consists of overland flow and, to a lesser extent, drainage from agricultural areas conveyed by tile drains and ground water.

An estimate of ground-water contribution to river discharge was calculated for various locations in the Cedar River basin and was determined to range from 56 to 80 percent of the total annual river discharge (fig. 3). A modified version of the computer program by Pettyjohn and Henning (1979) was used to calculate ground-water contribution. This program analyzed river hydrographs for the 1985 water year (October 1, 1984, to September 30, 1985) using three methods of hydrograph separation: local minimum, fixed interval, and sliding interval. The results of the hydrograph separation for 10 locations within the basin are reported as an estimated range of ground-water contribution. Results indicate that ground-water contribution can vary substantially within the Cedar River basin. Some of this variation may be because of the method of hydrograph separation, poorly developed surface drainage systems, or can represent actual differences in the quantity of ground-water contribution.

The ground-water contribution to the river discharge may vary because of overburden, geology, topography, or the presence of buried valleys and tile drains. For instance, the quantity of overland flow in the basin upstream from Northwood is less than 20 percent while ground-water contribution may be as much as 80 percent of the stream discharge (fig. 3). The separation of overland flow from ground-water flow at Northwood is more complicated because of the poorly developed surface-drainage system that has resulted in numerous lakes and swamps. Furthermore, in this same area, discharge from tile drains may provide

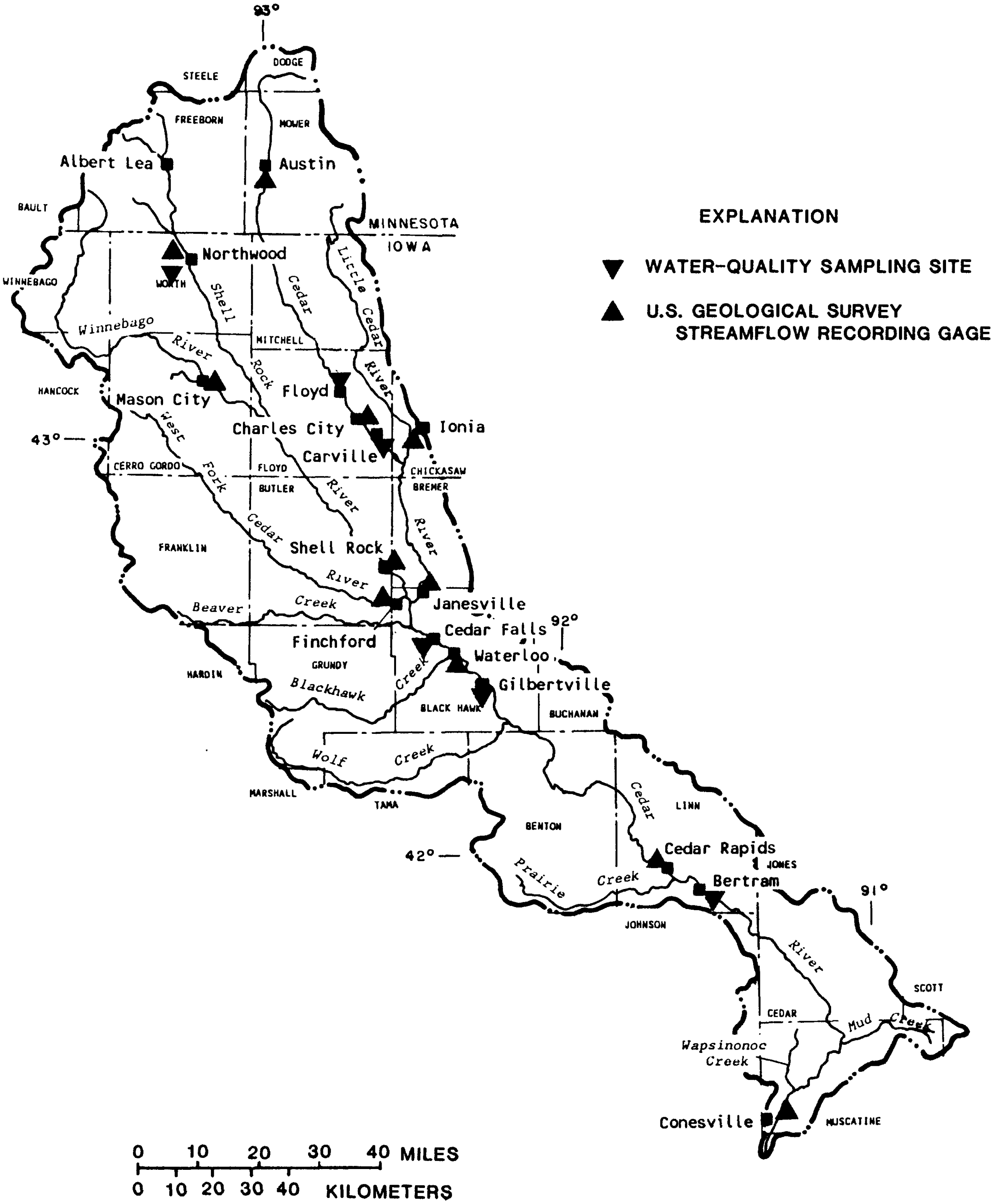
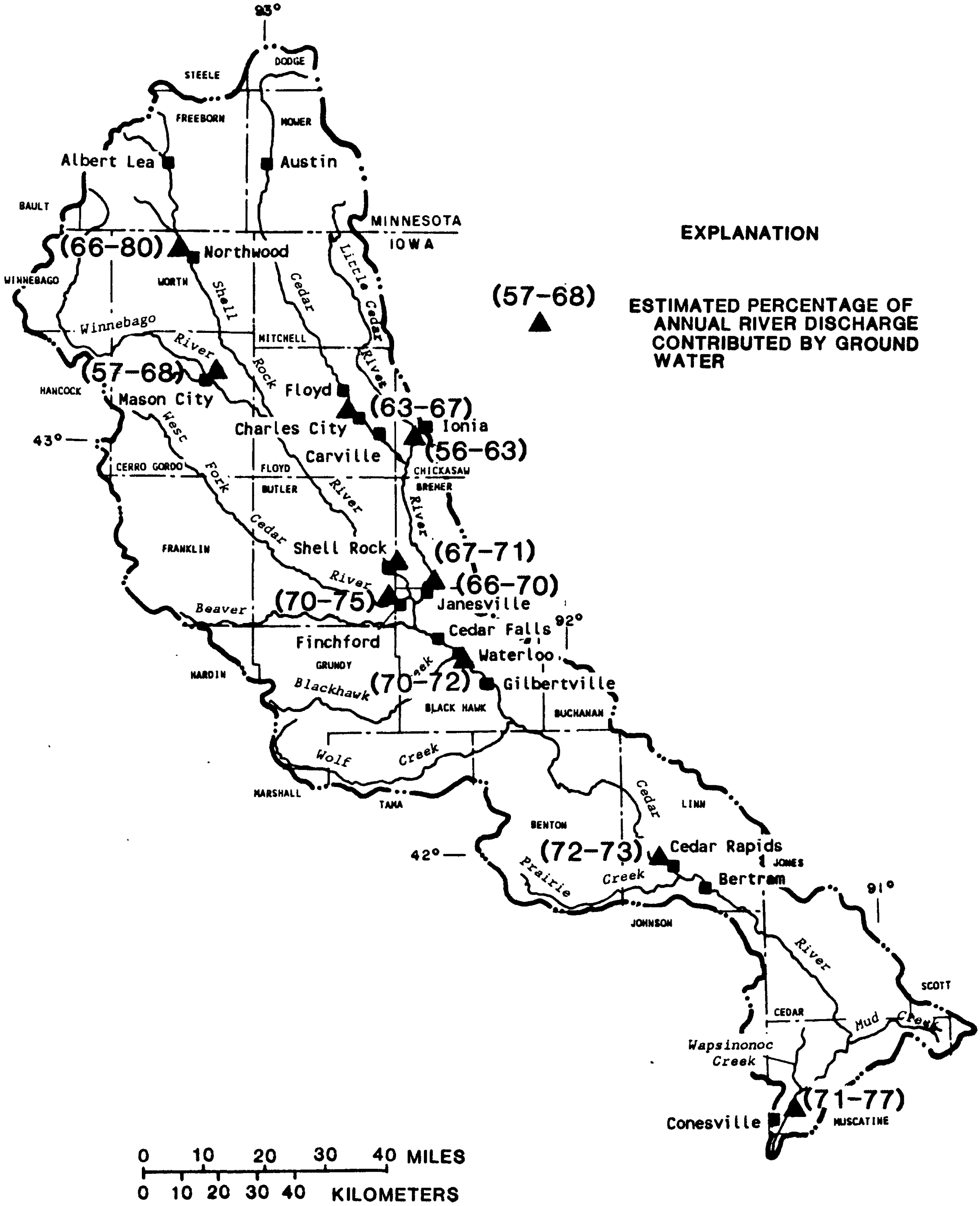


Figure 2.--Location of water-quality sampling sites and U.S. Geological Survey streamflow recording gages.



EXPLANATION

(57-68) ▲ ESTIMATED PERCENTAGE OF ANNUAL RIVER DISCHARGE CONTRIBUTED BY GROUND WATER

Figure 3.—Estimated range of ground-water contribution to annual river discharge, October 1, 1984, through September 30, 1985.

a large quantity of the ground-water contribution. The separation of tile-drain discharge flow from overland flow and ground-water discharge is difficult and can affect the calculations. Drainage tile is installed at a depth of 3 to 5 ft to decrease the water table in the soil horizon. The drainage tile intercepts some recharge to the deeper aquifers. During a summer when precipitation is greater than average, discharge from tile drains can continue during the entire summer.

LAND AND WATER USE

Land use in the basin consists of 81 percent crop land, 7 percent pasture, and 12 percent forest and urban (U.S. Department of Agriculture, 1976, p. 18). Corn and soybeans are the principal grain crops and are grown on more than 60 percent of the cropland (U.S. Department of Agriculture, 1976, p. 16).

U.S. Geological Survey records of estimated and reported water use for 1985 indicate municipal suppliers of water for domestic and industrial uses provide about 22,000 Mgal/yr, almost all of which is from ground water (fig. 4). The principal water users in the Cedar River basin and the quantity contributed by ground water and surface water also are shown in figure 4. Estimated nonirrigation agricultural water use is 10,000 Mgal/yr, about 75 percent from ground water. Self- and public-supplied water for industrial and domestic uses is about 6,400 Mgal/yr, which is about 40 percent surface water and 60 percent ground water. Domestic use, self- and public-supplied, is about 3,500 Mgal/yr, which is almost entirely ground water.

DATA COLLECTION

Water samples were collected at six sites in the Cedar River basin (fig. 2) from May 1984 through November 1985. Sampling sites were located upstream and downstream from the metropolitan areas of Charles City and Waterloo to document water-quality changes because of industry or other urban-related effects. Sampling sites at Floyd and Carville are upstream and downstream from Charles City. The upstream sampling site is at the bridge on U.S. Highway 218 in the city of Floyd; the downstream sampling site is at the bridge on County Road B-59 about 1 mi west of Carville. Sampling sites at Cedar Falls and Gilbertville are upstream and downstream from Waterloo. The upstream sampling site is at the bridge on U.S. Highway 20 in Cedar Falls; the downstream sampling site is at the bridge on County Highway D-38 in Gilbertville. Downstream from Cedar Rapids, the fifth site is located 1.5 mi south of Bertram at the bridge on U.S. Highway 30. The sixth site is located on the Shell Rock River about 2 mi south of Northwood at the bridge on County Highway A 27 at the U.S. Geological Survey gaging station. Samples were collected approximately monthly at each site. For a normal sampling period, all sites were visited in 3 days from upstream to downstream. During the last 2 months of the study, samples were not collected at the sites in Floyd and Cedar Falls.

Depth integrated water samples were collected over a considerable range of streamflow conditions. Because discharge can greatly affect water quality, an effort was made to sample the rivers from base flow to flood conditions. The flow-duration curve for the Cedar River at Cedar Rapids for discharge from water years 1943 through 1980 is shown in figure 5. The instantaneous discharge at the Bertram sampling site during the study also is shown. Samples for organic analysis were depth integrated from only the deepest point in the river channel, whereas the remaining water-quality samples were a composite of depth integrated samples collected at 15 to 20 equal distant stations across the river.

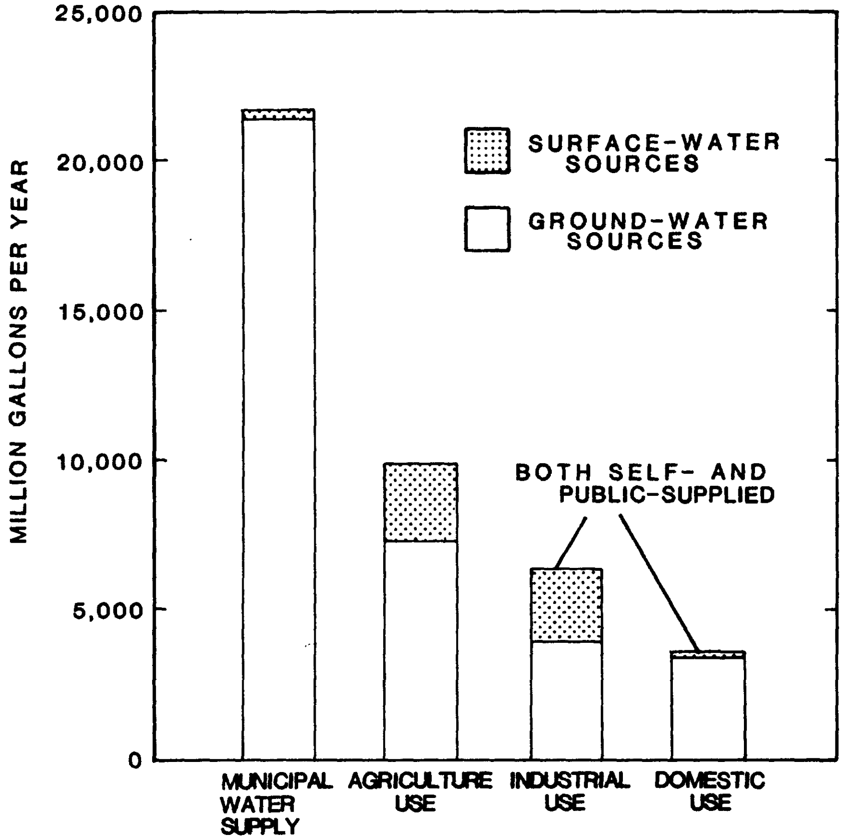


Figure 4.--Water supply and use, 1985.

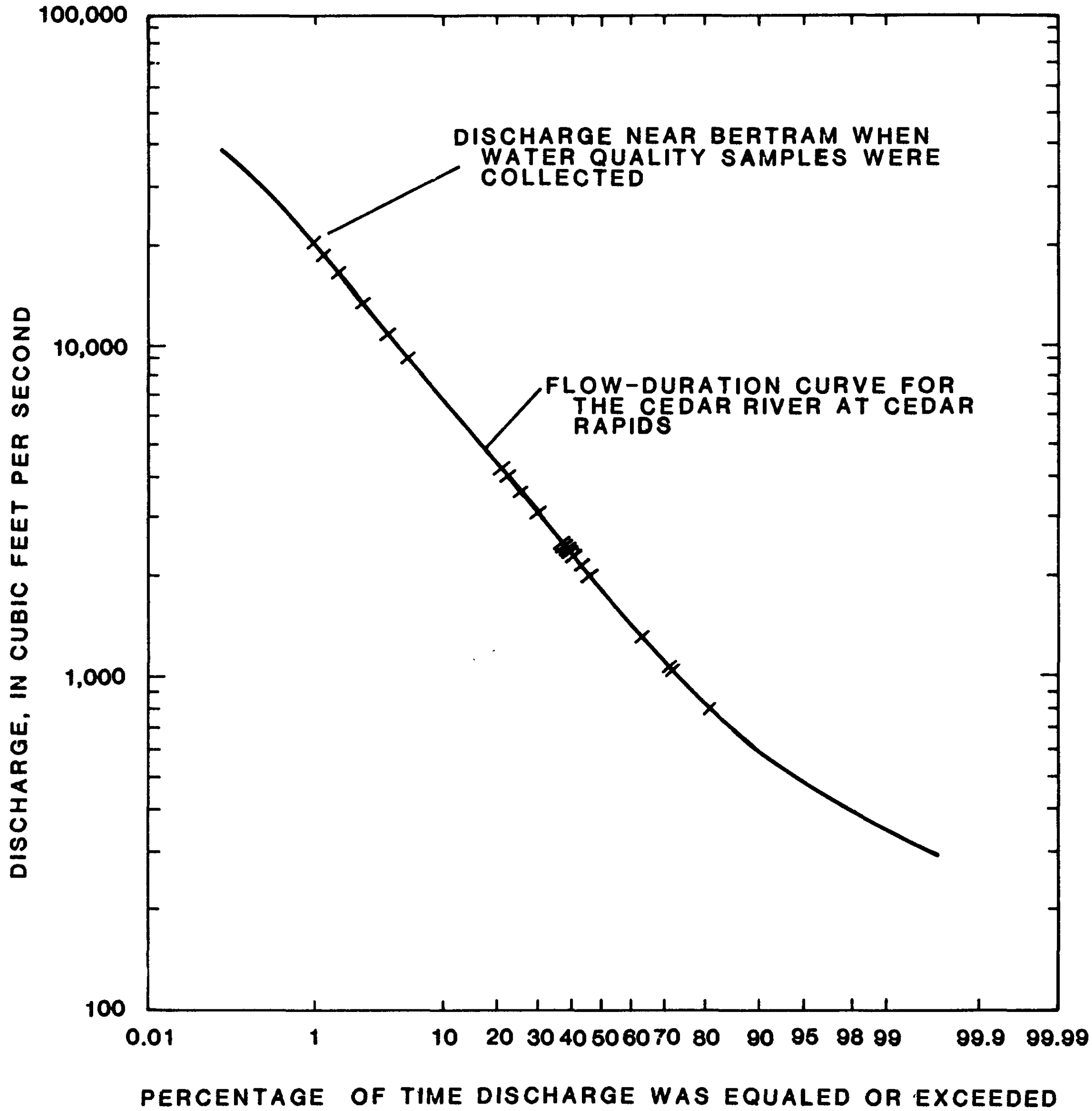


Figure 5.--Flow-duration curve for the Cedar River at Cedar Rapids, water years 1943-80, and discharge at the sampling site near Bertram, May 1984 through November 1985.

Discharge at each sampling site was estimated from recorded discharge at four U.S. Geological Survey gaging stations near Northwood, Charles City, Waterloo, and Cedar Rapids (fig. 2). The difference in the size of the drainage basin from each gaging station to the nearby sampling site is about 5 percent. Based on this difference, the discharge at the sampling site was estimated to be either 5 percent greater or less than the discharge at the nearby gaging station. That is, if the sampling site is upstream from the gaging station, the stream discharge at the sampling site was estimated to be 5 percent less than at the gaging station; if the sampling site is downstream from the gaging station, the discharge at the sampling site is estimated to be 5 percent more than that at the gaging station.

Determinations of specific conductance, pH, temperature, and dissolved oxygen were made onsite in accordance with standard U.S. Geological Survey procedures (Skougstad and others, 1979). The separation of the sediment from the water sample was done by the University of Iowa Hygienic Laboratory by centrifugation. For herbicide determination, two sets of samples were collected. Analysis of a centrifuged water sample provided concentrations of dissolved herbicides, whereas analysis of a non-centrifuged sample provided concentrations of total-recoverable herbicides.

The U.S. Geological Survey's water-quality laboratory in Denver, Colorado, determined concentrations of suspended organic carbon, whereas the University of Iowa Hygienic Laboratory determined concentrations of the remaining constituents. The University of Iowa Hygienic Laboratory used methods described by the U.S. Environmental Protection Agency (1983) for the analyses of the inorganic and organic constituents. The extraction of herbicides from the samples was done using a solvent that consisted of 45 percent methylene chloride and 55 percent hexane. For analysis of herbicides, each sample was processed using two gas-chromatograph columns. The second column confirmed the presence of the herbicide; the average of the two concentrations was reported.

WATER QUALITY

Suspended Sediment

There is a significant correlation between stream discharge and suspended-sediment concentration ($r = 0.77$ to 92) when each sampling site is analyzed separately. There can be substantial changes in the suspended-sediment concentrations and loads (concentration multiplied by river discharge and converted to tons per day) in the Cedar River even during a normal 3-day sampling period. The suspended-sediment loads at the sites in Floyd, in Cedar Falls, and near Bertram from May 1984 through September 1985 are shown in figure 6. Generally, a substantial increase in suspended-sediment load between Cedar Falls and Bertram is not apparent. The lack of large tributaries between these two sampling sites apparently has resulted in only a small increase in suspended-sediment load, except when the river discharge is changing rapidly. The variable nature of the river discharge was demonstrated in December 1984 when suspended-sediment load near Bertram markedly deviated from the load in Cedar Falls. A warming trend during the 3-day sampling period caused snowmelt that substantially increased runoff and subsequently increased the streamflow and suspended-sediment load.

