

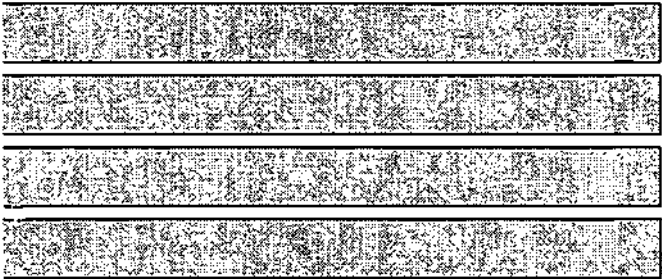
Contract Report 602

Watershed Monitoring for the Lake Decatur Watershed

by
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Prepared for the
City of Decatur

July 1996



Illinois State Water Survey
Hydrology Division
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

Watershed Monitoring for the Lake Decatur Watershed

Technical Report

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Introduction

Lake Decatur is the water supply reservoir for the City of Decatur. The reservoir was created in 1922 by constructing a dam to impound the flow of the Sangamon River. The original dam had a crest elevation of 28 feet above the river bottom and a length of one-third of a mile. The dam created a lake with a volume of 20,000 acre-feet and an area of 4.4 square miles. The dam was later modified in 1956 to increase the maximum capacity of the lake to 28,000 acre-feet. Water withdrawal from the lake has been increasing over the years, reaching 36 million gallons per day in 1994. It is projected that the increasing demand will continue in the near future.

The drainage area of the Sangamon River upstream of Decatur is 925 square miles. The watershed includes portions of seven counties in east-central Illinois as shown in figure 1. The predominant land use in the watershed is row crop agriculture comprising nearly 90 percent of the land area. The major urban areas within the watershed are Decatur, Monticello, and Gibson City.

Lake Decatur has been experiencing water quality problems for some time. The lake has high concentrations of total dissolved solids and nitrates, and nitrate concentrations have been relatively high in recent years. This has created a serious situation for the drinking water supply of the City of Decatur. The Illinois Environmental Protection Agency (IEPA) has issued nine nitrate warnings to the city from 1979 to 1996 for noncompliance with IEPA drinking water standards for nitrate when concentrations exceeded 10 milligrams per liter (mg/l).

On June 10 1992, a Letter of Commitment (LOC) was signed between the IEPA and the City of Decatur. The LOC requires the city to take several steps to reduce nitrate levels in Lake Decatur to acceptable concentrations within nine years of signing the LOC. One of the steps required the city to conduct a two-year monitoring study of the Lake Decatur watershed to better understand the sources of nitrates in the watershed. The Illinois State Water Survey (ISWS) received a grant from the City of Decatur, conducted the two-year monitoring study, and developed land use management strategies that could

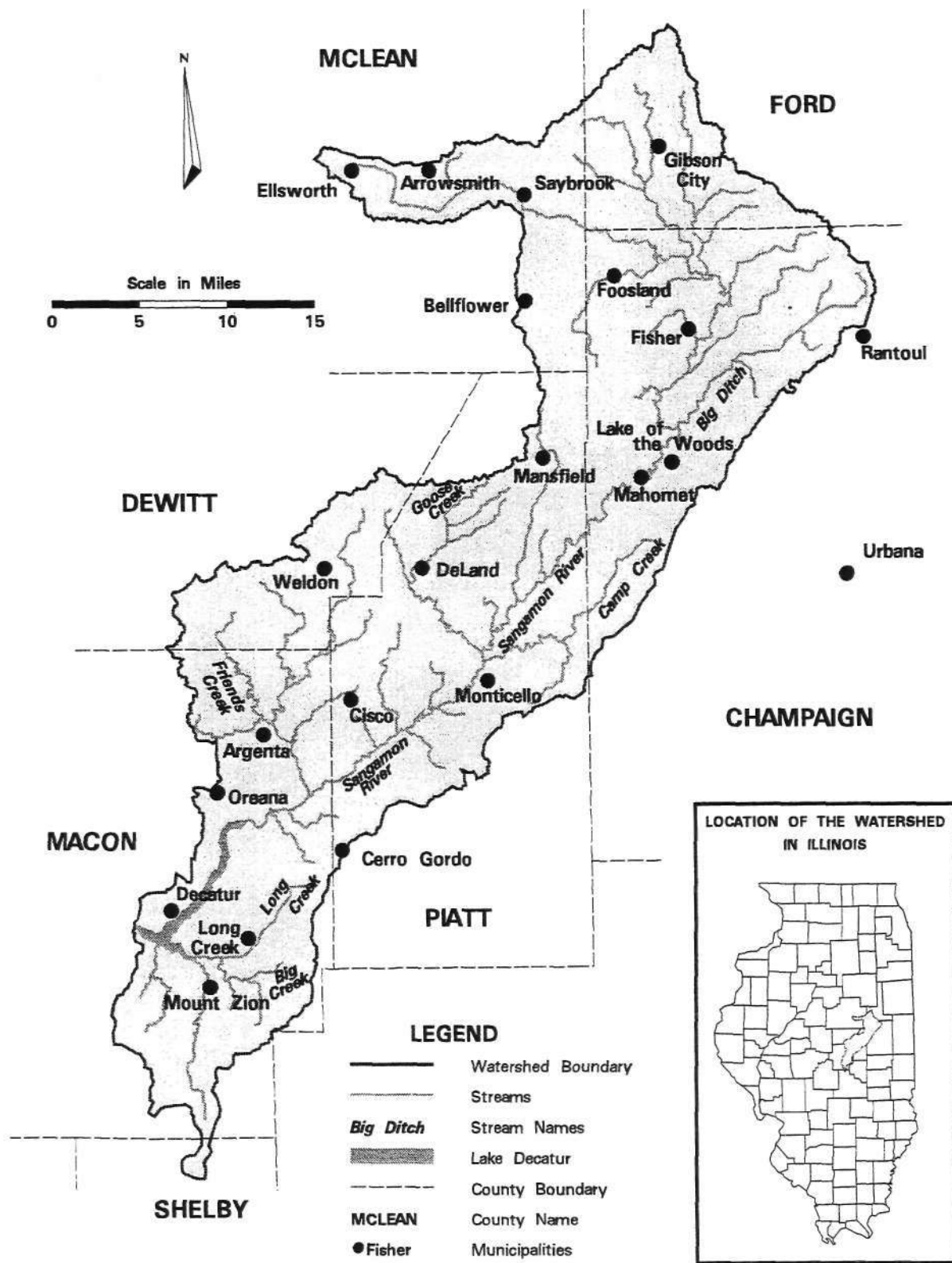


Figure 1. Location of the Lake Decatur watershed

eventually bring the city under compliance with the IEPA drinking water standards. The results of the study are published in Illinois State Water Survey Miscellaneous Publication 169, *Watershed Monitoring and Land Use Evaluation for the Lake Decatur Watershed*. The watershed management recommendations are available from the City of Decatur or the ISWS.

This technical report is a combination of the first two years of data collection (May 1993 through April 1995) and a third year of data collection performed from May 1995 through April 1996. The report is organized into three sections: Introduction, Background, and Hydrologic and Water Quality Monitoring. The introduction and background sections are condensed versions of the corresponding sections in ISWS MP 169. The section on hydrologic and water quality monitoring discusses the monitoring results of the three years of data collection.

Acknowledgments

This work was supported by the City of Decatur. Keith Alexander, Lake Manager, served as project manager, and his cooperation and assistance are greatly appreciated.

Several other city officials and staff have also been very cooperative and supportive: Terry M. Howley, Mayor; James C. Bacon, Jr., City Manager; Bruce A. McNabb, Public Works Director; Stephen F. John, Ex-Council Member; and John Smith, Water Production Manager.