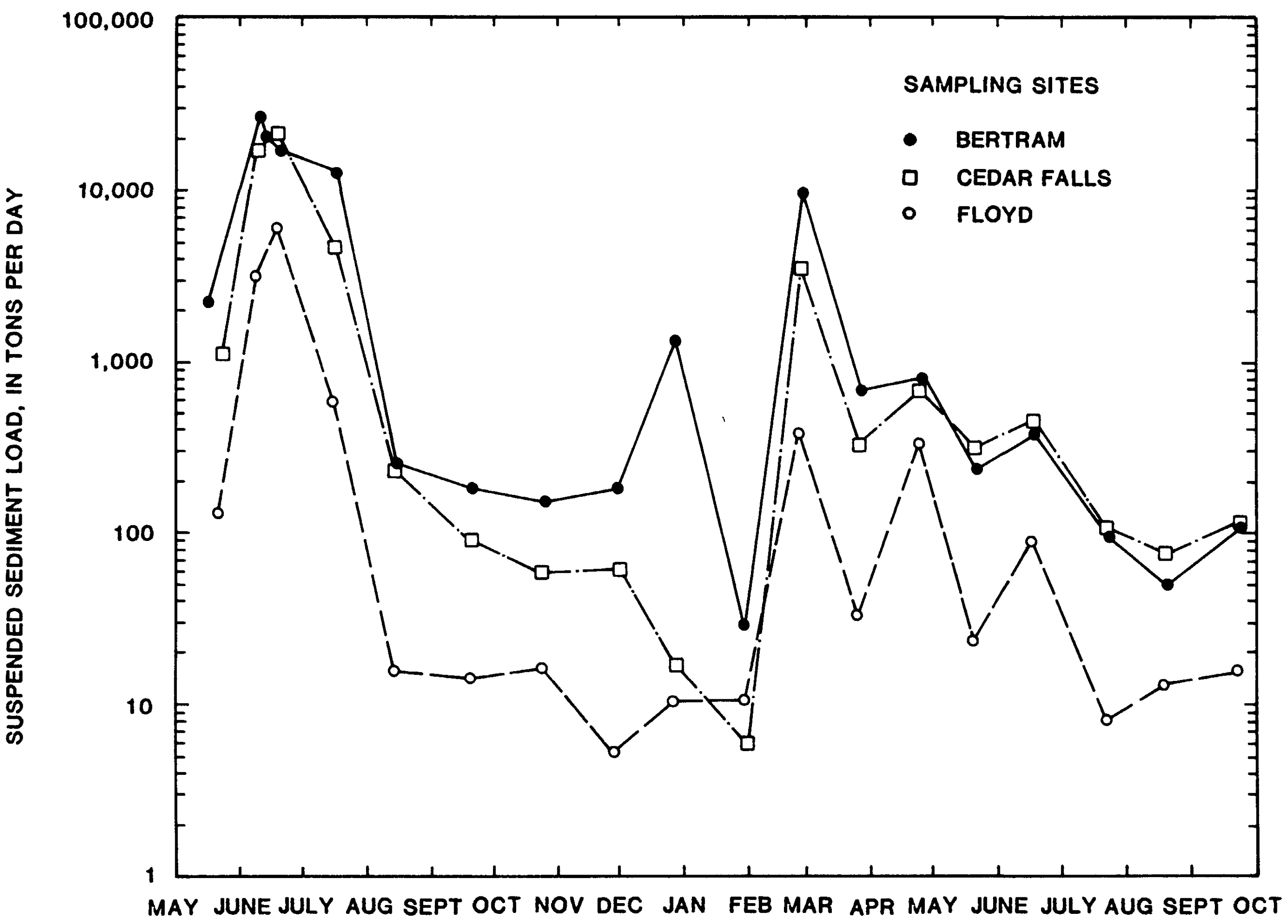


Figure 6.--Suspended-sediment load at three sampling sites, May 1984 through October 1985.

Results of particle-size analyis of the suspended sediment are listed in table 1 (at the back of the report). Generally, more than 90 percent of the suspended sediment is finer than 0.062 mm, which is the division between silt and sand established by the U.S. Geological Survey (Guy, 1973, p. 7). The predominance of small particles provides a larger surface area to adsorb trace-element ions or herbicides.

Inorganic Constituents

Occurrence and Distribution

Dissolved-solids concentrations normally were less than the secondary standard of 500 mg/L (milligrams per liter) for public water supplies established by the U.S. Environmental Protection Agency (1985b). The median concentration at each site generally was about 300 mg/L (fig. 7). At the sampling site near Northwood on the Shell Rock River, a maximum concentration of 563 mg/L was detected. At this sampling site, dissolved-solid concentrations are largest during base-flow conditions; however, this is not always the case for the sampling sites along the Cedar River.

Water in the Cedar River is a calcium bicarbonate type. Physical properties and chemical concentrations of the samples are included in tables 1 and 2 (at the back of the report). The average chemical composition of samples collected near Bertram from May 1984 through April 1985 is shown in figure 8. Statistical summaries of selected inorganic constituents at the sampling sites are shown in figures 7, 9, 10, and 11.

The statistical summaries (figs. 7, 9, 10, and 11) indicate the 25th-, 50th- (median), and 75th-percentile concentrations as well as the maximum and minimum concentrations of various constituents. The maximum and minimum concentrations define the detected range of occurrence of the constituents. The maximum and minimum constituent concentrations may represent extraordinary events or occasionally may indicate random errors in the data base. Although it is extremely useful to understand the significance of maximum and minimum concentrations for specific purposes of users, they are less significant for general knowledge of the range of the stream quality. When extreme concentrations are substantially greater than the 75th-percentile concentration, the 50th-percentile concentration may provide more useful information about typical constituent concentrations than does the mean concentration; the mean concentration may be affected by the extreme concentrations, whereas the 50th-percentile concentration is not.

The median dissolved-oxygen concentration of all samples is about 8.0 mg/L (fig. 7) and the median oxygen saturation is more than 90 percent. At all sites, the minimum dissolved-oxygen concentration exceeded 5 mg/L, which is the minimum required to maintain an abundant fish population (U.S. Environmental Protection Agency, 1976, p. 123). The dissolved-oxygen concentration may be decreased by processes that consume organic matter. The dissolved-oxygen concentrations at the downstream sites are not less than those at the upstream sites (fig. 7). This would indicate that the Cedar River and Shell Rock River are assimilating organic or other oxidizable material without significant degradation of stream quality.

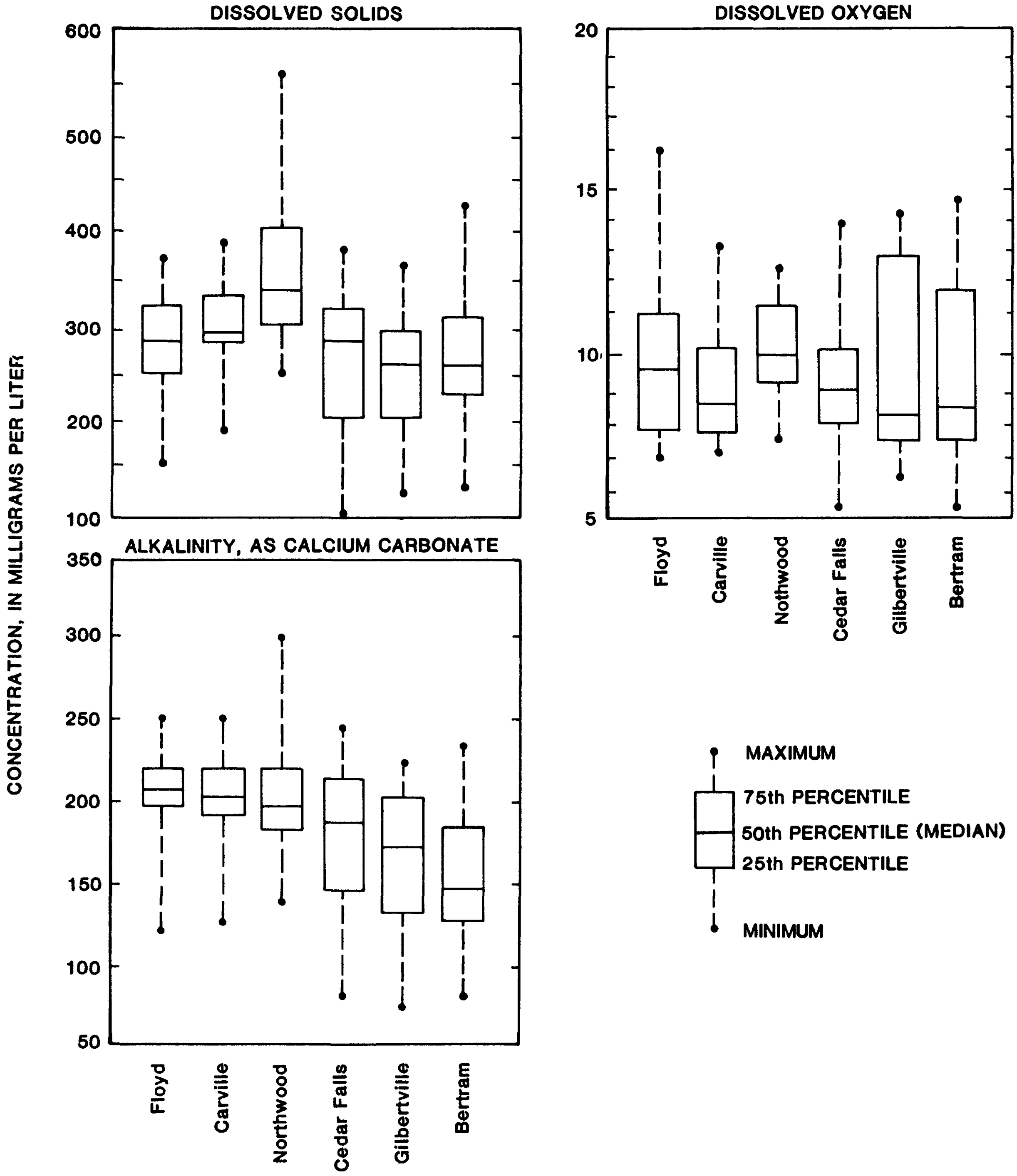


Figure 7.—Statistical summary of dissolved solids, dissolved oxygen, and alkalinity, May 1984 through September 1985.

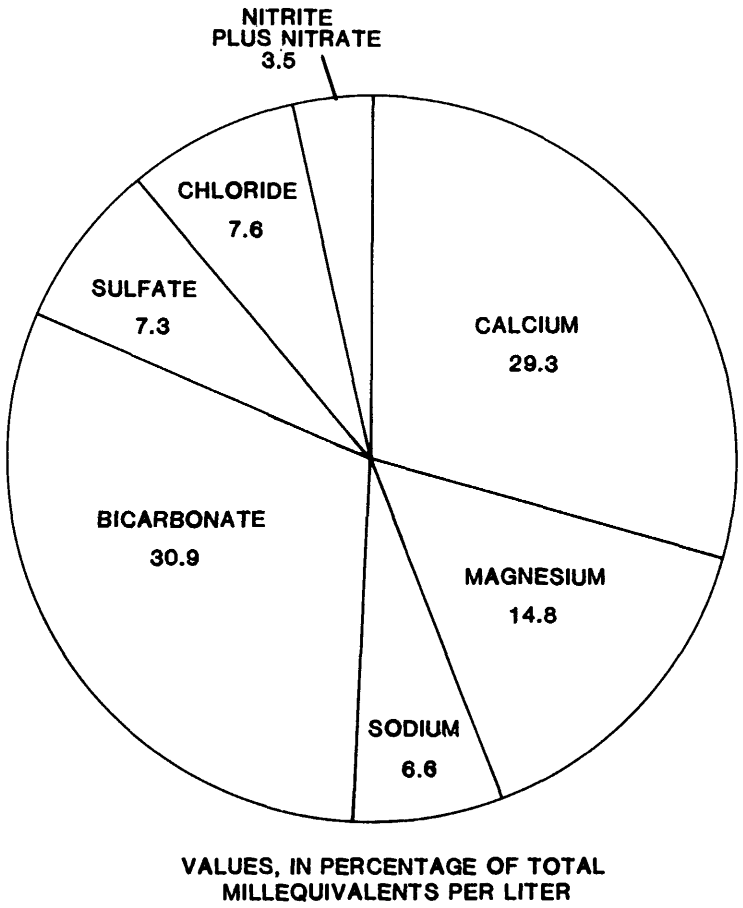


Figure 8.--Average chemical composition for samples collected from the Cedar River near Bertram, May 1984 through April 1985.

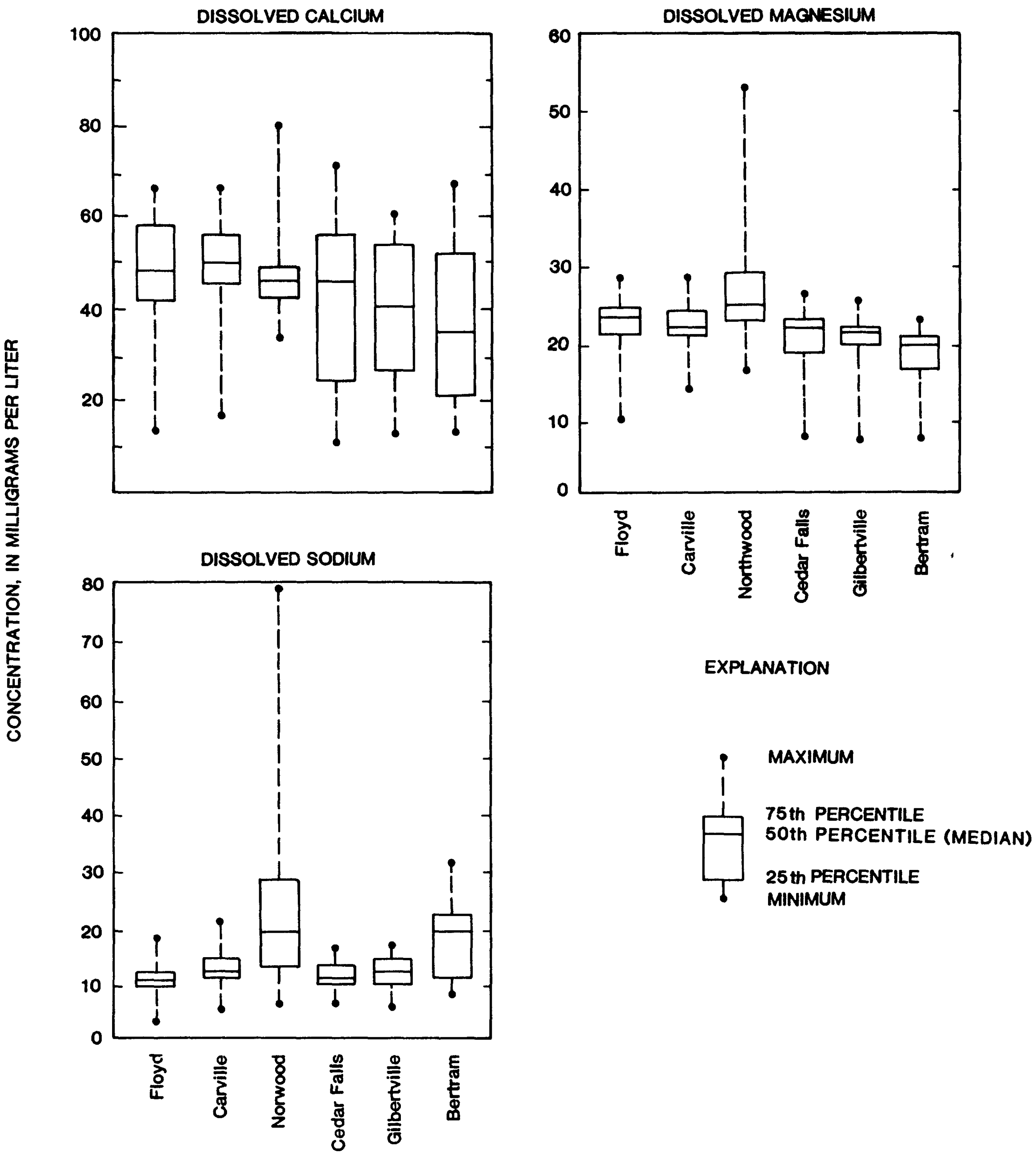


Figure 9.—Statistical summary of dissolved calcium, dissolved magnesium, and dissolved sodium, May 1984 through September 1985.

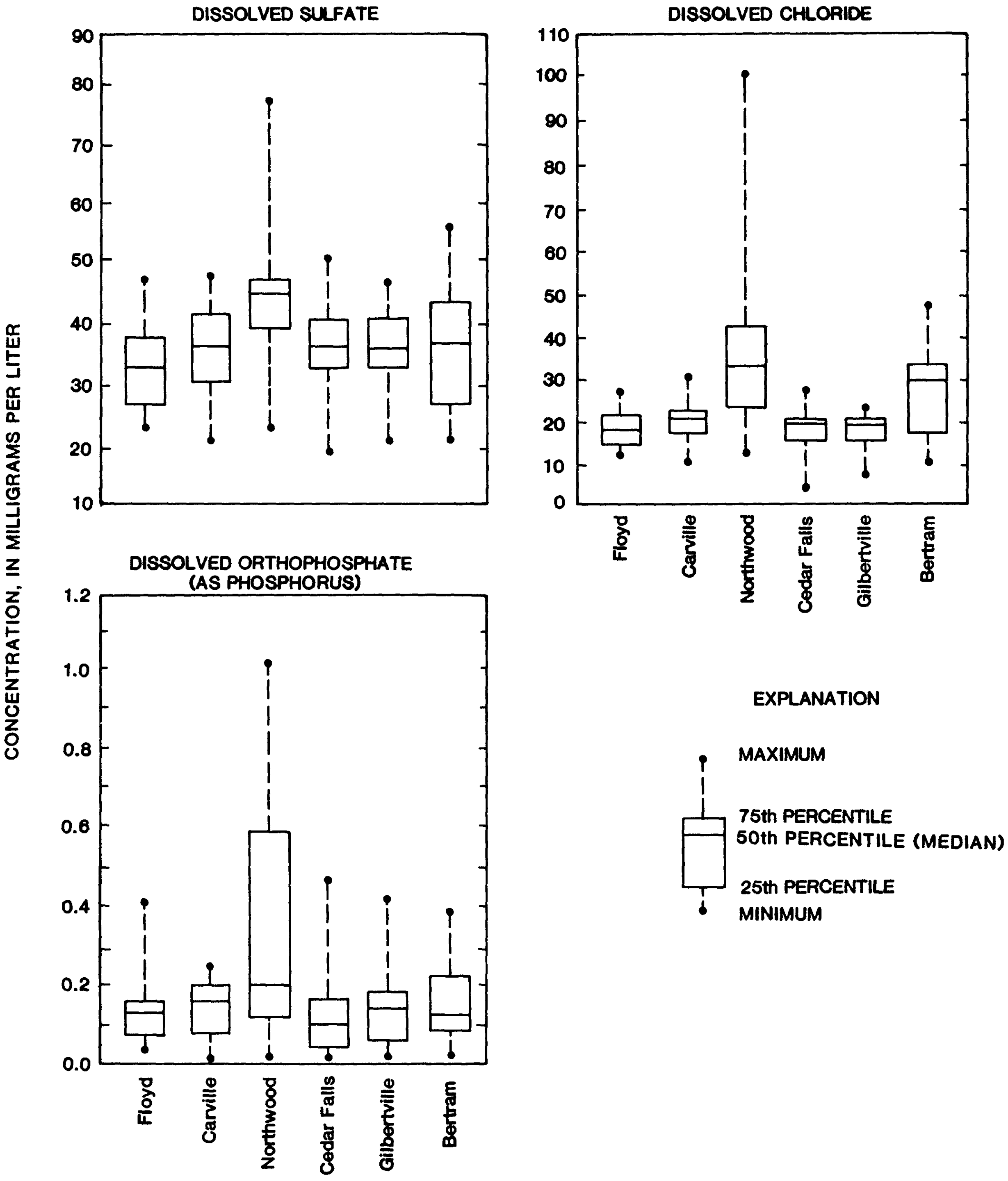


Figure 10.—Statistical summary of dissolved sulfate, dissolved chloride, and dissolved orthophosphate (as phosphorus), May 1984 through September 1985.

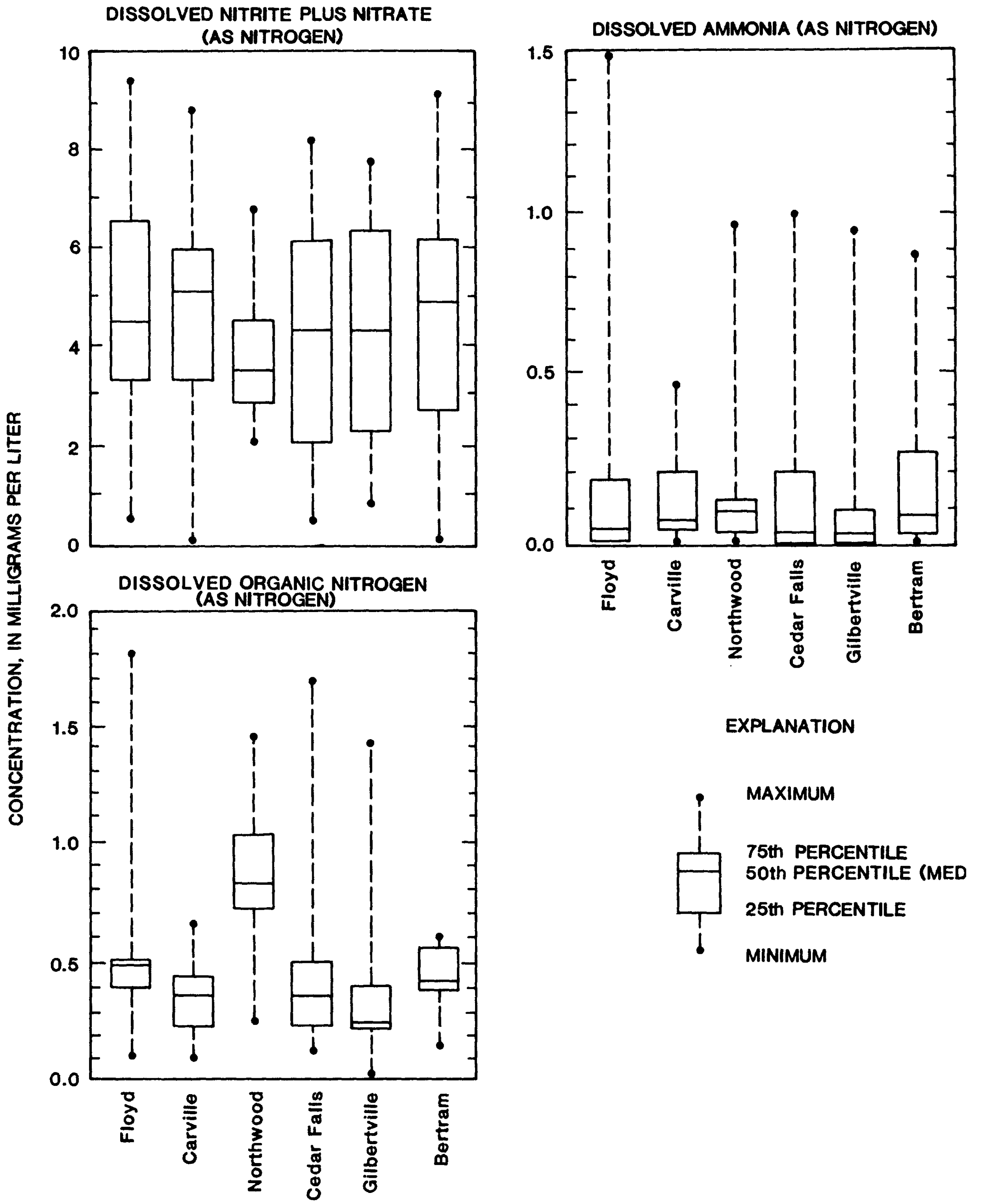


Figure 11.— Statistical summary of dissolved nitrite plus nitrate (as nitrogen), dissolved ammonia (as n and dissolved organic nitrogen (as nitrogen), May 1984 through September 1985.

Statistical analysis of alkalinity in the Cedar River basin is expressed in milligrams per liter as calcium carbonate (fig. 7). The value of bicarbonate (fig. 8) is calculated from the alkalinity of the samples. Alkalinity in almost all natural waters is produced by the dissolved carbon-dioxide species, bicarbonate, and carbonate (Hem, 1985, p. 106). With the median pH of about 8.0 detected in the Cedar River basin, the most active species is bicarbonate.