We gratefully acknowledge the laboratory analyses performed by the following chemists in the Office of Analytical & Water Treatment Services at the Illinois State Water Survey in Champaign: Loretta M. Skowron, Lauren F. Sievers, Daniel L. Webb, Saada E. Hamdy, Sue R. Bachman, and Lavanya Reddy. Assistance in field work, data entry, and/or analysis was provided by Darin Strako, Jeffrey Paris, and Sandy Howard. Brett Ward, Office of Surface Water Information: Systems, Information, & GIS, provided the Geographic Information System (GIS) work presented in this report. Becky Howard produced the report, which was edited by Eva Kingston; and Linda Hascall and David Cox provided expert advice on illustration layout.

Background

Water Quality Problems in Lake Decatur

Lake Decatur has experienced water quality problems over the years. Past studies by the U.S. Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA) have documented water quality problems in the lake (USEPA, 1975; IEPA, 1978). Most of the problems are associated with nonpoint source pollution generated in the watershed of the Upper Sangamon River. The lake generally has high levels of total dissolved solids and nitrates. Currently, the most pressing water quality problem in Lake Decatur is high concentrations of nitrates.

The source of the nitrate that eventually reaches Lake Decatur is, of course, found in the watershed of the Upper Sangamon River that feeds into Lake Decatur. To characterize and quantify the spatial and temporal distribution of nitrate yield in the Upper Sangamon, the City of Decatur has continued to support further watershed monitoring through a grant to the Illinois State Water Survey (ISWS). The purpose of the monitoring is to collect reliable hydrologic and water quality data throughout the watershed to gain an understanding of the sources of nitrate in the watershed and then to solicit full cooperation of those residing and farming in the watershed in resolving the problem by presenting this information in an unbiased manner. Without such cooperation, it will be almost impossible to develop effective programs to deal with the problem.

Physical Characteristics of the Lake Decatur Watershed

The Lake Decatur watershed lies in a climate region classified as humid continental, which is typical for central Illinois and is located in the Till Plains section of the Central Lowland physiographic province. The Till Plains section is generally characterized by broad till plains, which are mostly in a youthful erosion stage. The Upper Sangamon watershed is located on the Bloomington Ridged Plain, a subdivision of the Till Plains section, and is characterized by low broad morainic ridges with intervening wide stretches of relatively flat or gently undulating ground moraine. A more detailed presentation of the watershed physical characteristics is available in ISWS Miscellaneous Publication 169 (Demissie et al., 1996).

Hydrologic and Water Quality Monitoring

. A watershed monitoring network has been established to provide streamflow and water quality data for the Sangamon River and its tributaries upstream of Lake Decatur for the purpose of establishing the sources of nitrate throughout the watershed. The network is comprised of eight stations (see figure 2) at which stage is continuously recorded and discharge is measured periodically. Water samples are collected and analyzed for nitrate on a weekly basis. The names of the streams, locations of the monitoring stations, and drainage areas are presented in table 1.

Hydrologic Monitoring

Continuous hydrologic monitoring at each station facilitates the calculation of continuous streamflow for the entire study period. This is essential for establishing the nitrate contribution to Lake Decatur from the Sangamon River and its tributaries.

Precipitation

Precipitation data for selected locations around the watershed have been retrieved from the Midwestern Climate Center database, which is operated by the ISWS. Six stations were selected from within and around the Lake Decatur watershed: Gibson City, Rantoul, Urbana, Clinton, Monticello, and Decatur. Their locations are shown in figure 2. The monthly precipitation was retrieved for May 1993 through April 1996. Figure 3 compares the monthly precipitation in inches between all six stations. Figure 4 presents the annual precipitation totals and long-term means. It should be noted that the stations are presented as they are located in the watershed from north to south (Gibson City is the station closest to the north end of the watershed, and Decatur is the farthest south).