The U.S. Environmental Protection Agency's (1986a) primary drinking water standards were not exceeded by any analyzed constituent. Maximum contamination limits for the analyzed constituents are as follows: dissolved fluoride, 2.4 mg/L, based on the mean annual temperature of Iowa; dissolved nitrite plus nitrate as nitrogen, 10 mg/L; dissolved arsenic, 50 µg/L (micrograms per liter); dissolved lead, 50 µg/L; and dissolved mercury, 2 µg/L (U.S. Environmental Protection Agency, 1986a, p. 523-527).

Nitrite plus nitrate was the most common form of nitrogen detected (fig. 11). The largest concentration of dissolved nitrite plus nitrate was 9.1 mg/L as nitrogen near Bertram during the peak discharge of June 1984. In the aerated water of the Cedar River basin, the nitrite ions would be oxidized to nitrate. Dissolved ammonia and dissolved organic nitrogen occurred in lesser concentrations than did dissolved nitrite plus nitrate (fig. 11). At the site near Northwood, the median concentration of dissolved organic nitrogen was 2.5 mg/L as nitrogen, which was greater than median concentrations detected at the other sampling sites.

Dissolved arsenic commonly was not detected, except at the site near Carville, where concentrations ranged from less than 10 to 30 µg/L. Concentrations of dissolved lead almost always were less than the detection limit of 10 µg/L. During the large spring discharge of June 1984, the total-recoverable concentration of lead was a maximum of 30 µg/L near Bertram. The maximum concentration of dissolved mercury was 0.6 µg/L, but mercury usually was less than the detection limit of 0.1 µg/L.

At times, the sewage effluent from Albert Lea and Northwood may have resulted in larger concentrations of dissolved orthophosphate at the sampling site near Northwood than at other sites in the basin (fig. 10). Dissolved-orthophosphate concentrations in sewage effluent from Albert Lea and Northwood were 9.1 and 3.5 mg/L on June 12, 1985 (Goeman, 1985, p. 20). These data also indicate that downstream dilution of dissolved orthophosphate does occur, but concentrations remained larger than 1 mg/L as phosphorus from Albert Lea to the sampling site near Northwood. The use of phosphate fertilizers in the basin is a possible source for the phosphorus but may be a minor source because phosphate is not mobile in soil or sediment (Hem, 1985, p. 126).

Maximum concentrations of dissolved iron (540 µg/L) and manganese (170 µg/L) exceeded the recommended secondary standards set by the U.S. Environmental Protection Agency (1986b) for public water supplies at the sampling site near Bertram on September 21, 1984. The secondary maximum contamination levels for the analyzed constituents are: dissolved iron, 300 µg/L; dissolved manganese, 50 µg/L; dissolved sulfate, 250 mg/L; and dissolved chloride, 250 mg/L (U.S. Environmental Protection Agency, 1986b, p. 584). Several times during the study, concentrations of dissolved iron and dissolved manganese were less than the detection limit of 10 µg/L. The largest concentrations of dissolved sulfate and dissolved chloride (fig. 10) were 78 and 100 mg/L.

Modes of Transport

Chemical constituents can be transported in the dissolved phase or the suspended phase (particulate or adsorbed to the suspended sediment). The constituents detected within the centrifuged sample represent those constituents transported in the dissolved phase. Concentrations of constituents in the non-centrifuged sample minus concentrations of the same constituents in the centrifuged sample represent the concentrations of constituents transported in the suspended phase. The analysis of the non-centrifuged sample does not distinguish concentrations of constituents present in the dissolved phase, as particulates, or adsorbed to the suspended sediment.

All major inorganic constituents were detected in the dissolved phase. Trace elements were detected in the dissolved and suspended phases. Nitrite plus nitrate as nitrogen, ammonia as nitrogen, and orthophosphate as phosphorus predominantly occurred in the dissolved phase, when they were detected.

Iron and manganese were detected primarily in the suspended phase, whereas copper, lead, and zinc were detected only in the suspended phase in small concentrations, where they were detected. Periods of large discharge, such as in February 1985, provided suspended sediment for sorption and the transportion of iron and manganese. During these periods, concentrations of total-recoverable iron and manganese were much greater than the concentrations of the dissolved ions. The correlation coefficient of suspended sediment with total-recoverable iron is 0.78, whereas the correlation coefficient of suspended sediment with total-recoverable manganese is 0.51. The smaller correlation coefficient for manganese is caused by the occurrence of large concentrations of particulate manganese during base flow when suspended-sediment concentrations are small. For example, the sample collected at the site near Carville on August 20, 1985, contained 250 µg/L of total-recoverable manganese, but only 10 µg/L of dissolved manganese. The suspended-sediment concentration for this sample was only 27 mg/L.

During base flow, the river discharge is derived from ground water and possibly from drainage from agricultural areas conveyed in tile drains. The dissolved-solids concentrations during base flow mainly are derived from ground-water dissolution of the minerals in rocks near the land surface. The largest concentrations of dissolved solids (as much as 563 mg/L) were detected at the site near Northwood during base flow (fig. 7). Only at this site did concentrations of dissolved solids increase during base flow. The layer of dissolved-solids concentrations at this sampling site may be caused by sewage effluent or variations in the composition and texture of glacial till and bedrock. The correlation coefficient of discharge with dissolved-solids concentrations is -0.6 for the site near Northwood and it is -0.41 when all the sampling sites are analyzed together.

Organic Constituents

Organic Carbon

Statistical summaries of dissolved, suspended, and total organic carbon are shown in figure 12. Greater 50th-percentile concentrations of organic carbon were detected at the site near Northwood than at the other sites. It is important to note that analysis for the suspended organic carbon was not done

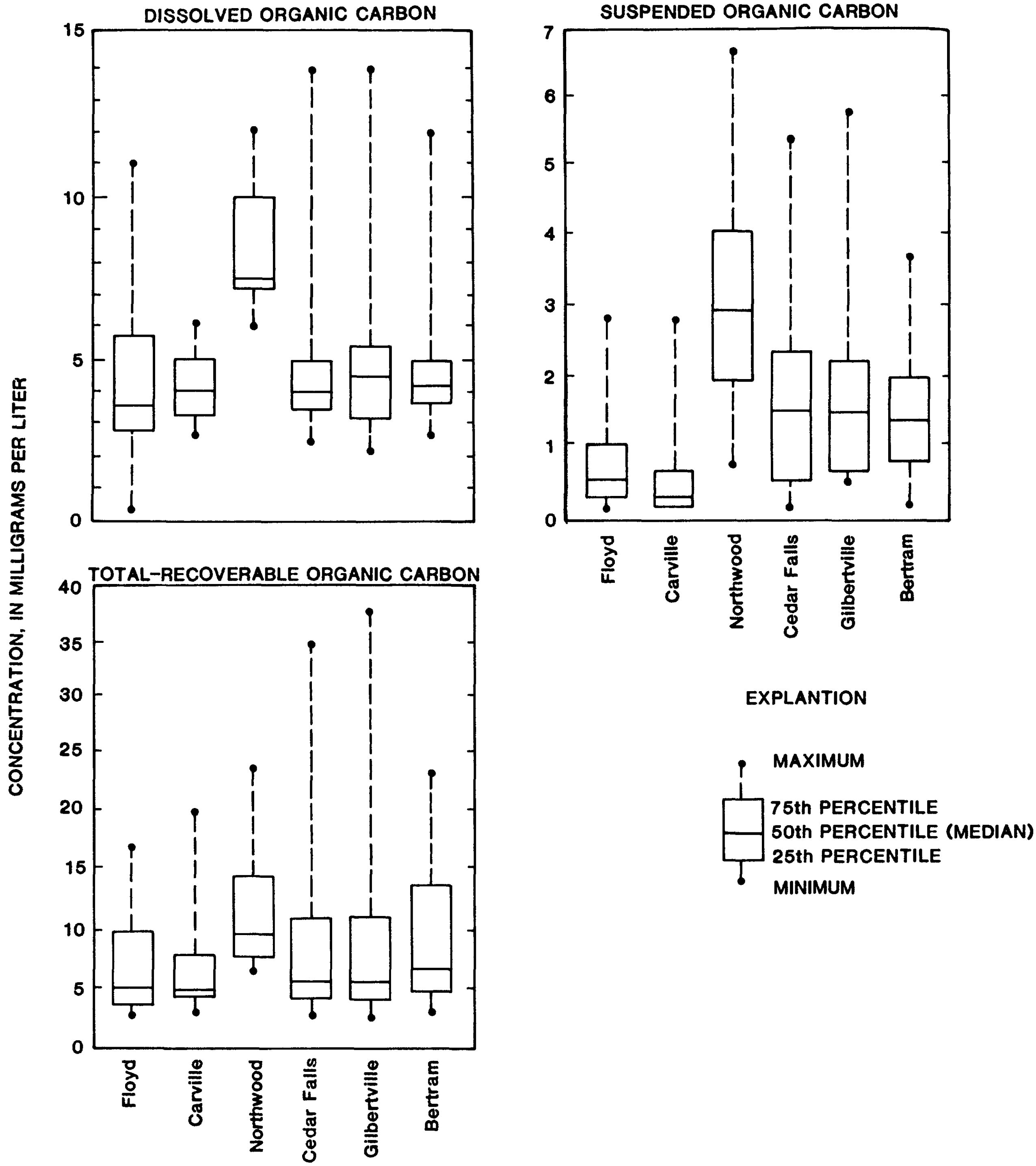


Figure 12.--Statistical summary of dissolved organic carbon, May 1984 through September 1985, suspended organic carbon, August 1984 through September 1985, and total-recoverable organic carbon, May 1984 through September 1985.

for all sampling periods; therefore, the statistical summary for the suspended organic carbon is based on a smaller number of samples compared to that for dissolved and total-recoverable organic carbon. In particular, data for suspended organic carbon are missing for the period of high river discharge. For this missing period, concentrations of suspended organic carbon can be estimated by subtracting concentrations of dissolved organic carbon from concentrations of total-recoverable organic carbon using the data in table 1.

Within the study area, organic carbon is transported in the dissolved phase, except during periods of high streamflow when large concentrations of suspended organic carbon were present at all sites. At Gilbertville, on June 10, 1984, during the large stream discharge of 13,400 ft^3/s, the concentration of total-recoverable organic carbon was 38 mg/L while the concentration of dissolved organic carbon was about 6 mg/L. This indicates that about 84 percent of the organic carbon was in the suspended phase. Herbicides constitute only a small part of the dissolved organic carbon, but are of increasing concern in the study of water quality.

Some of the suspended organic carbon may be in particulate form or may be adsorbed on the suspended sediment. The source of the suspended sediment is mainly the glacial till and loess in the area. The glacial till in the study area is similar to that in southeast Iowa where the till was determined to contain 44 to 59 percent expandable clay (Hallberg, 1980, p. 11). These clays are generally noted for their capacity to adsorb organic molecules when compared to nonexpanding clay minerals (Guenzi, 1974, p. 7). During and after periods of extremely large river discharge, larger concentrations of organic carbon were transported in the suspended phase. The greater discharge provides greater concentrations of suspended sediment and organic carbon.

Herbicides

Occurrence and distribution

Generally herbicides were detected only in the dissolved phase. Their occurrence in the Cedar River basin primarily is related to period of application, river discharge, basin size, and herbicide solubility. The herbicide concentrations detected for all samples from all sites are listed in table 2. Analysis of the data indicates that dissolved and total-recoverable concentrations normally were within 20 percent of each other. This indicates that herbicides were primarily transported in the dissolved phase. The maximum concentrations of the dissolved herbicides for all sampling sites during the study were alachlor 23.0 μg/L, atrazine 16 μg/L, cyanazine 8.7 μg/L, metolachlor 11.0 μg/L, and metribuzin 3.0 μg/L. Trifluralin was not detected in concentrations larger than the detection limits of 0.05 μg/L (dissolved) and 0.1 μg/L (total recoverable). The load (concentration of the herbicide multiplied by the river discharge and converted to tons per day) of these herbicides and the river discharge at the sampling site near Bertram during the study are shown in figure 13.

After application of herbicides, both in the wet spring of 1984 and in the drier spring of 1985, the largest number of herbicides and largest concentrations were detected. Some of these herbicides, such as alachlor, atrazine, cyanazine, and metolachlor persist into the summer and in some cases were detected in the fall and winter. Atrazine was consistently detected throughout the study; the largest concentrations were detected in June 1984,

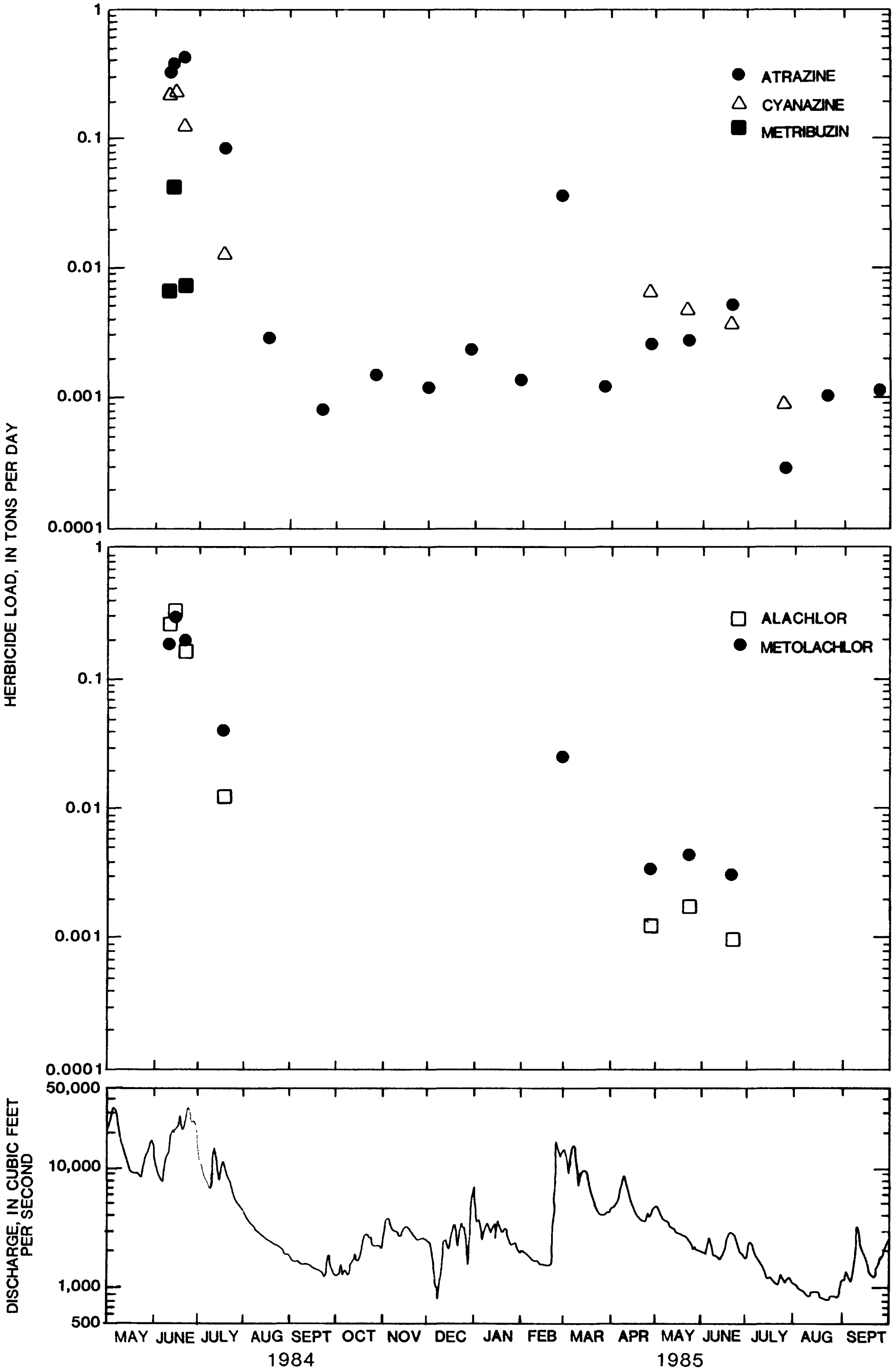


Figure 13.—Herbicide load and river discharge near Bertram, May 1984 through September 1985.

during peak river discharge. The discharge hydrograph, total-recoverable atrazine concentrations, and atrazine load for four sampling sites are shown in figures 14 through 17. After application of herbicides in the spring of 1985, concentrations and loads of atrazine increased even though the discharge decreased.

Herbicide concentrations and loads were larger during high flow compared to low flow during all times of the year, but increased concentrations of some herbicides also occurred during low flow in the spring. Concomitant large river discharges with peak atrazine concentrations and loads occurred in May, June, and July 1984 at all sites, and in February 1985 at the site near Bertram (figs. 14-17). The large concentrations of atrazine and other herbicides occurred during surface runoff, generally during spring and early summer. However, concentrations of some inorganic ions were small because of dilution. In February 1985, metolachlor also was detected in the large river discharge at the sites in Cedar Falls and near Bertram, which were the only sites for which herbicide samples were collected that month (fig. 13). Metolachlor was not detected in the previous or following month at any of the sampling sites.

Atrazine concentrations in March 1985 were small at all the sampling sites, especially considering that river discharge (which is predominately ground water at this time) was relatively large. The flushing effect of the high flows from the snowmelt in February 1985 may have been responsible for the small concentrations of atrazine in March 1985. The persistent concentrations and loads of atrazine and the detection of metolachlor during this snowmelt period indicate that some herbicides occur throughout the hydrologic system and their presence in the Cedar River is not always related to time of application. Possibly the soil in the fields and drainage ditches may be a reservoir for atrazine and metolachlor.

Within the same physiographic area, basin size seemed to control herbicide concentration during the large runoff in June 1984. The concentration of a herbicide often varied from one site to the next downstream site during a single sampling period. However, in June 1984, the largest concentrations of herbicides were detected at the upstream sampling sites (in Floyd and near Carville) within the Iowan Erosional Surface. In June 1984, the atrazine concentrations did not decrease as quickly at the site near Bertram as at the site near Carville. However, the peak concentrations were not as large at the site near Bertram (figs. 14-17). Based on these data, the larger drainage basins may provide a more stable study area than the smaller drainage basins. This could make timing of sample collection, in respect to peak runoff, less critical in large basins than in small basins. However, data collected for this study also indicate that the smaller drainage basins can have larger concentrations of herbicides.

Because atrazine consistently was detected throughout the study, an effort was made to determine the quantity of atrazine applied and then to determine the percentage transported by the Cedar River. An estimate of total atrazine applied in the basin is based on the data collected by Iowa State University (table 3 at the back of the report) and on soil types and soil pH. Much of the agricultural data is reported by crop districts (fig. 18).

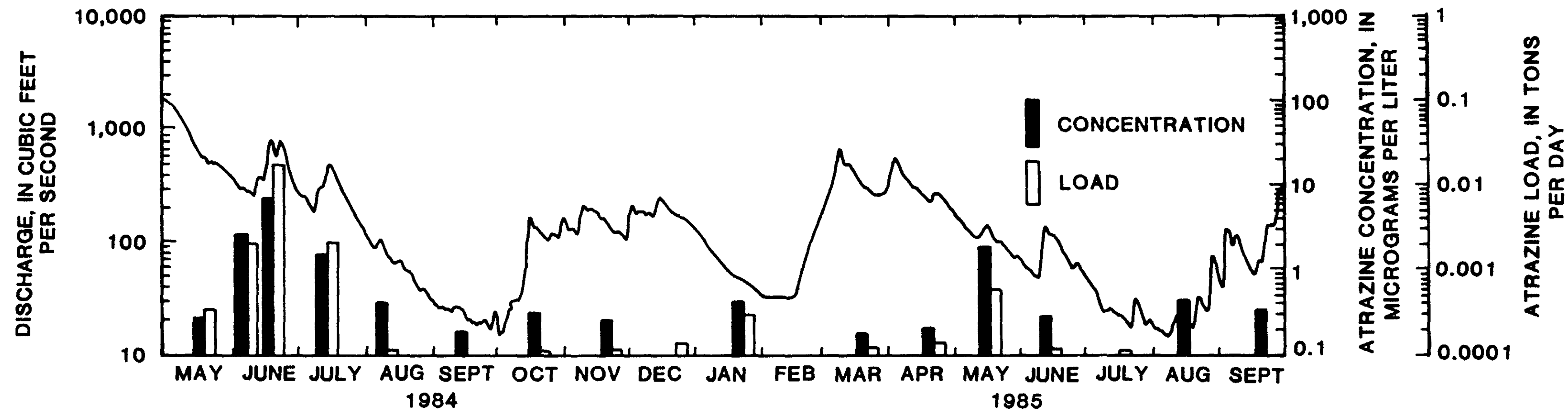


Figure 14.--Hydrograph of the Shell Rock River at Northwood, and total-recoverable concentration and load of atrazine at the sampling site near Northwood, May 1984 through 1985.

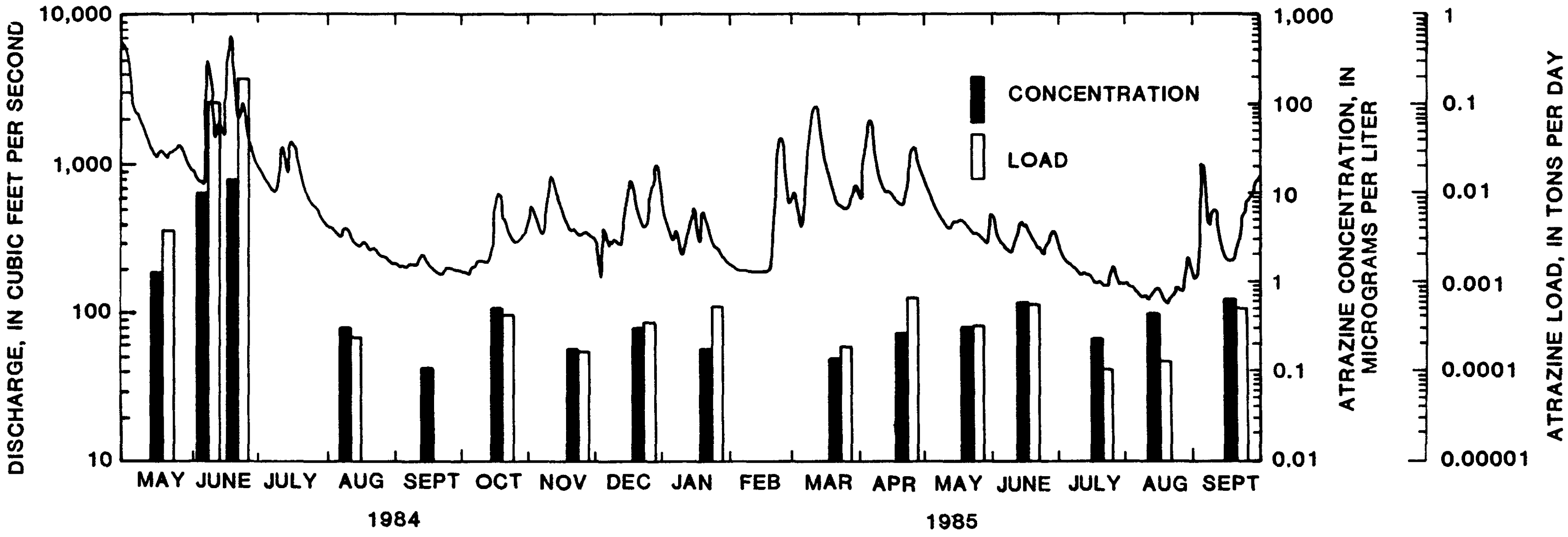


Figure 15.--Hydrograph of the Cedar River at Charles City, and total-recoverable concentration and load of atrazine at the sampling site near Carville, May 1984 through September 1985.

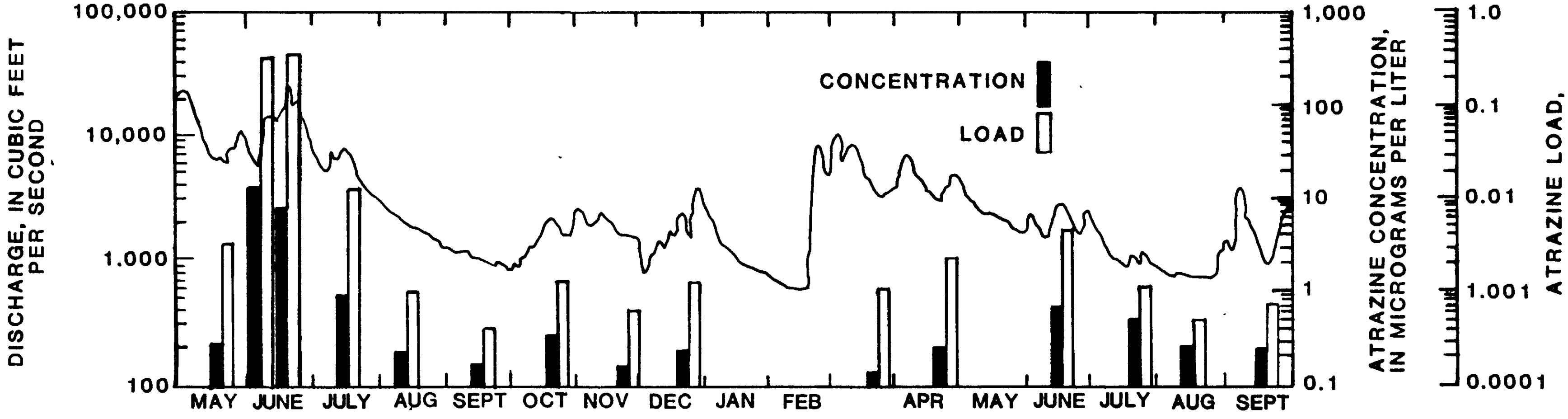


Figure 16.--Hydrograph of the Cedar River at Waterloo, and total-recoverable concentration and load of atrazine at the sampling site in Gilbertville, May 1984 through September 1985.

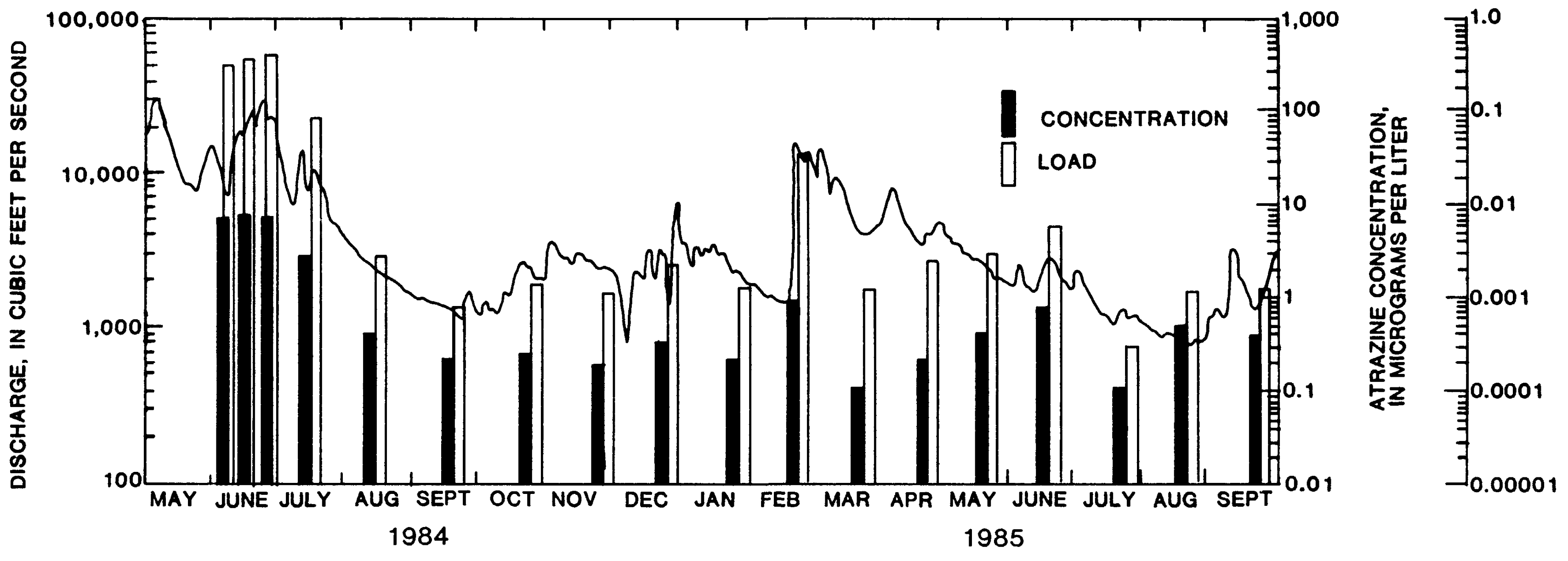


Figure 17.--Hydrograph of the Cedar River at Cedar Rapids, and total-recoverable concentration and load of atrazine at the sampling site near Bertram, May 1984 through September 1985.

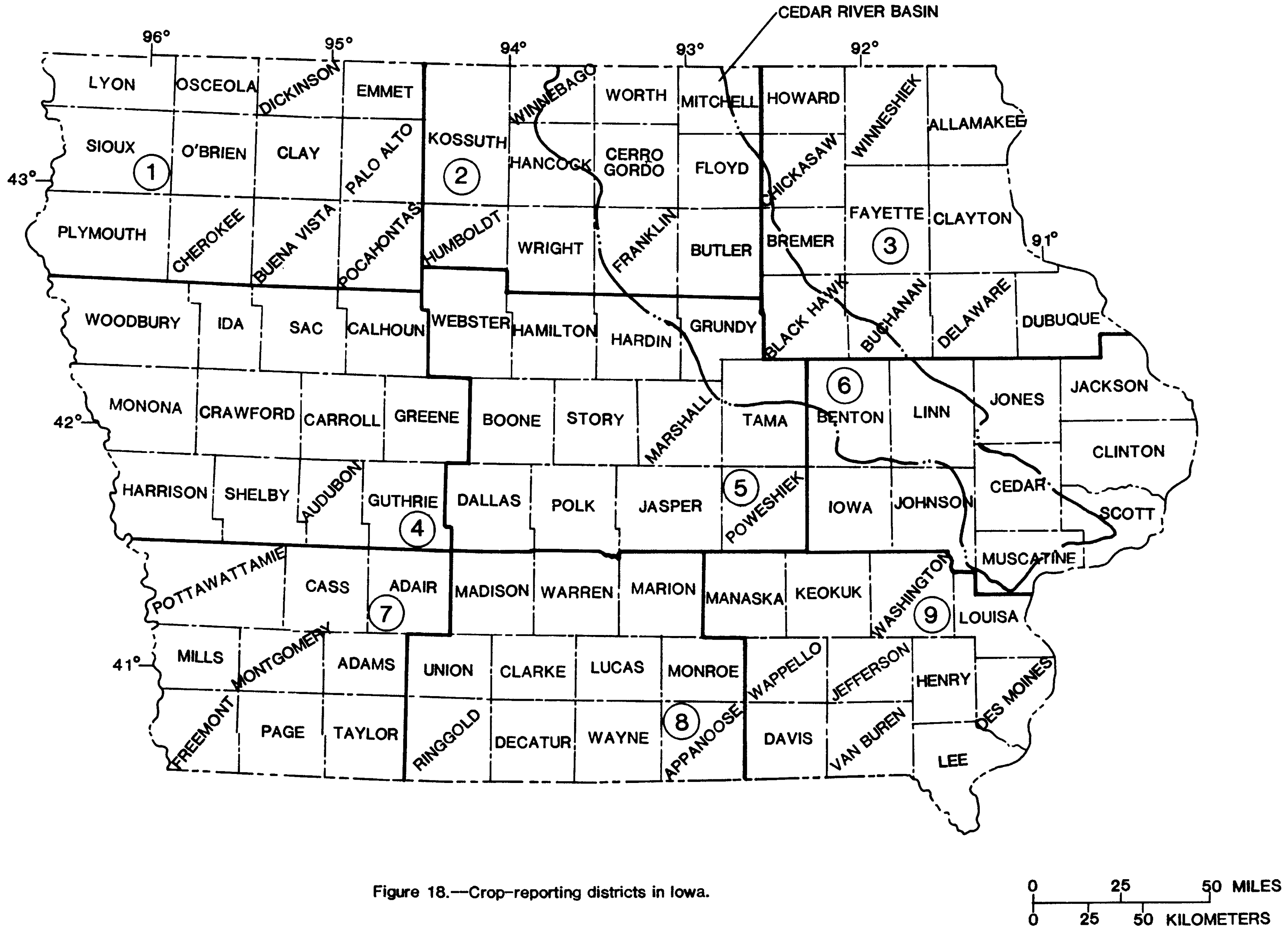


Figure 18.—Crop-reporting districts in Iowa.

The location of the sampling site near Northwood within the Cary drift seems at times to control the herbicide concentrations. The concentrations of herbicides at this sampling site during June 1984 were less than those at the other sites even though the drainage basin is the smallest in the study area. Furthermore, even in the dry spring of 1984, May was the only month when herbicides other than atrazine were detected at the site near Northwood; concentrations of these herbicides were about 75 percent less than those at the other sampling sites.

More than twice the quantity of atrazine was applied in District 6 than in District 2 even though fewer acres of corn were planted in District 6 (table 3). This variation in the use of atrazine may be because of the difference in soil pH, which affects atrazine residue in the soil from the previous year. Neutral and alkaline soil conditions are thought to promote atrazine residue in the soil, whereas acidic soil conditions do not (Weber and Weed, 1974, p. 232-233). The soils in District 2 are derived from the Wisconsin glacial till, whereas the soils in District 6 are derived from the older pre-Illinoian glacial till and loess. Calcium carbonate has been removed from the older soils because leaching has continued for a longer period and possibly because more efficient leaching processes occur in the deeper valleys in District 6. Leaching of the calcium carbonate has resulted in a more acidic soil pH. The pH is 7.0 or larger in about 50 percent of the top soils in District 2, whereas the pH is less than 7.0 in 90 percent of the soils in District 6 (Gerald Miller, Iowa State University, oral commun., 1986). Furthermore, corn is planted in consecutive years on about 60 percent of cultivated acreage in District 6, but only or about 25 percent of the acreage in District 2 (Becker and Stockdale, 1980). Residual atrazine held within the soil from the previous application would be a greater concern when crop rotation is common as in District 2; therefore, atrazine use would be less common.

The soils of the Cedar River basin predominantly are older acidic soils except for those in the upper reaches of the basin. Therefore, the best estimate of atrazine use is probably based on the agricultural statistics for District 6, where the use of atrazine is much more common.

The total quantity of atrazine applied was calculated to be about 900 tons for the 1985 growing season of which about 1.5 percent ultimately was transported by the Cedar River. About 2 million acres of corn were planted in 1985 in the Cedar River basin in Iowa north of Cedar Rapids (Skow and Holden, 1986, p. 30). Estimated corn production for counties in Minnesota were based on the corn production in counties in Iowa along the State border. Seventy percent of the corn was assumed to have been treated with atrazine at a rate of 1.6 lb per acre. Monthly atrazine loads (in tons per month) were calculated from data collected at the sampling site near Bertram from June 1984 through March 1985 by multiplying the atrazine concentration (micrograms per liter) times stream discharge (cubic feet per second) times 8.09×10^{-5}. Loads for April and May 1984 were conservatively estimated at 0.35 ton per month, because no data are available for these months. The 12 monthly tonnages of atrazine were totaled and a yearly load of about 16 tons was calculated. This tonnage is about 1.5 percent of the 1,100 tons of atrazine applied. However, 70 percent of the total atrazine transported during this 1-year period occurred in June 1984 when the river discharge was large because of runoff. Therefore, it seems that large quantities of runoff during periods of herbicide application can result in the majority of the atrazine transported during an entire year.

If atrazine use is based on the use in District 2, the total annual loss is about 4 percent of that applied. The total atrazine applied to the basin north of Cedar Rapids is estimated to be about 430 tons based on the use in District 2. The yearly atrazine load in the Cedar River near Bertram is about 16 tons, which is about 4 percent of the 430 tons applied.

Atrazine has the least solubility of the wettable powder herbicides and is the most commonly detected. The most commonly used herbicides with their solubilities and type of application are listed in table 4 at the back of the report. The fact that atrazine is the most used of the five herbicides in District 6 may alone explain the large concentrations and persistent detection of atrazine in the river. However, Wauchope (1978, p. 466), after an extensive literature review, also reported an inverse dependence of runoff concentration on the solubility of a wettable powder herbicide.

Many factors seem to have a part in the occurrence and distribution of herbicides, although their occurrence in Iowa rivers is widespread and has been known for a number of years. Richard and others (1974, p. 117) stated that every primary river basin in Iowa had some degree of pesticide contamination during the growing season of 1974.

Conveyance to streams

Herbicides were primarily transported in the dissolved phase. Numerous studies already have indicated that the same herbicides predominately are transported in the dissolved phase (Hall, 1974, p. 178; Ritter and others, 1974, p. 38; Glotfelty and others, 1984, p. 120).

Wauchope (1978, p. 469) made an extensive literature review of pesticide studies and determined that even when pesticide concentrations associated with suspended sediment in runoff are two to three orders of magnitude greater than those in the dissolved phase, the suspended sediment usually is such a small fraction (by weight or by volume) of the runoff that most pesticides are still transported in the dissolved phase. Many of the studies that Wauchope (1978) reviewed were edge-of-field studies, where concentrations of sediment and pesticides may be markedly different than those in large drainage basins, such as the basins investigated in this study. However, the total quantity of herbicides transported by adsorbtion on sediment may still be related to the concentration of sediment available to transport the herbicides. If concentrations of herbicides adsorbed on the suspended sediment in the Cedar River basin are assumed to be as large as Wauchope (1978, p. 469) reported, the majority of the herbicides would still be transported in the dissolved phase because of the small concentrations of suspended sediment normally present in the Cedar River basin.

The lack of detection of adsorbed herbicides also may indicate a need for re-examination of traditionally acceptable methods of treating water samples at the sampling site, separating sediment and water, and extracting organic compounds from sediment. New techniques are being developed to separate more completely the herbicides from the sediment (Thomas Steinheimer, U.S. Geological Survey, oral commun., 1987). For this study, the quantity of herbicide adsorbed to the sediment could only be determined indirectly by comparing the concentration of herbicide detected in the dissolved phase with the concentration detected in the dissolved plus suspended phase. The surface of a sediment particle exposed to a water solution is covered with a tightly bound layer of water molecules. Near or within this layer are solute ions or molecules held by electrostatic attractive forces of various types (Hem, 1985, p. 27). The separation of herbicides from the sediment may be incomplete because of the bonding of the herbicide with the sediment or the interference of water in the solvent-extraction technique.

There are significant implications to the fact that herbicides are transported in the dissolved phase. Wauchope (1978, p. 459 and 469) states that pesticides, including herbicides and insecticides, with solubilities of 10 µg/L or larger are transported mainly in the dissolved phase during runoff. Erosion-control practices, except as they control the volume of water and sediment reaching a stream, can be expected to have little effect on runoff losses of pesticides. Noted exceptions are the organochlorine pesticides, paraquat, and arsenical pesticides that are strongly adsorbed on sediment.

Herbicides can enter the river in four ways: spillage directly into or near the river, overland flow or runoff from storms or snowmelt, discharge from agricultural areas conveyed by tile drains, or ground-water discharge. Spillage of herbicides and misuse may result in their detection in the rivers. However, the persistent detection of atrazine throughout the sampling period and the detection of other herbicides during the time of application indicates more than an isolated case of spillage. No data are available to support misuse; the Cedar River basin is so large that it would be difficult to locate and document these occurrences.

During times of peak river discharge, concentrations of herbicides were large, but exactly how these herbicides reached the river and where they came from in the basin is not known. The large concentrations of atrazine were detected in June and July 1984, February 1985, and June 1985 (figs. 13-16). Furthermore, a variety of herbicides were detected in large concentrations during the spring of 1984 (fig. 12). Surface runoff after herbicide application, such as in the spring of 1984, has the largest effect on the transport of herbicides. However, the quantity of herbicide contributed by surface runoff, tile drains, and ground water is not known. Movement of herbicides through tile drains and ground water may increase when the water table rises because of precipitation or snowmelt. Freeze and Cherry (1979, p. 219) state that only a part of the basin regularly contributes to runoff. Therefore, herbicides transported to the river by overland flow may originate from only part of the basin.

The concentration of herbicides in runoff probably depends on a number of conditions, such as time since application, quantity of rainfall, slope and area of the drainage basin, soil moisture, soil composition, and quantity of herbicide applied. However, a review of the current literature and the interpretation of the data for the Cedar River basin indicates that some conditions contribute more than other conditions to the conveyance of herbicides in runoff within the Cedar River basin.

A 3-year study of the Wye River estuary, a tributary of Chesapeake Bay, Maryland, determined that the total quantity of herbicides reaching the estuary depended on the timing of runoff with application (Glotfelty and others, 1984, p. 115). The study indicated that 2 to 3 percent of applied atrazine moved into the estuary when substantial runoff occurred within 2 weeks of application.

Peak concentrations of alachlor and atrazine in runoff also were detected for eight subbasins of the Rhode River basin in Maryland during the months that they were applied (Wu and others, 1983, p. 333).

Basin slope seems to exert control on herbicide concentrations in runoff. The type of soil cover and the composition of material forming the land surface (bedrock, colluvium, residual soil, and so forth) also will control the quantity of runoff and probably herbicide concentrations in the runoff. Runoff losses of wettable powder-formulated herbicides were estimated by Wauchope (1978, p. 470) to be 2 percent for slopes of 10 percent or less, and 5 percent for slopes greater than 10 percent. The average slope of the Cedar River basin is less than 10 percent; the calculated losses of atrazine are similar to Wauchope's estimate of 2 percent.

Discharge into the Cedar River from tile drains and from ground water may contribute significant quantities of herbicides. Certain parts of a basin regularly contribute runoff to streams, whereas other areas seldom or never contribute runoff to streams (Freeze and Cherry, 1979, p. 219). This would indicate that in some areas of the basin, most of the applied herbicide would remain where applied and would be available for leaching to tile drains and deeper ground-water flow. Discharge from tile drains continues after runoff has ceased and is more prevalent in topographically flat areas. Flow of ground water is contributed to the river throughout the year. In the flatter, northern part of the Cedar River basin north of Northwood, discharge from tile drains may represent a substantial part of the river discharge when the soil is saturated and may contribute a larger percentage of the annual discharge than that contributed by runoff. The proportion of discharge from the tile drains in the river discharge at the site near Northwood may explain why concentrations of herbicides were less at this site than those at the site in Floyd during the large river flow in May, June, and July 1984. The soil north of Northwood may be filtering and retaining more of the herbicides.

The presence of herbicides in the ground-water system is indicated by their detection in the river during dry periods. When runoff and discharge from tile drains are not available, ground water is the sole source of water in the river. During the dry spring of 1985, alachlor, atrazine, cyanazine, metolachlor, and metribuzin were detected in the Cedar River. Concentrations of these herbicides were less than those detected during the previous wet spring of 1984. It is not clear if the small quantity of precipitation that occurred during the dry spring could have transported herbicides in overland flow and discharge from tile drains, or if these herbicides were transported by the deeper ground-water system. In May 1985, no substantial runoff occurred for about a month, yet the herbicide concentrations did not decrease from those detected in April 1985. Conveyance of herbicides to the streams at this time probably would be by tile drains or shallow ground water. During excessive rainfall, the increasing river stage may cause surface water movement and herbicide transport to alluvial aquifers and may be released later during base flow. During extremely dry weather, such as August and September 1984 and August 1985, atrazine concentrations ranged from 0.11 to 0.55 μg/L. The detection of atrazine during these dry periods almost certainly indicates its presence in ground water. This is substantiated by Detroy and others (1988), who detected atrazine in 18 percent of 456 samples collected from 355 shallow municipal wells throughout Iowa. These wells were less than 150 ft deep and were completed in Quaternary deposits or bedrock.

SUMMARY

The chemical composition of the water from the Cedar and Shell Rock Rivers indicates that the water is calcium bicarbonate type, and that the water quality is fairly consistent throughout the Cedar River basin. The data indicate no obvious degradation of water quality between upstream and downstream sites on streams in the Cedar River basin. Furthermore, concentrations of dissolved fluoride, dissolved nitrite plus nitrate, dissolved arsenic, dissolved lead, and dissolved mercury did not exceed the primary standards for public water supplies established by the Federal government. Concentrations of dissolved iron and manganese exceeded secondary standards for public-water supplies only once, September 21, 1984, and only at the sampling site near Bertram. At the sampling site near Northwood, concentrations of dissolved solids, organic nitrogen, orthophosphate, and organic carbon were larger than at sampling sites in other parts of the basin. The larger concentrations of organic nitrogen and orthophosphate may be because of sewage effluent from Albert Lea and Northwood.

The occurrence and transport of some of the chemical constituents may be related to physiography. There are two distinct physiographic areas in the basin. One area is north of Northwood within the Cary drift. This area is characterized by flat topography, a poorly developed drainage network, and basic to neutral soils. The second area, the remaining part of the basin, is within the Iowan Erosional Surface. This area is characterized by greater topographic relief, a well-developed drainage network, and acidic soils. Within the Cary drift, ground water and discharge from agricultural areas conveyed by tile drains may contribute a larger proportion of the annual river discharge than does the remaining part of the basin. Flood runoff per square mile in this part of the basin is about one-fourth of that in the remaining part of the basin. Herbicide use varied markedly between the two physiographic areas. This also may affect the quality of runoff. Only at the sampling site near Northwood did the dissolved-solids concentration increase during base flow. During times of high discharge, smaller concentrations of herbicides were detected at the sampling site near Northwood than at the sampling site in Floyd. Furthermore, even in the dry spring of 1985, May was the only month when herbicides, other than atrazine, were detected at the sampling site near Northwood; the concentrations were about 75 percent less than those at the other sampling sites.