**Table 1. Streamflow and Stage Monitoring Stations
in the Lake Decatur Watershed**

<i>Station number</i>	<i>Location</i>	<i>Drainage area (sq mi)</i>
101	Long/Big Creek at Twin Bridge Road	46.2
102	Friends Creek at Rte. 48 near Argenta	111.9
103	Goose Creek near DeLand	45.1
104	Camp Creek near White Heath	47.2
105	Sangamon River at Shively Bridge near Mahomet	368.2
106	Big Ditch near Fisher	38.2
111	Sangamon River at Monticello	543.4
112	Sangamon River at Fisher	245.6

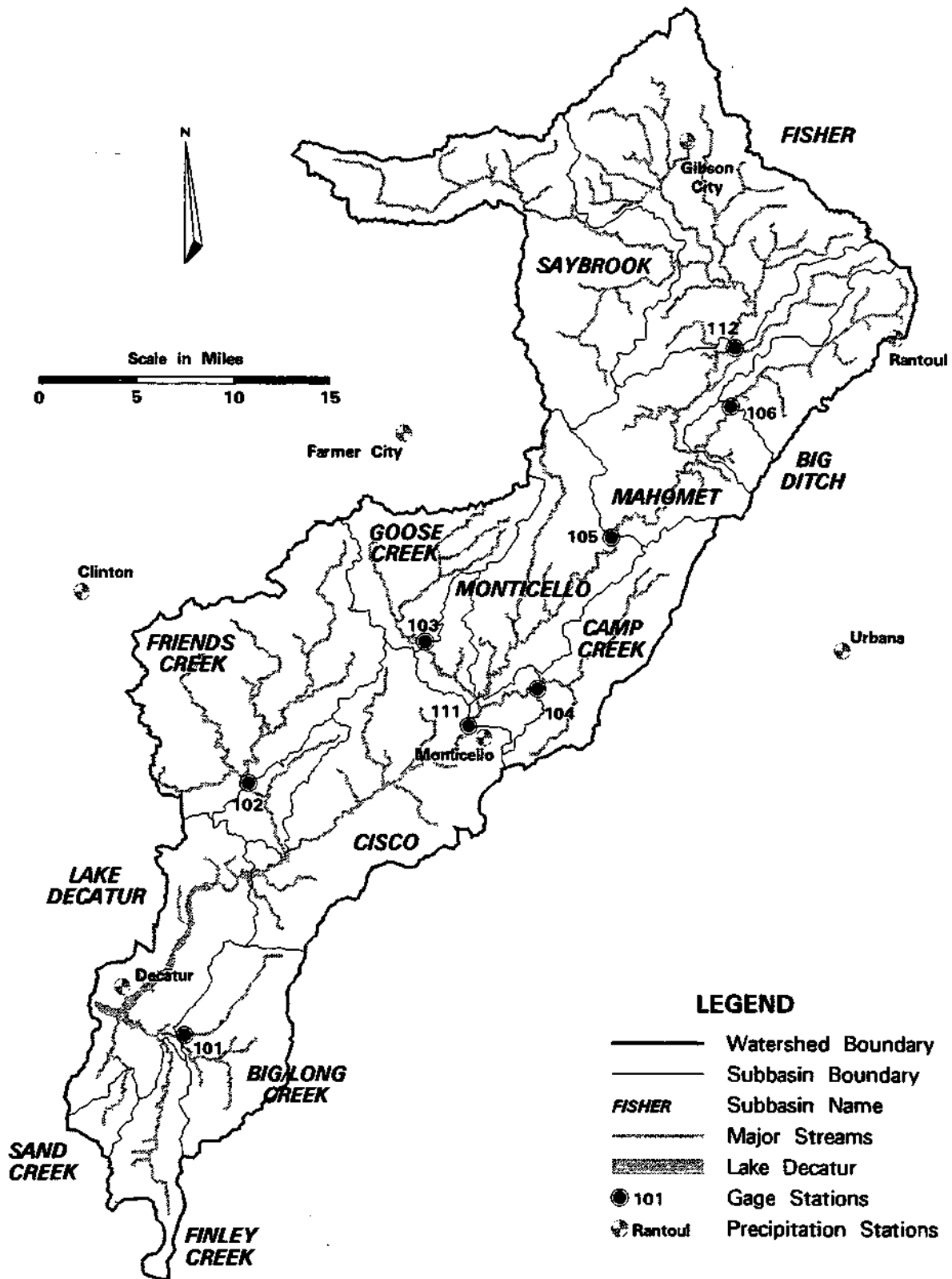


Figure 2. Location map of stream and rain monitoring stations in the Lake Decatur watershed