Organic carbon was transported in the dissolved or suspended phase, whereas iron and manganese almost always were transported in the suspended phase. During periods of large discharge, organic carbon was transported predominately in the suspended phase. Occasionally small quantities of copper, lead, and zinc were transported in the suspended phase. Herbicides constitute a small part of the total organic carbon but were not determined to be transported in the suspended phase. The lack of detection of adsorbed herbicides may indicate a need for re-examination of traditionally acceptable methods of treating water samples at the sampling site, separating sediment and water, and extracting of organic compounds from sediment.

The herbicides detected in the dissolved phase and their occurrence is related primarily to rate of application, river discharge (runoff versus baseflow), and size of the drainage basin. The largest concentrations of several dissolved herbicides were detected after application in the spring and early summer in both wet and dry periods. However, concentrations of atrazine

also were detected in the winter during periods of runoff resulting from snowmelt. In June 1984, runoff from a large rainstorm, which occurred shortly after herbicide application, conveyed about 70 percent of the annual atrazine load to the Cedar River. The rest of the detected atrazine was conveyed to the river by runoff, tile drainage, or ground water.

Large basins may provide more stable study areas than small basins because concentrations of herbicides within the basins do not fluctuate as rapidly. The timing of sample collection with regard to peak runoff would not be as critical in a larger drainage basin compared to a smaller drainage basin. Water samples collected at the sampling site near Bertram (basin size about 6,500 mi^2) had concentrations of herbicides that persisted for a longer period when compared to the smaller drainage basins. However, data collected for this study indicate that the smaller drainage basins can have larger concentrations of herbicides.

Atrazine consistently was detected in the Cedar River basin when ground water was the sole source of stream discharge. Discharge from tile drains and ground water probably provided from 56 to 80 percent of the annual river discharge within the study area. The large percentage of ground-water contribution and the fact that atrazine is detected throughout the year indicate its presence in the ground water. How these herbicides are transported through the ground-water system and whether the tile drains or the natural ground-water system provides the main conduit for movement are not known. Alluvial aquifers also may play have a substantial role in herbicide transport by storing herbicides during excessive rainfall and releasing them during base flow. More information is needed about the relation between herbicide solubility, type of application, and subsequent movement in runoff, tile drains, and in the natural ground-water system.

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TABLES

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25° Celsius; °C, degrees Celsius; mg/L, milligrams per liter; deg. C, degrees Celsius; µg/L, micrograms per liter; tons/d, tons per day; sed, sediment; susp, suspended; diam, diameter; mm, millimeter; --, no data; <, less than]

Date	Time	Stream-flow, instan-taneous (ft^3/s)	Spe-cific con-duct-ance (µS/cm)	pH (stand-ard units)	Temper-ature, air (°C)	Temper-ature, water (°C)	Oxygen, dis-solved (mg/L)	Oxygen, dis-solved (per-cent satur-ation)	Oxygen demand, chem-ical (high level) (mg/L)	Hard-ness (mg/L as $CaCO_3$)	Hard-ness, noncar-bonate (mg/L $CaCO_3$)
					CEDAR RIVER AT FLOYD						
1984 May											
22...	0840	1,010	535	8.3	--	18.0	9.2	102	20	270	74
June											
09...	1610	3,620	390	7.9	--	18.5	7.4	83	52	180	59
19...	0820	4,720	420	7.9	--	19.0	7.4	81	52	210	74
July											
16...	1555	1,530	525	8.0	--	23.5	7.4	91	28	280	81
Aug											
14...	0815	275	510	8.6	--	22.0	8.3	98	20	270	63
Sept											
19...	0820	186	535	8.1	--	16.5	9.6	101	17	260	35
Oct											
24...	1000	303	570	8.2	6.0	6.0	8.4	69	12	290	83
Nov											
28...	1000	335	615	7.2	-1.0	1.5	13.0	96	4	290	69
Dec											
27...	1000	384	649	8.0	3.5	1.0	12.0	87	16	330	110
1985 Jan											
29...	1000	965	645	7.2	-5.0	0.0	10.3	73	32	320	76
Feb											
25...	1300	2,330	315	7.2	3.0	0.0	13.3	94	16	130	--
Mar											
25...	1430	470	528	8.0	5.0	5.5	--	--	16	250	60
Apr											
24...	1630	1,100	525	8.4	18.0	17.0	9.6	103	29	260	67
May											
20...	1515	366	570	8.4	24.0	21.0	--	--	20	290	72
June											
17...	1530	327	550	8.0	24.0	22.5	8.6	103	28	270	67
July											
22...	1600	141	430	8.7	29.0	30.0	7.1	97	16	250	42
Aug											
19...	1520	102	450	8.8	25.0	23.0	16.3	195	32	250	84
Sept											
23...	1500	266	495	7.8	11.0	13.5	10.2	104	12	260	52

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Alka-linity, labora-tory (mg/L as $CaCO_3$)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl	Flou-ride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, residue at 105 deg. C, dis-solved (mg/L)	Solids, residue at 105 deg. C, total (mg/L)
					CEDAR RIVER AT FLOYD--continued						
1984 May											
22...	72	22	7.4	1.6	196	32	21	0.20	7.4	318	396
June											
09...	49	14	6.3	3.0	121	22	15	.20	10	202	579
19...	56	16	5.9	3.0	132	20	16	.20	13	266	543
July											
16...	73	23	11	2.4	196	27	20	.20	16	260	486
Aug											
14...	68	24	2.6	11	206	32	18	--	2.2	287	350
Sept											
19...	66	22	12	2.4	220	36	20	--	8.6	327	362
Oct											
24...	78	23	10	3.9	206	44	23	--	16	311	370
Nov											
28...	79	23	10	2.0	223	--	24	.20	13	356	377
Dec											
27...	87	28	11	2.4	224	40	16	.20	16	368	394
1985 Jan											
29...	85	26	17	2.6	243	32	28	.20	17	368	379
Feb											
25...	34	9.8	9.2	6.2	--	24	15	.10	10	173	--
Mar											
25...	69	20	9.1	2.8	195	24	19	.20	14	293	340
Apr											
24...	65	24	8.8	2.2	194	30	20	.20	7.0	296	439
May											
20...	78	23	11	2.1	217	36	22	.25	5.2	327	355
June											
17...	70	22	10	2.2	198	20	22	.23	12	337	454
July											
22...	62	24	9.7	2.4	212	36	22	.25	9.8	290	321
Aug											
19...	52	28	16	2.4	161	32	24	.20	3.0	222	282
Sept											
23...	68	21	8.8	2.4	204	24	17	.20	12	288	325

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Nitrogen, organic, dissolved (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
					CEDAR RIVER AT FLOYD--continued						
1984 May											
22...	7.1	7.2	<0.01	0.02	0.11	0.3	--	0.28	0.08	0.12	0.08
June											
09...	9.1	8.9	.20	.24	.9	2.4	0.7	2.2	--	.35	.15
19...	9.4	9.5	.52	.32	.95	2.3	.43	2.	.17	.47	.16
July											
16...	6.6	6.7	.01	.01	.55	1.2	.54	1.2	.19	.43	.13
Aug											
14...	3.10	3.10	< .01	< .01	.36	.67	--	--	.11	.16	.04
Sept											
19...	3.70	3.50	< .01	< .01	3.2	.99	--	--	.09	.18	.06
Oct											
24...	4.90	4.90	.04	.04	.7	.79	.66	.75	.23	.28	.21
Nov											
28...	5.90	5.90	.06	.07	.16	.42	.1	.35	.26	.31	.06
Dec											
27...	7.40	7.30	.18	.19	.27	.38	.09	.19	.21	.25	.15
1985 Jan											
29...	5.40	5.50	.51	.51	.71	.82	.2	.31	.18	.21	.18
Feb											
25...	3.40	4.30	1.50	1.50	3.4	3.8	1.9	2.3	.48	.69	.42
Mar											
25...	4.30	4.30	.18	.19	.71	.79	.53	.6	.33	.26	.16
Apr											
24...	4.50	4.70	.04	.03	.45	1.4	.41	1.4	.28	.40	.08
May											
20...	4.20	4.30	.01	.02	.42	.87	.41	.85	.25	.29	.15
June											
17...	5.50	5.40	.02	.04	.53	1.3	.51	1.3	.32	.36	.29
July											
22...	1.30	1.30	<.01	<.01	.49	.98	--	--	.22	.28	.13
Aug											
19...	.70	<.10	.02	.07	.54	1.6	.52	1.5	.19	.17	.16
Sept											
23...	3.00	3.00	.01	.01	--	--	--	--	.11	.16	.09

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Arsenic, dis- solved (µg/L as As)	Arsenic, total (µg/L as As)	Copper, dis- solved (µg/L as Cu)	Copper, total recov- erable (µg/L as Cu)	Iron, total recov- erable (µg/L as Fe)	Iron, dis- solved (µg/L as Fe)	Lead, dis- solved (µg/L as Pb)	Lead, total recov- erable (µg/L as Pb)	Manga- nese, total recov- erable (µg/L as Mn)	Manga- nese, dis- solved (µg/L as Mn)
CEDAR RIVER AT FLOYD--continued										
1984 May										
22...	<10	<10	<10	<10	--	--	<10	<10	--	--
June										
09...	<10	<10	<10	<10	1,400	--	<10	20	230	--
19...	<10	<10	<10	<10	5,600	--	<10	<10	20	--
July										
16...	<10	<10	<10	<10	--	140	--	--	--	<10
Aug										
14...	<10	<10	<10	20	--	--	<10	<10	--	--
Sept										
19...	<10	<10	<10	<10	160	<10	<10	<10	60	10
Oct										
24...	<10	<10	<10	<10	370	20	<10	<10	70	10
Nov										
28...	<10	<10	<10	<10	170	<10	<10	20	20	20
Dec										
27...	<10	<10	<10	<10	130	<10	<10	<10	10	<10
1985 Jan										
29...	<10	<10	10	10	120	10	<10	<10	30	<10
Feb										
25...	<10	<10	<10	--	--	190	<10	--	--	30
Mar										
25...	<10	<10	<10	40	560	<10	<10	--	40	<10
Apr										
24...	<10	<10	<10	<10	1,300	40	<10	<10	210	20
May										
20...	<10	<10	30	30	390	10	<10	<10	7	10
June										
17...	<10	<10	<10	30	1,800	<10	<10	<10	210	20
July										
22...	<10	<10	30	30	240	40	<10	<10	50	<10
Aug										
19...	<10	<10	<10	<10	240	10	<10	<10	170	<10
Sept										
23...	<10	<10	<10	<10	270	50	<10	<10	70	<10

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Mercury, dis-solved (µg/L as Hg)	Mercury, total recov-erable (µg/L as Hg)	Zinc, dis-solved (µg/L as Zn)	Zinc, total recov-erable (µg/L as Zn)	Carbon, organic, dis-solved (mg/L as C)	Carbon, organic, sus-pended total (mg/L as C)	Carbon, organic, total (mg/L as C)	Sedi-ment, sus-pended (mg/L)
			CEDAR RIVER AT FLOYD--continued					
1984 May								
22...	<0.1	<0.10	<10	20	2.5	--	2.8	48
June								
09...	<.1	<.10	<10	30	5.9	--	9.8	324
19...	<.1	.10	30	80	4.8	--	17	470
July								
16...	<.1	<.10	<10	<10	.5	--	13	137
Aug								
14...	<.1	<.10	<10	<10	.2	0.7	3.5	21
Sept								
19...	<.1	<.10	<10	<10	3.5	1.1	5.7	28
Oct								
24...	<.1	<.10	<10	<10	4.3	.4	4.7	20
Nov								
28...	<.1	<.10	<10	<10	3.0	.4	3.1	6
Dec								
27...	<.1	.10	<10	<10	3.1	.3	3.3	10
1985 Jan								
29...	<.1	.10	<10	<10	2.3	.2	2.5	4
Feb								
25...	.1	--	<10	<10	11	1.4	13	57
Mar								
25...	.1	.20	10	10	4.2	.4	5.5	25
Apr								
24...	<.1	.20	<10	<10	5.8	2.9	8.7	106
May								
20...	<.1	.10	<10	10	7.0	.7	7.4	23
June								
17...	<.1	.20	<10	20	6.0	--	11	98
July								
22...	<.1	<.10	<10	<10	2.9	--	3.3	21
Aug								
19...	.1	.30	<10	<10	3.7	--	4.6	46
Sept								
23...	<.1	<.10	10	10	2.7	--	2.9	21

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Sediment, discharge, suspended (tons/d)	Sed. susp. sieve diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.002 mm	Sed. susp. fall diam. % finer than 0.004 mm	Sed. susp. fall diam. % finer than 0.008 mm	Sed. susp. fall diam. % finer than 0.016 mm	Sed. susp. fall diam. % finer than 0.031 mm	Sed. susp. fall diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.125 mm	Sed. susp. fall diam. % finer than 0.250 mm	Sed. susp. fall diam. % finer than 0.500 mm
						CEDAR RIVER AT FLOYD--continued					
1984 May											
22...	131	96	65	76	81	87	95	--	--	--	--
June											
09...	3,170	--	69	76	81	87	--	98	98	99	100
19...	5,990	--	38	43	49	54	--	60	61	67	98
July											
16...	566	--	51	63	74	82	--	97	98	99	100
Aug											
14...	16	95	34	47	56	69	90	--	--	--	--
Sept											
19...	14	98	27	33	54	65	81	--	--	--	--
Oct											
24...	16	95	--	--	--	--	--	--	--	--	--
Nov											
28...	5.4	95	--	--	--	--	--	--	--	--	--
Dec											
27...	10	65	--	--	--	--	--	--	--	--	--
1985 Jan											
29...	10	72	--	--	--	--	--	--	--	--	--
Feb											
25...	359	98	--	--	--	--	--	--	--	--	--
Mar											
25...	32	98	--	--	--	--	--	--	--	--	--
Apr											
24...	313	--	40	50	62	76	91	95	98	99	100
May											
20...	23	94	--	--	--	--	--	--	--	--	--
June											
17...	87	99	74	85	92	96	96	--	--	--	--
July											
22...	8.0	97	--	--	--	--	--	--	--	--	--
Aug											
19...	13	99	--	--	--	--	--	--	--	--	--
Sept											
23...	15	92	--	--	--	--	--	--	--	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Time	Streamflow, instantaneous (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Temperature, air (°C)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	Oxygen demand, chemical (high level) (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L $CaCO_3$)
CEDAR RIVER NEAR CARVILLE											
1984 May											
22...	1245	1,100	540	8.5	--	20.0	9.8	113	20	270	73
June											
10...	0940	3,930	400	7.9	--	18.5	7.9	88	40	65	--
19...	1130	5,120	385	8.1	--	20.5	7.5	86	44	190	63
July											
17...	0820	1,360	495	8.2	--	22.0	7.3	87	28	250	69
Aug											
14...	1115	299	530	8.1	--	24.5	7.5	93	20	270	61
Sept											
19...	1130	204	520	8.3	--	17.0	8.5	91	28	250	60
Oct											
24...	1200	328	556	7.9	12.0	6.5	8.9	74	16	290	90
Nov											
28...	1245	363	598	8.1	0.0	2.5	13.2	101	8	290	64
Dec											
27...	1230	415	640	7.2	3.5	1.0	12.8	93	12	330	100
1985 Jan											
29...	1330	1,110	695	7.8	-3.0	0.0	10.4	74	8	320	72
Mar											
26...	0900	500	520	7.9	10.0	6.0	--	--	24	250	60
Apr											
25...	0900	910	540	8.4	13.0	15.0	8.6	88	24	270	78
May											
21...	0915	375	580	8.2	14.0	18.0	--	--	20	280	66
June											
18...	0845	355	580	8.0	17.0	18.0	7.2	79	45	270	60
July											
23...	0900	154	580	8.3	19.5	22.0	8.1	95	20	310	87
Aug											
20...	0910	110	400	8.6	14.0	19.0	10.4	115	44	190	44
Sept											
24...	0910	289	500	7.9	7.0	11.5	10.0	95	12	260	60
Oct											
28...	1445	430	590	8.2	15.0	11.5	13.2	124	12	310	75
Nov											
18...	1300	720	570	6.6	12.0	6.0	13.6	116	8	280	68

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Alka-linity, labora-tory (mg/L as $CaCO_3$)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Flou-ride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, residue at 105 deg. C, dis-solved (mg/L)	Solids, residue at 105 deg. C, total (mg/L)
					CEDAR RIVER NEAR CARVILLE--continued						
1984 May											
22...	74	21	9.3	1.7	198	32	19	0.20	8.2	311	349
June											
10...	--	14	5.1	2.7	125	19	14	.20	11	255	594
19...	52	14	6.1	2.9	125	18	16	.20	12	243	562
July											
17...	67	20	10	2.3	181	35	18	.20	16	293	478
Aug											
14...	68	24	13	2.7	208	31	20	.20	2.8	306	366
Sept											
19...	61	24	15	2.3	191	40	24	--	1.0	303	321
Oct											
24...	78	23	11	4.1	199	36	22	--	17	302	343
Nov											
28...	78	22	11	2.0	221	36	22	.20	12	353	372
Dec											
27...	87	27	12	2.6	224	41	28	.20	16	363	402
1985 Jan											
29...	85	26	20	2.6	247	44	32	.20	16	382	407
Mar											
26...	69	20	10	2.9	195	26	20	.20	14	295	336
Apr											
25...	70	23	9.7	2.0	192	28	21	.20	7.8	295	404
May											
21...	77	22	13	2.1	217	38	23	.25	5.6	333	389
June											
18...	70	22	13	2.2	205	33	23	.25	11	370	439
July											
23...	77	28	15	2.7	221	34	24	.25	11	292	378
Aug											
20...	36	24	18	2.3	145	39	24	.25	<.1	210	259
Sept											
24...	70	21	10	2.6	201	26	18	.20	11	293	334
Oct											
28...	81	26	9.7	2.0	234	44	24	.35	10	340	381
Nov											
18...	73	23	10	2.1	209	34	24	.20	4.8	333	324

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers23 at the six sampling sites--Continued

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Nitrogen, organic, dissolved (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
					CEDAR RIVER NEAR CARVILLE--continued						
1984 May											
22...	7.1	7.1	0.02	0.01	0.19	0.27	0.17	0.26	0.07	0.12	0.07
June											
10...	8.9	8.8	.21	.19	.65	2.2	.44	2.0	--	.34	.20
19...	8.6	8.5	.48	.39	.84	2.4	.36	2.0	.18	.51	.17
July											
17...	6.1	6.1	.04	.05	.28	1.1	.24	1.0	.18	.38	.14
Aug											
14...	3.40	3.40	.01	.01	.39	.94	.38	.93	.43	.22	.06
Sept											
19...	3.20	3.10	< .01	< .01	.22	.97	--	--	.03	.17	.01
Oct											
24...	4.70	4.70	.08	.11	.79	.68	.71	.57	.24	.31	.24
Nov											
28...	5.90	6.00	.18	.18	.43	.51	.25	.33	.28	.29	.05
Dec											
27...	7.60	7.40	.24	.25	.36	.45	.12	.20	.23	.27	.16
1985 Jan											
29...	5.70	5.70	.45	.23	.71	.52	.26	.29	.19	.21	.19
Mar											
26...	4.40	4.30	.22	.21	.89	.88	.67	.67	.19	.26	.16
Apr											
25...	5.30	5.20	.03	.04	.44	1.3	.41	1.3	.31	.40	.09
May											
21...	4.30	4.20	.04	.03	.52	1.1	.48	1.1	.25	.34	.20
June											
18...	5.30	5.30	.11	.10	.43	1.3	.32	1.2	.21	.33	.21
July											
23...	2.70	2.60	.04	.05	.70	1.5	.66	1.5	.31	.41	.21
Aug											
20...	.30	.40	.04	.05	.43	2.0	.39	2.0	.14	.29	.13
Sept											
24...	2.80	2.90	.07	.13	--	--	--	--	.24	.23	.23
Oct											
28...	6.30	6.20	.01	.03	.40	.55	.39	.52	.13	.08	.13
Nov											
18...	4.00	5.50	<.01	<.01	.78	.49	--	--	.06	.08	.05

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Arsenic, dis-solved (µg/L as As)	Arsenic, total (µg/L as As)	Copper, dis-solved (µg/L as Cu)	Copper, total recov-erable (µg/L as Cu)	Iron, total recov-erable (µg/L as Fe)	Iron, dis-solved (µg/L as Fe)	Lead, dis-solved (µg/L as Pb)	Lead, total recov-erable (µg/L as Pb)	Manga-nese, total recov-erable (µg/L as Mn)	Manga-nese, dis-solved (µg/L as Mn)
					CEDAR RIVER NEAR CARVILLE--continued					
1984 May										
22...	<10	<10	<10	<10	--	--	<10	<10	--	--
June										
10...	<10	<10	<10	<10	2,600	--	<10	10	190	--
19...	<10	<10	<10	<10	5,600	--	<10	<10	20	--
July										
17...	<10	<10	<10	<10	--	<10	--	--	--	<10
Aug										
14...	20	20	<10	30	--	--	<10	<10	--	--
Sept										
19...	20	20	<10	<10	250	<10	<10	<10	100	40
Oct										
24...	<10	<10	<10	<10	250	<10	<10	<10	50	20
Nov										
28...	<10	<10	<10	10	160	<10	<10	20	50	40
Dec										
27...	<10	<10	<10	<10	200	40	<10	<10	10	10
1985 Jan										
29...	10	10	10	40	130	10	<10	<10	80	20
Mar										
26...	20	20	20	30	560	50	<10	<10	50	40
Apr										
25...	<10	<10	<10	<10	910	20	<10	<10	120	<10
May										
21...	10	10	20	60	810	10	<10	<10	90	10
June										
18...	<10	<10	<10	10	960	<10	<10	<10	150	20
July										
23...	30	30	40	40	600	<10	<10	<10	80	<10
Aug										
20...	20	20	<10	<10	470	<10	<10	<10	250	10
Sept										
24...	20	20	<10	<10	440	<10	<10	<10	80	<10
Oct										
28...	20	20	<10	10	270	<10	<10	<10	40	20
Nov										
18...	<10	<10	<10	<10	--	--	<10	<10	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Mercury, dissolved (µg/L as Hg)	Mercury, total recoverable (µg/L as Hg)	Zinc, dissolved (µg/L as Zn)	Zinc, total recoverable (µg/L as Zn)	Carbon, organic, dissolved (mg/L as C)	Carbon, organic, suspended total (mg/L as C)	Carbon, organic, total (mg/L as C)	Sediment, suspended (mg/L)
CEDAR RIVER NEAR CARVILLE--continued								
1984 May								
22...	0.1	<0.1	<10	<10	3.3	--	3.3	31
June								
10...	.2	.2	<10	40	4.3	--	13	278
19...	<.1	<.1	30	130	5.7	--	20	295
July								
17...	<.1	<.1	<10	<10	5.3	--	10	152
Aug								
14...	<.1	.1	10	<10	2.8	1.1	3.4	53
Sept								
19...	<.1	<.2	<10	10	4.2	.7	7.5	48
Oct								
24...	<.1	<.1	<10	<10	4.4	.4	5.4	15
Nov								
28...	<.1	<.1	<10	<10	3.4	.3	5.0	9
Dec								
27...	<.1	<.1	<10	<10	3.0	.3	3.5	6
1985 Jan								
29...	<.1	<.1	<10	10	2.8	.2	3.0	3
Mar								
26...	<.1	<.1	10	10	3.9	.3	4.9	22
Apr								
25...	<.1	<.1	<10	<10	5.3	2.9	8.2	80
May								
21...	.1	.2	<10	10	5.1	.6	6.5	54
June								
18...	<.1	.1	<10	<10	5.4	--	7.2	55
July								
23...	<.1	<.1	<10	<10	3.2	--	4.1	36
Aug								
20...	.2	.2	<10	<10	3.6	--	4.7	27
Sept								
24...	<.1	.1	10	110	2.8	--	4.3	31
Oct								
28...	<.1	<.1	<10	10	4.7	.4	5.3	17
Nov								
18...	<.1	<.1	<10	20	3.5	1.2	4.5	11

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Sediment, discharge, suspended (tons/d)	Sed. susp. sieve diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.002 mm	Sed. susp. fall diam. % finer than 0.004 mm	Sed. susp. fall diam. % finer than 0.008 mm	Sed. susp. fall diam. % finer than 0.016 mm	Sed. susp. fall diam. % finer than 0.031 mm	Sed. susp. fall diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.125 mm	Sed. susp. fall diam. % finer than 0.250 mm	Sed. susp. fall diam. % finer than 0.500 mm
					CEDAR RIVER NEAR CARVILLE--continued						
1984 May											
22...	92	98	63	74	85	89	91	--	--	--	--
June											
10...	2,950	100	73	82	85	92	--	--	--	--	--
19...	4,080	--	61	73	83	93	--	98	99	99	100
July											
17...	556	99	65	79	86	92	97	--	--	--	--
Aug											
14...	43	99	55	69	85	94	96	--	--	--	--
Sept											
19...	26	99	21	32	49	95	99	--	--	--	--
Oct											
24...	13	98	--	--	--	--	--	--	--	--	--
Nov											
28...	8.8	82	--	--	--	--	--	--	--	--	--
Dec											
27...	6.7	95	--	--	--	--	--	--	--	--	--
1985 Jan											
29...	9.0	99	--	--	--	--	--	--	--	--	--
Mar											
26...	30	97	--	--	--	--	--	--	--	--	--
Apr											
25...	197	98	41	50	66	81	93	--	--	--	--
May											
21...	55	98	--	--	--	--	--	--	--	--	--
June											
18...	53	100	--	--	--	--	--	--	--	--	--
July											
23...	15	99	50	66	83	94	96	--	--	--	--
Aug											
20...	8.0	99	--	--	--	--	--	--	--	--	--
Sept											
24...	24	97	--	--	--	--	--	--	--	--	--
Oct											
28...	20	--	--	--	--	--	--	84	--	--	--
Nov											
18...	21	89	--	--	--	--	--	--	--	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Time	Streamflow, instantaneous (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Temperature, air (°C)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	Oxygen demand, chemical (high level) (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L $CaCO_3$)
					SHELL ROCK RIVER NEAR NORTHWOOD						
1984 May											
21...	1635	482	530	8.5	--	22.0	9.4	114	48	260	89
June											
09...	1330	284	530	8.4	--	19.5	10.0	115	56	260	74
18...	1615	910	405	8.1	--	22.0	--	--	77	200	66
July											
16...	1215	504	458	8.7	--	25.0	10.0	127	81	230	52
Aug											
13...	1515	79	615	8.4	--	27.0	9.1	119	60	290	73
Sept											
18...	1400	27	750	8.6	--	22.0	11.8	139	42	330	73
Oct											
23...	1352	118	562	7.7	12.0	9.0	9.2	82	68	260	65
Nov											
27...	1500	127	579	8.6	0.0	4.0	12.5	100	52	260	67
Dec											
26...	1530	170	--	8.0	-2.0	2.0	12.0	100	--	--	--
1985 Jan											
28...	1430	40	940	7.3	-8.0	0.0	12.5	89	36	410	110
Mar											
25...	1145	252	520	7.7	2.5	3.5	--	--	36	290	64
Apr											
24...	1400	236	565	8.3	16.0	15.0	10.0	104	53	390	200
May											
20...	1230	110	600	7.7	20.0	19.0	--	--	61	360	73
June											
17...	1315	100	610	8.5	22.0	21.5	11.0	130	100	280	73
July											
22...	1345	21	900	8.7	24.0	28.0	7.4	98	36	330	62
Aug											
19...	1315	15	938	8.5	24.0	24.0	14.4	177	40	390	110
Sept											
23...	1230	69	640	8.0	9.0	12.0	10.6	103	60	270	54
Oct											
28...	1200	144	690	8.4	15.0	9.0	14.2	126	49	340	92
Nov											
18...	1200	170	690	8.4	9.0	6.0	13.0	109	37	310	79

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Flouride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 105 deg. C, dissolved (mg/L)	Solids, residue at 105 deg. C, total (mg/L)
SHELL ROCK RIVER NEAR NORTHWOOD--continued											
1984 May											
21...	67	23	8.3	2.5	173	42	23	0.20	8.0	315	400
June											
09...	62	25	13	2.8	184	44	28	.20	12	327	440
18...	54	17	6.4	3.3	139	22	17	.20	15	275	585
July											
16...	54	22	12	2.3	173	32	23	.20	17	276	500
Aug											
13...	71	27	26	4.3	215	44	40	--	28	390	485
Sept											
18...	83	29	35	5.4	254	58	56	.25	18	484	502
Oct											
23...	66	23	18	3.7	195	44	35	--	27	315	398
Nov											
27...	63	26	15	3.1	197	42	32	.20	10	347	412
1985 Jan											
28...	100	38	35	5.0	298	78	58	.25	21	532	559
Mar											
25...	63	19	12	3.6	172	33	24	.15	14	299	337
Apr											
24...	67	53	15	3.2	188	46	30	.20	10	330	454
May											
20...	63	25	20	3.4	187	46	37	.25	11	359	440
June											
17...	64	29	18	3.3	206	42	35	.25	16	390	507
July											
22...	79	33	58	5.8	271	60	82	.35	21	524	556
Aug											
19...	95	37	79	6.4	282	56	100	.35	9.5	563	628
Sept											
23...	67	25	28	4.3	216	37	46	.20	28	404	465
Oct											
28...	83	32	16	3.6	247	46	36	.30	22	365	458
Nov											
18...	77	29	19	3.5	233	56	38	.35	17	406	429

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Nitrogen, organic, dissolved (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
					SHELL ROCK RIVER NEAR NORTHWOOD--continued						
1984 May											
21...	4.80	4.80	0.02	0.02	0.30	--	0.28	--	0.05	0.17	0.02
June											
09...	4.00	3.90	.10	.20	.94	3.2	.84	3.0	--	.18	.09
18...	6.90	6.80	.44	.56	1.2	3.8	.76	3.2	.28	.73	.20
July											
16...	3.10	3.20	.01	.01	1.1	3.8	1.1	3.8	.17	.52	.11
Aug											
13...	3.00	3.00	.09	.10	1.1	3.0	1.0	2.9	.66	.93	.62
Sept											
18...	5.90	5.80	.01	.06	.78	2.2	.77	2.1	1.10	1.20	1.00
Oct											
23...	2.60	2.60	.95	1.00	1.7	3.6	.75	2.6	.62	.87	.54
Nov											
27...	3.40	3.20	.10	.15	1.1	2.9	1.0	2.8	.25	.70	.01
1985 Jan											
28...	5.80	5.90	.70	.71	1.8	2.3	1.1	1.6	.94	1.10	.93
Mar											
25...	3.60	3.60	.13	.13	.99	1.7	.86	1.6	.28	.44	.21
Apr											
24...	3.50	3.60	.11	.06	.98	2.6	.87	2.5	.33	.54	.20
May											
20...	2.50	2.60	.02	.03	.81	2.3	.79	2.3	.46	.98	.41
June											
17...	3.00	3.10	.01	.08	1.5	4.9	1.5	4.8	.47	.90	.43
July											
22...	4.40	4.50	.03	.31	1.4	2.7	1.4	2.4	.86	.31	.14
Aug											
19...	9.00	9.20	.02	.11	.77	2.1	.75	2.0	1.20	1.50	1.10
Sept											
23...	3.80	3.70	.05	.06	--	--	--	--	.90	1.20	.89
Oct											
28...	4.20	4.10	.11	.13	1.1	2.3	.99	2.2	.41	.55	.41
Nov											
18...	5.10	5.00	<.01	.02	.72	1.5	--	1.5	.34	.50	.32

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Arsenic, dis- solved (µg/L as As)	Arsenic, total (µg/L as As)	Copper, dis- solved (µg/L as Cu)	Copper, total recov- erable (µg/L as Cu)	Iron, total recov- erable (µg/L as Fe)	Iron, dis- solved (µg/L as Fe)	Lead, dis- solved (µg/L as Pb)	Lead, total recov- erable (µg/L as Pb)	Manga- nese, total recov- erable (µg/L as Mn)	Manga- nese, dis- solved (µg/L as Mn)
				SHELL ROCK RIVER NEAR NORTHWOOD--continued						
1984 May										
21...	<10	<10	<10	<10	--	--	<10	<10	--	--
June										
09...	<10	<10	<10	<10	560	--	<10	<10	140	--
18...	<10	<10	<10	<10	7,600	--	<10	<10	40	--
July										
16...	<10	<10	<10	<10	--	130	--	--	--	40
Aug										
13...	<10	<10	<10	20	--	--	<10	10	--	--
Sept										
18...	<10	<10	<10	<10	140	<10	<10	<10	50	20
Oct										
23...	<10	<10	<10	<10	370	10	<10	<10	110	<10
Nov										
27...	<10	<10	<10	<10	300	10	<10	<10	100	30
1985 Jan										
28...	<10	<10	10	30	220	<10	<10	<10	120	20
Mar										
25...	<10	<10	10	30	450	30	<10	<10	110	30
Apr										
24...	<10	<10	<10	<10	980	20	<10	<10	190	40
May										
20...	<10	<10	60	130	790	<10	<10	<10	180	20
June										
17...	<10	<10	10	50	1,300	<10	<10	<10	280	<10
July										
22...	<10	<10	100	90	150	<10	<10	<10	140	20
Aug										
19...	<10	<10	<10	<10	190	10	<10	<10	90	30
Sept										
23...	<10	<10	10	10	420	30	<10	<10	150	30
Oct										
28...	<10	<10	<10	<10	340	<10	<10	<10	110	20
Nov										
18...	<10	<10	<10	<10	--	20	<10	<10	--	30

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Mercury, dis- solved (µg/L as Hg)	Mercury, total recov- erable (µg/L as Hg)	Zinc, dis- solved (µg/L as Zn)	Zinc, total recov- erable (µg/L as Zn)	Carbon, organic, dis- solved (mg/L as C)	Carbon, organic, sus- pended total (mg/L as C)	Carbon, organic, total (mg/L as C)	Sedi- ment, sus- pended (mg/L)
			SHELL ROCK RIVER NEAR NORTHWOOD--continued					
1984 May								
21...	0.1	<0.1	<10	30	6.0	--	6.6	63
June								
09...	<.1	<.1	<10	<10	6.2	--	13	42
18...	<.1	<.1	30	100	10	--	24	319
July								
16...	<.1	.2	<10	20	9.6	--	19	127
Aug								
13...	<.1	.1	<10	<10	7.3	3.2	8.2	49
Sept								
18...	.6	.4	<10	<10	7.6	2.4	10	13
Oct								
23...	<.1	<.1	<10	<10	10	1.8	10	34
Nov								
27...	<.1	.1	10	<10	7.6	3.2	9.2	37
1985 Jan								
28...	<.1	<.1	<10	<10	7.2	.9	7.4	4
Mar								
25...	.3	.1	10	10	7.4	6.6	11	25
Apr								
24...	<.1	<.1	<10	<10	12	5.0	17	93
May								
20...	<.1	.1	<10	10	10	2.7	11	62
June								
17...	<.1	.2	10	40	10	--	20	101
July								
22...	<.1	<.1	<10	<10	6.9	--	6.9	18
Aug								
19...	.2	.2	<10	<10	6.3	--	7.8	18
Sept								
23...	<.1	.1	30	40	7.1	--	7.5	32
Oct								
28...	<.1	<.1	<10	20	8.9	.8	11	24
Nov								
18...	<.1	<.1	<10	10	9.2	2.4	9.7	39

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Sediment, discharge, suspended (tons/d)	Sed. susp. sieve diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.002 mm	Sed. susp. fall diam. % finer than 0.004 mm	Sed. susp. fall diam. % finer than 0.008 mm	Sed. susp. fall diam. % finer than 0.016 mm	Sed. susp. fall diam. % finer than 0.031 mm	Sed. susp. fall diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.125 mm	Sed. susp. fall diam. % finer than 0.250 mm	Sed. susp. fall diam. % finer than 0.500 mm
						SHELL ROCK RIVER NEAR NORTHWOOOD--continued					
1984 May											
21...	82	96	50	64	79	87	94	--	--	--	--
June											
09...	32	--	49	65	81	88	--	--	--	--	--
18...	784	--	74	78	88	93	--	98	99	100	--
July											
16...	173	--	59	72	81	88	93	95	98	100	--
Aug											
13...	10	99	50	66	85	94	97	--	--	--	--
Sept											
18...	0.95	96	55	64	74	83	90	--	--	--	--
Oct											
23...	11	97	--	--	--	--	--	--	--	--	--
Nov											
27...	13	99	--	--	--	--	--	--	--	--	--
1985 Jan											
28...	2.8	100	--	--	--	--	--	--	--	--	--
Mar											
25...	17	97	--	--	--	--	--	--	--	--	--
Apr											
24...	59	98	38	53	71	84	96	--	--	--	--
May											
20...	18	98	49	71	87	95	95	--	--	--	--
June											
17...	27	98	39	61	71	92	96	--	--	--	--
July											
22...	1.0	95	--	--	--	--	--	--	--	--	--
Aug											
19...	0.73	91	--	--	--	--	--	--	--	--	--
Sept											
23...	6.0	98	--	--	--	--	--	--	--	--	--
Oct											
28...	9.3	--	--	--	--	--	--	100	--	--	--
Nov											
18...	18	99	--	--	--	--	--	--	--	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Time	Streamflow, instantaneous (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Temperature, air (°C)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	Oxygen demand, chemical (high level) (mg/L)	Hardness (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L $CaCO_3$)
					CEDAR RIVER AT CEDAR FALLS						
1984 May											
23...	0940	5,720	540	8.5	--	17.5	9.1	100	24	280	77
June											
10...	1310	12,800	320	7.5	--	19.5	6.6	74	87	140	35
20...	0910	22,800	320	7.9	--	22.0	5.6	66	52	160	44
July											
17...	1215	7,440	500	8.2	--	22.5	--	--	45	260	71
Aug											
15...	0855	1,880	430	8.3	--	23.5	8.4	102	36	220	66
Sept											
20...	0830	947	420	8.4	--	19.0	10.1	112	38	170	22
Oct											
24...	1530	1,450	567	7.8	12.0	7.5	7.8	66	16	300	91
Nov											
28...	1445	1,430	595	8.1	3.5	3.0	14.0	107	12	290	63
Dec											
27...	1530	1,430	662	7.6	5.0	0.0	12.0	84	12	330	100
1985 Jan											
30...	0900	740	605	7.6	-12.0	0.0	10.2	71	12	320	81
Feb											
26...	1000	7,710	266	7.2	1.0	0.0	--	--	64	110	29
Mar											
26...	1120	3,130	545	7.8	12.0	6.5	--	--	16	260	63
Apr											
25...	1200	3,350	520	8.4	14.5	15.0	9.6	98	33	260	70
May											
21...	1130	1,980	510	8.2	20.0	19.0	--	--	28	250	76
June											
18...	1115	2,500	610	7.8	18.0	19.0	8.1	90	20	290	83
July											
23...	1130	790	440	8.5	24.0	23.0	7.9	94	28	190	47
Aug											
20...	1130	680	420	8.2	14.5	21.0	9.0	103	32	200	50
Sept											
24...	1130	1,110	480	8.1	12.0	12.0	11.1	105	24	250	59

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl	Flouride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, residue at 105 deg. C, dissolved (mg/L)	Solids, residue at 105 deg. C, total (mg/L)
					CEDAR RIVER AT CEDAR FALLS--continued						
1984 May											
23...	77	21	7.2	2.2	202	32	19	0.20	8.3	329	397
June											
10...	41	10	6.3	3.9	109	18	9.5	.30	9.1	206	688
20...	44	11	6.4	3.4	111	15	10	.25	11	204	532
July											
17...	71	20	9.1	3.1	189	33	17	.25	15	315	569
Aug											
15...	50	23	10	3.5	154	32	18	.20	6.6	263	320
Sept											
20...	36	19	12	3.0	146	40	22	--	1.2	228	297
Oct											
24...	82	23	11	4.1	208	49	22	--	15	310	342
Nov											
28...	78	22	10	3.3	222	42	22	.20	11	352	381
Dec											
27	90	26	13	2.9	228	43	28	.20	16	381	416
1985 Jan											
30...	88	25	15	3.6	242	49	24	.20	16	384	407
Feb											
26...	30	8.3	8.6	7.1	80	22	12	.10	11	138	313
Mar											
26...	71	19	8.6	3.4	193	30	19	.20	14	307	354
Apr											
25...	66	22	10	3.2	185	34	22	.20	5.2	295	408
May											
21...	65	22	11	2.3	177	32	22	.25	4.0	269	340
June											
18...	77	24	10	2.4	208	36	23	.25	12	381	480
July											
23...	38	23	12	2.9	143	40	22	.25	2.6	224	296
Aug											
20...	44	22	14	2.8	150	36	23	.20	2.4	222	280
Sept											
24...	66	21	12	2.9	192	40	20	.20	12	297	345

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Nitrogen, organic, dissolved (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
					CEDAR RIVER AT CEDAR FALLS--continued						
1984 May											
23...	7.10	7.10	0.01	0.02	0.16	0.35	0.15	0.33	0.05	0.09	0.05
June											
10...	6.20	6.00	.49	.52	.86	3.8	.37	3.3	--	.47	.18
20...	6.30	6.20	.33	.37	.88	3.6	.55	3.2	.19	.58	.16
July											
17...	6.50	6.40	<.01	.02	.46	1.8	--	1.8	.15	.43	.11
Aug											
15...	2.30	2.30	<.01	<.01	.30	1.7	--	--	.07	.22	.01
Sept											
20...	2.00	2.00	<.01	<.01	.26	1.4	--	--	.03	.16	.03
Oct											
24...	3.90	3.90	.21	.06	.38	.6	.17	.54	.32	.54	.21
Nov											
28...	4.70	4.70	.05	.06	.63	.7	.58	.64	.28	.33	.04
Dec											
27...	6.20	6.60	.08	.08	.26	.4	.18	.32	.20	.24	.13
1985 Jan											
30...	5.70	5.60	.22	.45	.48	.89	.26	.44	.24	.28	.21
Feb											
26...	3.60	3.70	1.00	1.00	2.8	3.4	1.8	2.4	.48	.76	.46
Mar											
26...	4.50	4.50	.04	.05	.55	.98	.51	.93	.14	.21	.11
Apr											
25...	4.50	4.30	.02	.02	.45	1.8	.43	1.8	.27	.38	.05
May											
21...	3.40	3.40	.01	.04	.53	1.7	.52	1.7	.19	.26	.04
June											
18...	8.30	8.40	.02	.07	.33	1.1	.31	1.0	.20	.30	.12
July											
23...	1.20	1.20	<.01	<.01	.62	1.8	--	--	.16	.26	.06
Aug											
20...	.60	.60	.04	.09	.30	1.7	.26	1.6	.16	.16	.13
Sept											
24...	2.10	1.90	.10	.04	--	--	--	--	.05	.23	.01

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Arsenic, dis-solved (µg/L as As)	Arsenic, total (µg/L as As)	Copper, dis-solved (µg/L as Cu)	Copper, total recov-erable (µg/L as Cu)	Iron, total recov-erable (µg/L as Fe)	Iron, dis-solved (µg/L as Fe)	Lead, dis-solved (µg/L as Pb)	Lead, total recov-erable (µg/L as Pb)	Manga-nese, total recov-erable (µg/L as Mn)	Manga-nese, dis-solved (µg/L as Mn)
				CEDAR RIVER AT CEDAR FALLS--continued						
1984 May										
23...	<10	<10	<10	<10	--	--	<10	<10	--	--
June										
10...	<10	<10	<10	<10	2,800	--	<10	<10	420	--
20...	<10	<10	<10	<10	8,400	--	<10	20	20	--
July										
17...	<10	<10	<10	<10	--	30	--	--	--	<10
Aug										
15...	<10	<10	<10	10	--	--	<10	<10	--	--
Sept										
20...	<10	<10	<10	<10	520	<10	<10	<10	140	<10
Oct										
24...	<10	<10	10	10	270	<10	<10	<10	50	<10
Nov										
28...	<10	<10	<10	10	220	<10	<10	<10	40	10
Dec										
27...	<10	<10	<10	<10	140	10	<10	<10	30	10
1985 Jan										
30...	<10	<10	<10	20	110	<10	<10	<10	30	20
Feb										
26...	<10	<10	<10	<10	2,200	210	<10	<10	160	30
Mar										
26...	<10	<10	10	30	550	60	<10	<10	50	10
Apr										
25...	<10	<10	<10	<10	500	40	<10	<10	140	<10
May										
21...	<10	<10	20	70	580	10	<10	<10	90	10
June										
18...	<10	<10	10	30	1,100	<10	<10	<10	110	<10
July										
23...	<10	<10	20	20	680	30	<10	<10	150	<10
Aug										
20...	<10	<10	<10	<10	590	<10	<10	<10	170	<10
Sept										
24...	<10	<10	10	30	410	30	<10	<10	90	10