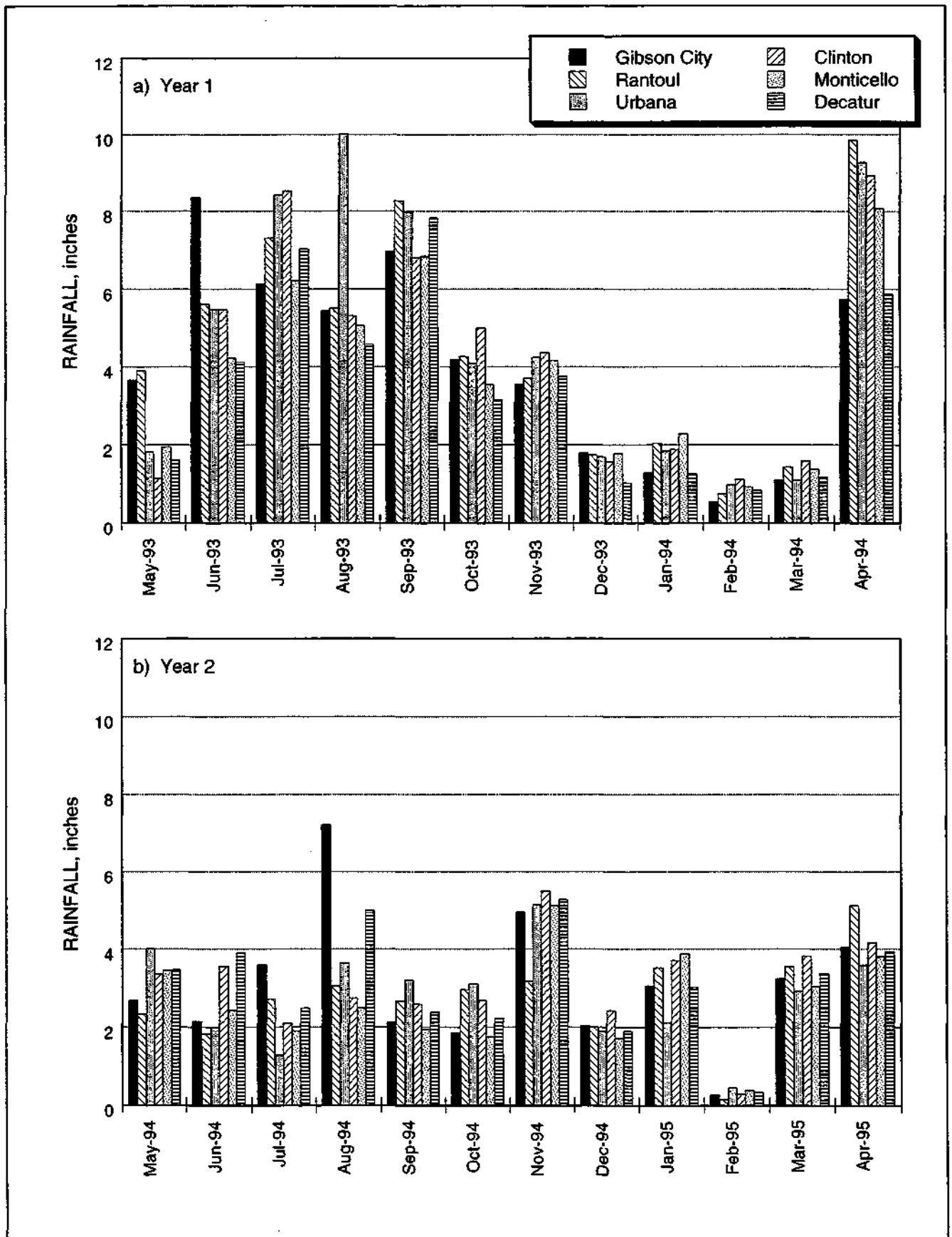


Figure 3. Monthly precipitation during study period