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Mercury, dis-solved (µg/L as Hg)	Mercury, total recov-erable (µg/L as Hg)	Zinc, dis-solved (µg/L as Zn)	Zinc, total recov-erable (µg/L as Zn)	Carbon, organic, dis-solved (mg/L as C)	Carbon, organic, sus-pended total (mg/L as C)	Carbon, organic, total (mg/L as C)	Sedi-ment, sus-pended (mg/L)
			CEDAR RIVER AT CEDAR FALLS--continued					
1984 May								
23...	--	<0.1	<10	<10	3.5	--	3.7	73
June								
10...	<0.1	.2	<10	50	5.0	--	35	494
20...	<.1	<.1	40	60	6.4	--	18	344
July								
17...	<.1	<.1	<10	<10	3.6	--	13	233
Aug								
15...	<.1	<.1	<10	<10	2.5	2.4	3.5	46
Sept								
20...	<.1	.2	<10	20	3.7	2.7	6.7	35
Oct								
24...	<.1	<.1	<10	<10	4.5	.7	5.5	14
Nov								
28...	<.1	<.1	10	<10	3.8	1.3	4.0	14
Dec								
27...	.1	<.1	<10	<10	4.0	.4	4.2	4
1985 Jan								
30...	<.1	<.1	<10	<10	2.6	.3	2.7	3
Feb								
26...	.3	.3	<10	<10	14	1.8	17	151
Mar								
26...	<.1	<.1	10	10	4.1	.6	5.3	35
Apr								
25...	<.1	<.1	<10	<10	5.6	5.4	11	76
May								
21...	.1	.4	<10	10	4.6	1.8	6.2	52
June								
18...	<.1	<.1	<10	20	5.0	--	6.2	53
July								
23...	<.1	<.1	<10	<10	4.3	--	4.5	44
Aug								
20...	<.1	.1	<10	<10	2.9	--	4.5	36
Sept								
24...	<.1	<.1	20	50	3.5	--	3.9	32

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Sediment, discharge, suspended (tons/d)	Sed. susp. sieve diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.002 mm	Sed. susp. fall diam. % finer than 0.004 mm	Sed. susp. fall diam. % finer than 0.008 mm	Sed. susp. fall diam. % finer than 0.016 mm	Sed. susp. fall diam. % finer than 0.031 mm	Sed. susp. fall diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.125 mm	Sed. susp. fall diam. % finer than 0.250 mm	Sed. susp. fall diam. % finer than 0.500 mm
						CEDAR RIVER AT CEDAR FALLS--continued					
1984 May											
23...	1,130	--	--	--	--	--	--	74	74	76	93
June											
10...	17,100	--	85	89	91	93	--	95	96	98	100
20...	21,200	--	81	82	85	88	--	90	90	93	97
July											
17...	4,680	--	57	66	75	85	--	96	96	97	100
Aug											
15...	234	98	33	48	73	94	98	--	--	--	--
Sept											
20...	89	98	49	82	85	91	98	--	--	--	--
Oct											
24...	59	99	--	--	--	--	--	--	--	--	--
Nov											
28...	21	98	--	--	--	--	--	--	--	--	--
Dec											
27...	6.0	96	--	--	--	--	--	--	--	--	--
1985 Jan											
30...	16	97	--	--	--	--	--	--	--	--	--
Feb											
26...	3,950	--	53	57	60	64	--	75	77	87	99
Mar											
26...	315	--	--	--	--	--	--	75	77	81	94
Apr											
25...	634	--	36	46	61	80	89	94	95	97	100
May											
21...	300	98	29	41	69	92	96	--	--	--	--
June											
18...	429	99	58	71	85	96	96	--	--	--	--
July											
23...	102	99	57	68	85	94	94	--	--	--	--
Aug											
0...	71	99	--	--	--	--	--	--	--	--	--
Sept											
24...	180	97	--	--	--	--	--	--	--	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Time	Stream-flow, instan-taneous (ft^3/s)	Spe-cific con-duct-ance (µS/cm)	pH (stand-ard units)	Temper-ature, air (°C)	Temper-ature, water (°C)	Oxygen, dis-solved (mg/L)	Oxygen, dis-solved (per-cent satur-ation)	Oxygen demand, chem-ical (high level) (mg/L)	Hard-ness (mg/L as $CaCO_3$)	Hard-ness, noncar-bonate (mg/L $CaCO_3$)
				CEDAR RIVER AT GILBERTVILLE							
1984 May											
23...	1315	5,960	550	8.6	--	20.0	7.3	84	28	280	78
June											
10...	1715	13,400	320	8.1	--	20.0	7.2	82	91	140	36
20...	1330	23,800	340	7.7	--	22.0	8.1	97	52	170	58
July											
19...	1115	6,550	560	8.2	--	22.5	7.4	88	28	270	76
Aug											
15...	1200	1,960	430	8.4	--	24.5	6.6	82	44	210	76
Sept											
20...	1230	985	418	8.7	--	18.0	7.8	84	38	190	53
Oct											
25...	1100	1,610	570	7.8	8.0	5.5	8.5	71	16	290	86
Nov											
30...	1030	1,620	589	8.4	1.0	3.0	13.1	100	12	280	62
Dec											
28...	0945	2,360	670	7.2	13.0	0.0	12.9	91	16	310	100
1985 Feb											
26...	1315	7,250	276	7.4	1.0	0.0	--	--	52	110	37
Mar											
26...	1445	3,700	535	7.7	23.0	8.5	--	--	20	250	59
Apr											
25...	1430	3,700	510	8.3	11.5	15.0	10.6	108	37	260	74
May											
21...	1400	2,170	470	8.7	22.0	22.0	--	--	41	220	69
June											
18...	1400	2,730	590	7.8	20.0	20.0	10.5	119	24	270	64
July											
23...	1400	893	410	8.9	29.0	25.0	7.9	98	36	190	60
Aug											
20...	1340	770	440	8.4	16.5	21.0	13.4	153	32	230	59
Sept											
24...	1445	1,240	460	8.5	17.0	14.0	14.2	141	32	230	61
Oct											
29...	0915	3,430	615	8.3	13.5	10.0	11.5	104	12	340	100
Nov											
19...	1000	4,200	620	7.2	-1.0	5.0	12.1	97	17	280	64

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Calcium, dis- solved (mg/L as Ca)	Magne- sium, dis- solved (mg/L as Mg)	Sodium, dis- solved (mg/L as Na)	Potas- sium, dis- solved (mg/L as K)	Alka- linity, labora- tory (mg/L as $CaCO_3$)	Sulfate, dis- solved (mg/L as SO_4)	Chlo- ride, dis- solved (mg/L as Cl)	Flou- ride, dis- solved (mg/L as F)	Silica, dis- solved (mg/L as SiO_2)	Solids, residue at 105 deg. C, dis- solved (mg/L)	Solids, residue at 105 deg. C, total (mg/L)
CEDAR RIVER AT GILBERTVILLE--continued											
1984 May											
23...	77	21	8.4	2.1	201	32	20	0.20	9.0	312	403
June											
10...	41	10	6.1	3.9	108	19	10	.30	8.3	194	890
20...	48	11	4.9	3.5	107	16	12	.30	11	209	--
July											
19...	73	21	10	2.6	193	39	18	.30	16	307	480
Aug											
15...	46	24	13	3.4	138	36	21	.20	6.2	246	334
Sept											
20...	38	22	14	3.1	132	44	24	--	1.0	227	319
Oct											
25...	80	23	13	4.1	208	44	24	--	16	306	352
Nov											
30...	76	22	12	3.1	218	42	23	.20	11	357	379
Dec											
28	81	25	23	3.5	203	35	46	.20	14	363	446
1985 Feb											
26...	32	8.3	7.8	7.2	77	22	11	.10	10	149	347
Mar											
26...	69	19	9.3	3.4	192	28	19	.20	13	299	365
Apr											
25...	66	22	11	3.1	181	37	22	.25	5.4	289	408
May											
21...	53	22	11	2.5	154	38	22	.25	2.8	250	337
June											
18...	74	21	11	2.4	207	40	24	.25	11	371	481
July											
23...	38	23	12	3.0	130	42	23	.30	1.0	217	293
Aug											
20...	54	22	15	3.0	166	36	15	.25	3.4	255	309
Sept											
24...	60	20	13	2.9	171	34	22	.20	9.5	268	341
Oct											
29...	91	28	9.7	2.2	239	40	24	.35	13	326	499
Nov											
19...	75	23	11	2.3	218	39	25	.25	8.4	351	377

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Nitrogen, organic, dissolved (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
					CEDAR RIVER AT GILBERTVILLE--continued						
1984 May											
23...	7.40	7.10	0.01	0.03	0.06	0.31	0.05	0.28	0.08	0.12	0.08
June											
10...	6.40	6.10	.77	.68	.92	4.5	.15	3.8	--	.57	.18
20...	6.40	6.50	.10	.36	.57	1.8	.47	1.4	.15	.68	.15
July											
19...	7.40	7.20	<.01	<.01	.45	1.4	--	--	.17	.37	.12
Aug											
15...	2.40	2.30	<.01	<.01	.32	2.0	--	--	.07	.26	<.01
Sept											
20...	1.80	1.80	<.01	.01	.17	1.4	--	1.4	.06	.26	.05
Oct											
25...	4.00	4.00	.09	.10	.34	.79	.25	.69	.39	.79	.25
Nov											
30...	4.80	5.10	.07	.11	.33	.81	.26	.70	.34	.38	.08
Dec											
28...	6.20	6.30	.15	.17	.41	.79	.26	.62	.19	.36	.19
1985 Feb											
26...	4.30	4.20	.97	1.00	2.5	4.0	1.5	3.0	.48	.86	.42
Mar											
26...	4.80	4.80	.05	.05	.49	.92	.44	.87	.17	.25	.14
Apr											
25...	4.50	4.70	.07	.03	.39	1.8	.32	1.8	.28	.41	.06
May											
21...	3.40	3.40	.01	.02	.41	2.0	.40	2.0	.15	.31	.03
June											
18...	7.80	7.80	.01	.01	.27	1.3	.26	1.3	.23	.31	.17
July											
23...	1.10	1.10	<.01	<.01	.56	2.2	--	--	.15	.34	.06
Aug											
20...	1.10	1.10	<.01	.02	.46	1.6	--	1.6	.19	.30	.18
Sept											
24...	1.60	1.60	.02	.05	--	--	--	--	.16	.14	.14
Oct											
29...	7.40	7.20	.01	.03	.28	.73	.27	.7	.08	.13	.08
Nov											
19...	5.60	7.40	<.01	.01	.42	.63	--	.62	.09	.15	.08

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Arsenic, dis-solved (µg/L as As)	Arsenic, total (µg/L as As)	Copper, dis-solved (µg/L as Cu)	Copper, total recov-erable (µg/L as Cu)	Iron, total recov-erable (µg/L as Fe)	Iron, dis-solved (µg/L as Fe)	Lead, dis-solved (µg/L as Pb)	Lead, total recov-erable (µg/L as Pb)	Manga-nese, total recov-erable (µg/L as Mn)	Manga-nese, dis-solved (µg/L as Mn)
CEDAR RIVER AT GILBERTVILLE--continued										
1984 May										
23...	<10	<10	<10	<10	--	--	<10	<10	--	--
June										
10...	<10	<10	<10	<10	3,500	--	<10	10	530	--
20...	<10	<10	<10	<10	8,500	--	<10	<10	20	--
July										
19...	<10	<10	<10	<10	--	<10	--	--	--	<10
Aug										
15...	<10	<10	10	30	--	--	<10	<10	--	--
Sept										
20...	<10	<10	<10	<10	360	<10	<10	<10	130	<10
Oct										
25...	<10	<10	<10	<10	270	10	<10	<10	50	10
Nov										
30...	<10	<10	<10	<10	170	<10	<10	<10	40	10
Dec										
28...	<10	<10	<10	<10	640	20	<10	<10	50	20
1985 Feb										
26...	<10	<10	<10	<10	3,000	180	<10	<10	180	30
Mar										
26...	<10	<10	10	20	580	<10	<10	<10	70	<10
Apr										
25...	<10	<10	<10	<10	940	50	<10	<10	140	<10
May										
21...	<10	<10	30	20	470	<10	<10	<10	60	<10
June										
18...	<10	<10	10	30	930	<10	<10	<10	110	<10
July										
23...	<10	<10	20	20	610	30	<10	<10	140	<10
Aug										
20...	<10	<10	<10	<10	580	<10	<10	<10	170	<10
Sept										
24...	<10	<10	<10	10	490	<10	<10	<10	110	10
Oct										
29...	<10	<10	<10	10	660	<10	<10	<10	70	<10
Nov										
19...	<10	<10	<10	<10	--	--	<10	<10	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Mercury, dis- solved (μg/L as Hg)	Mercury, total recov- erable (μg/L as Hg)	Zinc, dis- solved (μg/L as Zn)	Zinc, total recov- erable (μg/L as Zn)	Carbon, organic, dis- solved (mg/L as C)	Carbon, organic, sus- pended total (mg/L as C)	Carbon, organic, total (mg/L as C)	Sedi- ment, sus- pended (mg/L)
		CEDAR RIVER AT GILBERTVILLE--continued						
1984 May								
23...	0.1	<0.1	<10	<10	2.2	--	2.6	65
June								
10...	<.1	<.1	<10	90	6.1	--	38	676
20...	<.1	<.1	30	140	5.2	--	18	372
July								
19...	<.5	<.5	<10	<10	3.6	--	9.0	157
Aug								
15...	<.1	<.1	<10	<10	2.7	3.2	4.3	73
Sept								
20...	<.1	<.1	<10	30	6.8	1.6	11	46
Oct								
25...	<.1	<.1	<10	<10	3.0	.6	4.3	17
Nov								
30...	<.1	<.1	10	<10	3.7	1.3	3.5	10
Dec								
28...	.1	.2	<10	<10	4.6	.7	5.2	43
1985 Feb								
26...	<.1	.1	<10	<10	14	1.8	18	166
Mar								
26...	.1	<.1	10	10	4.4	.6	5.4	33
Apr								
25...	<.1	<.1	<10	<10	6.3	5.7	12	74
May								
21...	<.1	<.1	<10	<10	5.4	2.3	5.8	70
June								
18...	<.1	<.1	<10	10	5.0	--	7.6	57
July								
23...	<.1	<.1	<10	<10	4.5	--	5.9	55
Aug								
20...	.1	.1	<10	<10	2.9	--	3.7	40
Sept								
24...	<.1	<.1	10	20	3.2	--	3.8	48
Oct								
29...	<.1	<.1	<10	10	4.6	.8	4.9	40
Nov								
19...	<.1	<.1	<10	10	4.1	1.2	4.3	27

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Sediment, discharge, suspended (tons/d)	Sed. susp. sieve diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.002 mm	Sed. susp. fall diam. % finer than 0.004 mm	Sed. susp. fall diam. % finer than 0.008 mm	Sed. susp. fall diam. % finer than 0.016 mm	Sed. susp. fall diam. % finer than 0.031 mm	Sed. susp. fall diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.125 mm	Sed. susp. fall diam. % finer than 0.250 mm	Sed. susp. fall diam. % finer than 0.500 mm
						CEDAR RIVER AT GILBERTVILLE--continued					
1984 May											
23...	1,050	--	--	--	--	--	--	92	93	94	98
June											
10...	24,400	--	76	79	82	84	--	89	90	90	94
20...	23,900	--	76	80	82	85	--	89	89	92	97
July											
19...	2,780	--	--	--	--	--	--	--	--	97	99
Aug											
15...	386	83	28	39	62	72	75	--	--	--	--
Sept											
20...	122	99	32	47	79	94	99	--	--	--	--
Oct											
25...	74	98	--	--	--	--	--	--	--	--	--
Nov											
30...	16	98	--	--	--	--	--	--	--	--	--
Dec											
28...	--	96	--	--	--	--	--	--	--	--	--
1985 Feb											
26...	3,250	--	67	72	75	81	--	94	96	99	100
Mar											
26...	330	97	--	--	--	--	--	--	--	--	--
Apr											
25...	847	99	40	51	62	91	95	--	--	--	--
May											
21...	421	99	31	42	73	96	96	--	--	--	--
June											
18...	480	99	48	58	74	92	98	--	--	--	--
July											
23...	133	99	49	69	89	94	96	--	--	--	--
Aug											
20...	83	98	--	--	--	--	--	--	--	--	--
Sept											
24...	281	--	--	--	--	--	--	97	97	98	100
Oct											
29...	370	97	--	--	--	--	--	--	--	--	--
Nov											
19...	306	97	--	--	--	--	--	--	--	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Time	Stream-flow, instan-taneous (ft^3/s)	Spe-cific con-duct-ance (µS/cm)	pH (stand-ard units)	Temper-ature, air (°C)	Temper-ature, water (°C)	Oxygen, dis-solved (mg/L)	Oxygen, dis-solved (per-cent satur-ation)	Oxygen demand, chem-ical (high level) (mg/L)	Hard-ness (mg/L as $CaCO_3$)	Hard-ness, noncar-bonate (mg/L $CaCO_3$)
					CEDAR RIVER NEAR BERTRAM						
1984 May											
17...	1200	9,230	555	8.6	25.0	18.5	10.6	116	--	270	74
June											
11...	1115	16,400	510	8.1	--	20.0	8.0	90	79	180	47
14...	1015	18,400	425	8.1	27.0	20.0	7.5	84	56	200	57
21...	1020	20,300	420	8.4	27.0	22.0	7.8	91	44	200	64
July											
18...	1215	10,800	420	8.2	--	23.0	7.7	92	57	220	67
Aug											
16...	1010	2,320	410	8.5	--	26.5	8.4	108	38	180	68
Sept											
21...	1225	1,340	380	8.9	--	22.0	7.2	84	48	170	56
Oct											
26...	1030	2,110	618	7.9	11.5	10.5	8.6	78	16	290	85
Nov											
30...	1400	2,170	630	8.2	0.0	5.0	14.8	187	12	280	65
Dec											
28...	1400	2,400	627	7.6	18.5	2.0	12.5	93	43	250	93
1985 Jan											
30...	1300	2,070	690	7.2	-10.0	0.0	14.8	103	12	310	80
Feb											
27...	1015	13,400	280	6.9	2.0	0.0	--	--	60	110	36
Mar											
27...	1100	4,020	544	8.3	11.0	9.5	--	--	20	260	71
Apr											
26...	1100	4,250	520	8.7	19.0	16.0	12.5	130	33	240	71
May											
22...	1030	2,400	470	8.8	18.0	21.0	--	--	45	190	67
June											
19...	0915	2,430	510	8.1	20.0	20.5	11.4	129	41	210	55
July											
24...	0915	1,070	450	7.7	30.0	25.0	6.5	81	36	160	51
Aug											
21...	0900	830	400	7.5	17.0	21.0	5.4	61	28	180	55
Sept											
25...	0930	1,090	444	8.4	10.0	13.5	10.1	100	36	190	52
Oct											
29...	1400	3,160	660	8.1	14.0	13.0	12.2	118	16	330	100
Nov											
19...	1300	3,610	570	7.0	1.0	7.5	11.6	99	21	270	74

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Alka-linity, labora-tory (mg/L as $CaCO_3$)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl	Flou-ride, dis-solved (mg/L as F)	Silica, dis-solved (mg/L as SiO_2)	Solids, residue at 105 deg. C, dis-solved (mg/L)	Solids, residue at 105 deg. C, total (mg/L)
					CEDAR RIVER NEAR BERTRAM--continued						
1984 May											
17...	75	20	9.6	4.5	196	36	24	--	7.3	338	430
June											
11...	50	13	7.4	3.1	131	26	15	0.25	9.1	264	825
14...	55	14	6.8	3.3	138	24	16	.30	11	230	534
21...	57	14	6.7	3.0	136	21	16	.25	12	251	571
July											
18...	60	17	9.7	3.0	153	24	16	.20	13	252	725
Aug											
16...	36	22	18	3.3	112	42	29	.20	1.2	220	291
Sept											
21...	32	21	20	3.5	110	56	33	--	2.4	280	288
Oct											
26...	80	23	20	3.9	209	43	32	--	14	331	377
Nov											
30...	78	21	18	3.0	216	45	34	.35	10	374	407
Dec											
28...	68	19	25	3.5	155	33	46	.20	11	322	529
1985 Jan											
30...	86	23	30	3.8	229	56	48	.20	16	422	441
Feb											
27...	32	8.2	7.7	6.7	78	22	13	.15	10	156	383
Mar											
27...	73	18	12	3.3	185	28	23	.20	12	311	371
Apr											
26...	65	20	14	2.8	174	34	28	.25	3.8	295	396
May											
22...	43	21	19	2.5	127	40	34	.20	1.2	249	319
June											
19...	48	21	20	2.7	151	40	34	.25	5.9	309	408
July											
24...	33	20	23	3.5	114	44	39	.25	1.0	232	282
Aug											
21...	37	22	29	3.5	128	50	45	.25	1.6	250	290
Sept											
25...	45	20	22	2.9	143	21	33	.20	7.4	268	296
Oct											
29...	89	27	16	2.8	231	42	34	.30	13	349	424
Nov											
19...	72	22	14	2.8	196	42	30	.25	8.6	350	390

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Nitrogen, NO_2+NO_3, dissolved (mg/L as N)	Nitrogen, NO_2+NO_3, total (mg/L as N)	Nitrogen, ammonia, dissolved (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Nitrogen, ammonia + organic, dissolved (mg/L as N)	Nitrogen, ammonia + organic, total (mg/L as N)	Nitrogen, organic, dissolved (mg/L as N)	Nitrogen, organic, total (mg/L as N)	Phosphorus, dissolved (mg/L as P)	Phosphorus, total (mg/L as P)	Phosphorus, orthophosphate, dissolved (mg/L as P)
CEDAR RIVER NEAR BERTRAM--continued											
1984 May											
17...	7.80	7.80	0.05	0.05	0.51	0.99	0.46	0.94	--	0.16	0.08
June											
11...	7.90	7.70	.44	.43	.70	3.7	.26	3.3	--	.47	.18
14...	9.30	9.10	.39	.09	.80	2.6	.41	2.5	--	.35	.19
21...	8.50	8.30	.35	.46	.52	1.7	.17	1.2	0.19	.57	.18
July											
18...	6.60	6.40	.02	.03	.61	1.4	.59	1.4	.19	.57	.13
Aug											
16...	2.00	1.80	<.01	<.01	.33	2.0	--	--	.10	.29	.03
Sept											
21...	1.10	1.20	.01	.01	1.9	.17	1.9	.16	.10	.29	.04
Oct											
26...	4.20	4.20	.03	.03	.33	1.3	.30	1.3	.40	.46	.28
Nov											
30...	5.10	5.10	.08	.12	.71	1.5	.63	1.4	.37	.48	.13
Dec											
28...	5.70	5.70	.22	.24	.86	1.8	.64	1.6	.30	.56	.30
1985 Jan											
30...	5.90	5.90	.57	.58	1.1	1.1	.53	.52	.38	.43	.38
Feb											
27...	4.30	4.20	.87	.89	2.4	3.4	1.5	2.5	.38	.77	.34
Mar											
27...	5.30	5.40	.15	.18	.61	1.0	.46	.82	.16	.25	.13
Apr											
26...	5.20	5.40	.08	.10	.52	1.7	.44	1.6	.29	.39	.06
May											
22...	3.70	3.70	.06	.06	.50	2.3	.44	2.2	.20	.37	.04
June											
19...	5.00	5.00	.06	.03	.48	2.6	.42	2.6	.12	.32	.09
July											
24...	.30	.30	.22	.26	.80	2.1	.58	1.8	.24	.38	.16
Aug											
21...	.40	.50	.01	.03	.47	1.5	.46	1.5	.27	.36	.26
Sept											
25...	.60	.60	.13	.17	--	--	--	--	.12	.33	.07
Oct											
29...	7.10	6.80	.10	.11	.49	.91	.39	.8	.18	.25	.18
Nov											
19...	5.70	7.70	.25	.30	.74	1.3	.49	1.0	.17	.24	.17

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Arsenic, dis-solved (μg/L as As)	Arsenic, total (μg/L as As)	Copper, dis-solved (μg/L as Cu)	Copper, total recov-erable (μg/L as Cu)	Iron, total recov-erable (μg/L as Fe)	Iron, dis-solved (μg/L as Fe)	Lead, dis-solved (μg/L as Pb)	Lead, total recov-erable (μg/L as Pb)	Manga-nese, total recov-erable (μg/L as Mn)	Manga-nese, dis-solved (μg/L as Mn)
				CEDAR RIVER NEAR BERTRAM--continued						
1984 May										
17...	10	10	10	20	--	<10	<10	<10	--	<10
June										
11...	<10	<10	<10	<10	3,000	--	<10	20	450	--
14...	<10	<10	<10	<10	4,200	<10	<20	30	40	40
21...	<10	<10	<10	<10	6,600	--	<10	30	20	--
July										
18...	<10	<10	<10	<10	--	20	--	--	--	<10
Aug										
16...	<10	<10	10	10	--	--	<10	10	--	--
Sept										
21...	<10	<10	<10	<10	660	540	<10	<10	190	170
Oct										
26...	<10	<10	10	10	320	<10	<10	<10	60	10
Nov										
30...	<10	<10	<10	<10	220	<10	<10	<10	40	10
Dec										
28...	<10	<10	<10	<10	3,300	70	<10	<10	220	30
1985 Jan										
30...	<10	<10	<10	50	110	10	<10	<10	30	10
Feb										
27...	<10	<10	<10	<10	4,100	190	<10	<10	180	40
Mar										
27...	<10	<10	<10	30	570	20	<10	<10	80	<10
Apr										
26...	<10	<10	<10	<10	610	60	<10	<10	90	20
May										
22...	<10	<10	30	60	450	<10	<10	<10	8	<10
June										
19...	<10	<10	<10	30	650	<10	<10	<10	120	<10
July										
24...	<10	<10	30	30	480	<10	<10	<10	190	10
Aug										
21...	<10	<10	<10	<10	490	<10	<10	<10	180	<10
Sept										
25...	<10	<10	10	20	250	<10	<10	<10	120	<10
Oct										
29...	<10	<10	<10	20	570	30	<10	<10	80	<10
Nov										
19...	<10	<10	--	<10	--	--	<10	<10	--	--

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Mercury, dis- solved (µg/L as Hg)	Mercury, total recov- erable (µg/L as Hg)	Zinc, dis- solved (µg/L as Zn)	Zinc, total recov- erable (µg/L as Zn)	Carbon, organic, dis- solved (mg/L as C)	Carbon, organic, sus- pended total (mg/L as C)	Carbon, organic, total (mg/L as C)	Sedi- ment, sus- pended (mg/L)
			CEDAR RIVER NEAR BERTRAM--continued					
1984 May								
17...	<0.1	<0.1	<10	40	5.7	--	12.0	91
June								
11...	.1	.2	<10	40	5.2	--	21	596
14...	<.1	<.1	40	90	6.7		24	405
21...	<.1	<.1	40	50	3.8	--	18	305
July								
18...	<.1	<.1	<10	<10	4.0	--	16	426
Aug								
16...	<.1	<.1	<10	<10	2.8	0.9	4.1	40
Sept								
21...	<.1	<.1	<10	<10	4.6	2.9	10	49
Oct								
26...	<.1	<.1	<10	<10	3.5	.7	4.3	26
Nov								
30...	<.1	<.1	<10	<10	3.5	1.9	4.9	30
Dec								
28...	.2	.2	<10	10	4.4	.8	5.6	193
1985 Jan								
30...	<.1	<.1	<10	10	3.5	.3	3.8	5
Feb								
27...	.2	.2	<10	<10	12	2.1	20	249
Mar								
27...	<.1	<.1	<10	<10	3.6	.8	5.4	59
Apr								
26...	<.1	<.1	<10	<10	4.9	3.7	8.6	65
May								
22...	.2	.2	<10	<10	5.0	1.9	6.9	34
June								
19...	<.1	.1	<10	30	5.1	--	6.4	54
July								
24...	<.1	<.1	20	30	3.7	--	4.4	31
Aug								
21...	<.1	<.1	<10	<10	3.9	--	4.5	21
Sept								
25...	<.1	<.1	50	90	4.3	--	8.2	34
Oct								
29...	<.1	<.1	<10	10	3.6	.5	4.5	38
Nov								
19...	<.1	<.1	<10	20	4.9	1.5	6.9	45

Table 1.--Physical and chemical characteristics of the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Sediment, discharge, suspended (tons/d)	Sed. susp. sieve diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.002 mm	Sed. susp. fall diam. % finer than 0.004 mm	Sed. susp. fall diam. % finer than 0.008 mm	Sed. susp. fall diam. % finer than 0.016 mm	Sed. susp. fall diam. % finer than 0.031 mm	Sed. susp. fall diam. % finer than 0.062 mm	Sed. susp. fall diam. % finer than 0.125 mm	Sed. susp. fall diam. % finer than 0.250 mm	Sed. susp. fall diam. % finer than 0.500 mm
					CEDAR RIVER NEAR BERTRAM--continued						
1984 May											
17...	2,270	--	42	51	65	79	86	88	89	97	100
June											
11...	26,300	--	68	76	84	89	--	97	97	99	100
14...	20,100	--	61	77	79	87	--	92	93	97	100
21...	16,700	--	66	77	81	87	--	92	93	97	100
July											
18...	12,400	--	58	69	77	83	--	92	93	95	100
Aug											
16...	251	--	50	64	67	78	85	89	90	92	99
Sept											
21...	178	--	44	53	66	70	74	88	93	98	100
Oct											
26.	148	88	--	--	--	--	--	--	--	--	--
Nov											
30...	176	57	--	--	--	--	--	--	--	--	--
Dec											
28...	1,250	--	25	35	49	65	84	92	93	99	100
1985 Jan											
30...	28	82	--	--	--	--	--	--	--	--	--
Feb											
27...	9,000	--	59	62	66	70	--	76	78	89	100
Mar											
27...	640	--	--	--	--	--	--	80	80	85	90
Apr											
26...	746	--	42	53	64	78	85	89	90	97	100
May											
22...	220	96	31	55	62	79	89	--	--	--	--
June											
19...	354	98	34	44	62	85	95	--	--	--	--
July											
24...	90	97	--	--	--	--	--	--	--	--	--
Aug											
21...	47	98	--	--	--	--	--	--	--	--	--
Sept											
25...	100	--	--	--	--	--	--	77	81	96	100
Oct											
29...	324	98	--	--	--	--	--	--	--	--	--
Nov											
19...	439	97	--	--	--	--	--	--	--	--	--

Table 2.--Concentrations of herbicides in the Cedar and Shell Rock Rivers at the six sampling sites

[μg/L, micrograms per liter; <, less than; --, no data]

Date	Alachlor, dissolved (μg/L)	Alachlor, total recoverable (μg/L)	Atrazine, dissolved (μg/L)	Atrazine, total recoverable (μg/L)	Cyanazine, dissolved (μg/L)	Cyanazine, total recoverable (μg/L)	Metolachlor, dissolved (μg/L)	Metolachlor, total recoverable (μg/L)	Metribuzin, dissolved (μg/L)	Metribuzin, total recoverable (μg/L)	Trifluralin, dissolved (μg/L)	Trifluralin, total recoverable (μg/L)
						CEDAR RIVER AT FLOYD						
1984 May												
22...	1.0	1.0	0.65	0.66	0.29	0.30	0.28	0.34	<0.05	<0.05	<0.05	<0.05
June												
09...	23.0	21.0	8.8	7.1	8.0	6.9	10.00	8.0	2.90	2.30	<.10	<.10
19...	7.4	7.5	8.0	8.3	5.5	5.3	5.6	5.8	.21	.19	<.10	<.10
July												
16...	1.0	1.0	2.1	2.2	.43	.38	.84	.87	<.10	<.10	<.10	<.10
Aug												
14...	<.1	<.1	.38	.31	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Sept												
19...	<.1	<.1	.13	.11	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Oct												
24...	<.1	<.1	.49	.53	.26	.29	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
28...	<.1	<.1	.18	.14	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Dec												
27...	<.1	<.1	.22	.25	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
1985 Jan												
29...	<.1	<.1	.14	.13	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Feb												
25...	--	--	--	--	--	--	--	--	--	--	--	--
Mar												
25...	<.1	<.1	.12	.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Apr												
24...	--	<.1	--	.20	--	<.10	--	.16	--	<.10	--	<.10
May												
20...	1.5	1.5	.45	.39	.76	.79	.73	.69	<.10	<.10	<.10	<.10
June												
17...	.48	.47	.66	.81	.73	.68	.91	.83	<.10	<.10	<.10	<.10
July												
22...	<.1	<.1	.14	.14	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Aug												
19...	<.1	<.1	.33	.31	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Sept												
23...	<.1	<.1	.75	.75	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05

Table 2.--Concentrations of herbicides in the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Alachlor, dissolved (µg/L)	Alachlor, total recoverable (µg/L)	Atrazine, dissolved (µg/L)	Atrazine, total recoverable (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine, total recoverable (µg/L)	Metolachlor, dissolved (µg/L)	Metolachlor, total recoverable (µg/L)	Metribuzin, dissolved (µg/L)	Metribuzin, total recoverable (µg/L)	Trifluralin, dissolved (µg/L)	Trifluralin, total recoverable (µg/L)
						CEDAR RIVER NEAR CARVILLE						
1984 May												
22...	0.8	0.85	1.4	1.3	0.24	0.29	0.50	0.50	<0.05	<0.05	<0.05	<0.05
June												
10...	21.0	22.0	8.6	9.9	8.0	8.5	7.4	7.9	3.0	3.0	<.10	<.10
19...	8.5	9.0	16.0	14.0	6.8	6.8	9.6	10.4	1.1	1.3	<.10	<.10
July												
17...	--	--	--	--	--	--	--	--	--	--	--	--
Aug												
14...	<.1	<.1	.32	.31	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Sept												
19...	<.1	<.1	.21	.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Oct												
24...	<.1	<.1	.61	.51	.14	.12	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
28...	<.1	<.1	.18	.14	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Dec												
27...	<.1	<.1	<.10	.31	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
1985 Jan												
29...	<.1	<.1	.17	.18	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Mar												
26...	<.1	<.1	.13	.14	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Apr												
25...	--	.1	--	.27	--	.26	--	.10	--	<.10	--	<.10
May												
21...	.60	.47	.33	.32	.54	.48	.56	.44	<.10	<.10	<.10	<.10
June												
18...	.61	.61	.64	.60	.61	.58	.54	.59	<.10	<.10	<.10	<.10
July												
23...	<.1	<.1	.24	.24	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Aug												
20...	<.1	<.1	.37	.45	<.10	<.10	<.10	.10	<.05	<.05	<.05	<.05
Sept												
24...	.36	.36	.65	.48	.16	.12	.37	.37	<.05	<.05	<.05	<.05
Oct												
28...	<.1	<.1	.49	.49	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
18...	<.1	<.1	1.7	1.3	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10

Table 2.--Concentrations of herbicides in the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Alachlor, dissolved (μg/L)	Alachlor, total recoverable (μg/L)	Atrazine, dissolved (μg/L)	Atrazine, total recoverable (μg/L)	Cyanazine, dissolved (μg/L)	Cyanazine, total recoverable (μg/L)	Metolachlor, dissolved (μg/L)	Metolachlor, total recoverable (μg/L)	Metribuzin, dissolved (μg/L)	Metribuzin, total recoverable (μg/L)	Trifluralin, dissolved (μg/L)	Trifluralin, total recoverable (μg/L)
					SHELL ROCK RIVER NEAR NORTHWOOD							
1984 May												
21...	<0.1	<0.1	0.25	0.28	0.10	0.10	0.12	0.10	<0.05	<0.05	<0.05	<0.05
June												
09...	.22	.24	2.5	2.7	.18	.22	.11	.52	<.10	<.10	<.10	<.10
18...	6.8	6.8	7.3	7.4	1.8	1.9	3.4	4.2	.53	.48	<.10	<.10
July												
16...	.21	.19	1.4	1.6	.30	.31	.30	.49	<.10	<.10	<.10	<.10
Aug												
13...	<.1	<.1	.55	.43	.10	.11	<.10	<.10	<.10	<.10	<.10	<.10
Sept												
18...	<.1	<.1	.21	.19	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Oct												
23...	<.1	<.1	.33	.32	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
27...	<.1	<.1	.24	.25	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Dec												
26...	<.1	<.1	.28	.29	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
1985 Jan												
28...	<.1	<.1	.41	.43	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Mar												
25...	<.1	<.1	.18	.18	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Apr												
24...	--	<.1	--	.21	--	.25	--	<.10	--	<.10	--	<.10
May												
20...	.18	.21	1.5	1.9	.20	.37	.11	<.10	<.10	<.10	<.10	<.10
June												
17...	<.1	<.1	.26	.28	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
July												
22...	<.1	<.1	<.10	<.10	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Aug												
19...	<.1	<.1	.33	.42	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Sept												
23...	<.1	<.1	.33	.31	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Oct												
28...	<.1	<.1	<.10	.18	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
18...	<.1	<.1	.27	.17	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10

Table 2.--Concentrations of herbicides in the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Alachlor, dissolved (μg/L)	Alachlor, total recoverable (μg/L)	Atrazine, dissolved (μg/L)	Atrazine, total recoverable (μg/L)	Cyanazine, dissolved (μg/L)	Cyanazine, total recoverable (μg/L)	Metolachlor, dissolved (μg/L)	Metolachlor, total recoverable (μg/L)	Metribuzin, dis--solved (μg/L)	Metribuzin, total recoverable (μg/L)	Trifluralin, dissolved (μg/L)	Trifluralin, total recoverable (μg/L)
CEDAR RIVER AT CEDAR FALLS												
1984 May												
23...	0.51	0.47	0.43	0.62	0.17	0.37	0.41	0.46	<0.05	<0.05	<0.05	<0.05
June												
10...	21.0	22.0	16.0	15.0	8.7	9.3	9.0	11.0	1.9	1.9	<.10	<.10
20...	8.2	8.2	15.0	14.0	7.2	7.1	8.1	7.9	2.3	2.4	<.10	<.10
July												
17...	.3	.19	1.3	1.4	.24	.31	.59	.74	<.10	<.10	<.10	<.10
Aug												
15...	<.1	<.1	.28	.30	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Sept												
20...	<.1	<.1	.10	.12	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Oct												
24...	<.1	<.1	.30	.39	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
28...	<.1	<.1	.19	.20	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Dec												
27...	<.1	<.1	.26	.25	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
1985 Jan												
30...	<.1	<.1	.16	.15	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Feb												
26...	<.1	<.1	1.0	.98	<.10	<.10	.92	1.5	<.10	<.10	<.10	<.10
Mar												
26...	<.1	<.1	.14	.14	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Apr												
25...	--	.18	--	.23	--	.15	--	.30	--	<.10	--	<.10
May												
21...	.36	.36	.26	.20	.34	.58	.44	.55	<.10	<.10	<.10	<.10
June												
18...	.48	.52	1.1	1.1	.68	.65	.90	.78	<.10	<.10	<.10	<.10
July												
23...	<.1	<.1	.23	.28	<.10	<.10	.20	.16	<.05	<.05	<.05	<.05
Aug												
20...	--	<.1	--	.40	--	<.10	--	<.10	--	<.05	--	<.05
Sept												
24...	<.1	<.1	.30	.724	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05

Table 2.--Concentrations of herbicides in the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Alachlor, dissolved (µg/L)	Alachlor, total recoverable (µg/L)	Atrazine, dissolved (µg/L)	Atrazine, total recoverable (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine, total recoverable (µg/L)	Metolachlor, dissolved (µg/L)	Metolachlor, total recoverable (µg/L)	Metribuzin, dissolved (µg/L)	Metribuzin, total recoverable (µg/L)	Trifluralin, dissolved (µg/L)	Trifluralin, total recoverable (µg/L)
CEDAR RIVER AT GILBERTVILLE												
1984 May												
23...	0.41	0.34	0.49	0.32	0.25	0.11	0.18	0.14	<0.05	<0.05	<0.05	<0.05
June												
10...	17.0	17.0	15.0	15.0	8.1	7.6	11.0	11.0	1.7	2.1	<.10	<.10
20...	5.0	4.9	8.0	9.1	4.7	4.9	7.0	6.9	.65	.73	<.10	<.10
July												
19...	.26	.30	1.1	1.0	.27	.29	.62	.38	<.10	<.10	<.10	<.10
Aug												
15...	<.1	<.1	.21	.26	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Sept												
20...	--	<.1	--	.19	--	<.10	--	<.10	--	<.10	--	<.10
Oct												
25...	<.1	<.1	.39	.40	<.10	<.10	.16	.13	<.10	<.10	<.10	<.10
Nov												
30...	<.1	<.1	.19	.19	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Dec												
28...	<.1	<.1	.26	.28	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
1985 Feb												
26...	--	--	--	--	--	--	--	--	--	--	--	--
Mar												
26...	<.1	<.1	.15	.15	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Apr												
25...	--	.23	--	.30	--	.15	--	.20	--	<.10	--	<.10
May												
21...	--	--	--	--	--	--	--	--	--	--	--	--
June												
18...	.33	.39	.65	.79	.24	.25	.42	.45	<.10	<.10	<.10	<.10
July												
23...	<.1	<.1	.56	.63	<.10	.15	.69	.58	.10	.13	<.05	<.05
Aug												
20...	<.1	<.1	.38	.30	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Sept												
24...	<.1	<.1	<.10	.28	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Oct												
29...	<.1	<.1	<.10	.26	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
19...	<.1	<.1	<.10	.26	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10

Table 2.--Concentrations of herbicides in the Cedar and Shell Rock Rivers at the six sampling sites--Continued

Date	Alachlor, dissolved (µg/L)	Alachlor, total recoverable (µg/L)	Atrazine, dissolved (µg/L)	Atrazine, total recoverable (µg/L)	Cyanazine, dissolved (µg/L)	Cyanazine, total recoverable (µg/L)	Metolachlor, dissolved (µg/L)	Metolachlor, total recoverable (µg/L)	Metribuzin, dis--solved (µg/L)	Metribuzin, total recoverable (µg/L)	Trifluralin, dissolved (µg/L)	Tri fluralin, total recoverable (µg/L)
CEDAR RIVER NEAR BERTRAM												
1984 June												
11...	6.5	6.1	7.6	7.4	5.3	5.0	4.1	4.1	0.14	0.15	<.10	<.10
14...	7.7	6.6	7.5	7.5	5.1	4.7	5.8	6.0	.90	.81	<.10	<.10
21...	2.5	3.0	7.4	7.5	2.5	2.6	3.0	3.9	.16	.13	<.10	<.10
July												
18...	--	.42	--	2.9	--	.43	--	1.4	--	<.10	--	<.10
Aug												
16...	<.1	<.1	.25	.44	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Sept												
21...	<.1	<.1	.29	.22	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Oct												
26...	<.1	<.1	.26	.26	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
30...	<.1	<.1	.21	.20	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Dec												
28...	<.1	<.1	.31	.35	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
1985 Jan												
30...	<.1	<.1	.21	.24	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Feb												
27...	<.1	<.1	.89	.96	<.10	<.10	.50	.71	<.10	<.10	<.10	<.10
Mar												
27...	<.1	<.1	.13	.11	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Apr												
26...	--	.11	--	.22	--	.57	--	.30	--	<.10	--	<.10
May												
22...	.24	.27	.35	.42	.50	.70	.49	.68	<.10	<.10	<.10	<.10
June												
19...	.20	.15	.95	.80	.49	.55	.60	.48	<.10	<.10	<.10	<.10
July												
24...	<.1	<.1	.10	.10	.40	.29	<.10	<.10	<.05	<.05	<.05	<.05
Aug												
21...	<.1	<.1	.47	.37	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Sept												
25...	<.1	<.1	.38	<.01	<.10	<.10	<.10	<.10	<.05	<.05	<.05	<.05
Oct												
29...	<.1	<.1	<.10	.28	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Nov												
19...	<.1	<.1	.26	.19	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10

Table 3.--Herbicide use in crop-reporting districts 2 and 6[a]

[Robert Hartzler, Iowa State University, written commun., 1986]

Herbicide	Crop	Percentage of crop receiving herbicide	Herbicide application (pounds per acre)	Total herbicide application (tons)
			Crop-reporting district 2[b]	
Alachlor	corn	42	2.7	985
	soybeans	16	2.5	281
Atrazine	corn	31	1.4	373
Cyanazine	corn	26	2.2	494
Metolachlor	corn	28	2.5	623
	soybeans	10	2.5	169
Metribuzin	soybeans	33	.42	96
			Crop-reporting district 6[c]	
Alachlor	corn	33	2.5	648
	soybeans	17	2.3	121
Atrazine	corn	71	1.6	911
Cyanazine	corn	35	1.8	507
Metolachlor	corn	29	2.3	523
	soybeans	13	2.3	89
Metribuzin	soybeans	46	.5	71

[a]About 3 percent of total acres surveyed statewide.
[b]1,750,000 acres of corn planted; 1,397,000 acres of soybeans planted.
[c]1,596,000 acres of corn planted; 617,000 acres of soybeans planted.

Table 4.--Properties of herbicides

[mg/L, milligrams per liter; --, no data;
from Berg, 1984, p. C150 and Wauchope, 1978, p. 460-466]

Common name	Pesticide class	Type of application	Solubility (mg/L)	Persistence in soil (months)
Alachlor	Anilide herbicide	Emulsion to soil surface	242	2
Atrazine	Triazine herbicide	Wettable powder applied to soil surface, spring	33	12
Cyanazine	Triazine herbicide	Wettable powder applied to soil surface, spring	171	12
Metolachlor	Anilide herbicide	Emulsion to soil surface	530	--
Metribuzin	Triazine herbicide	Wettable powder applied to soil surface, spring	1,220	5
Trifluralin	Dinitroaniline herbicide	Emulsion to sprays incorporated into soil	.05	6