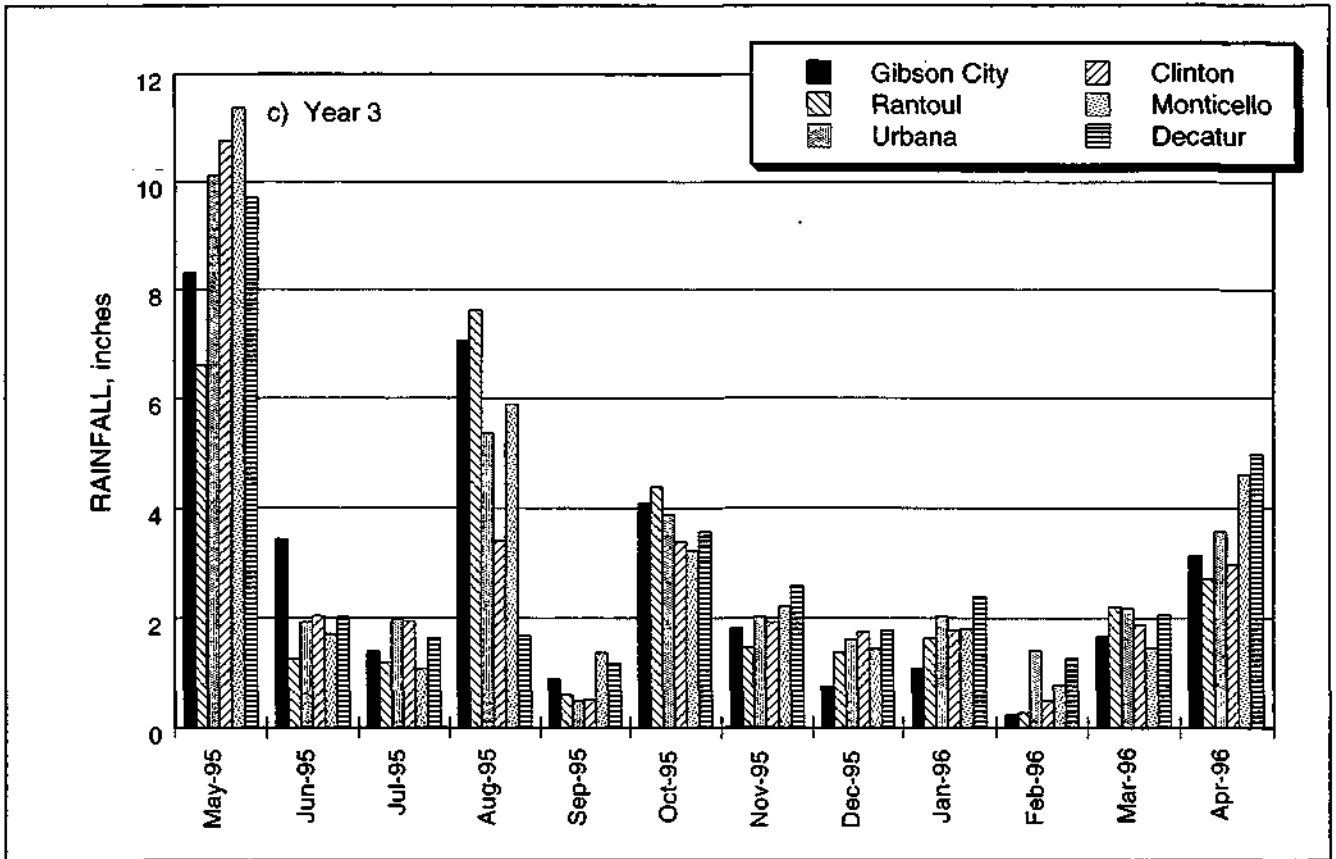


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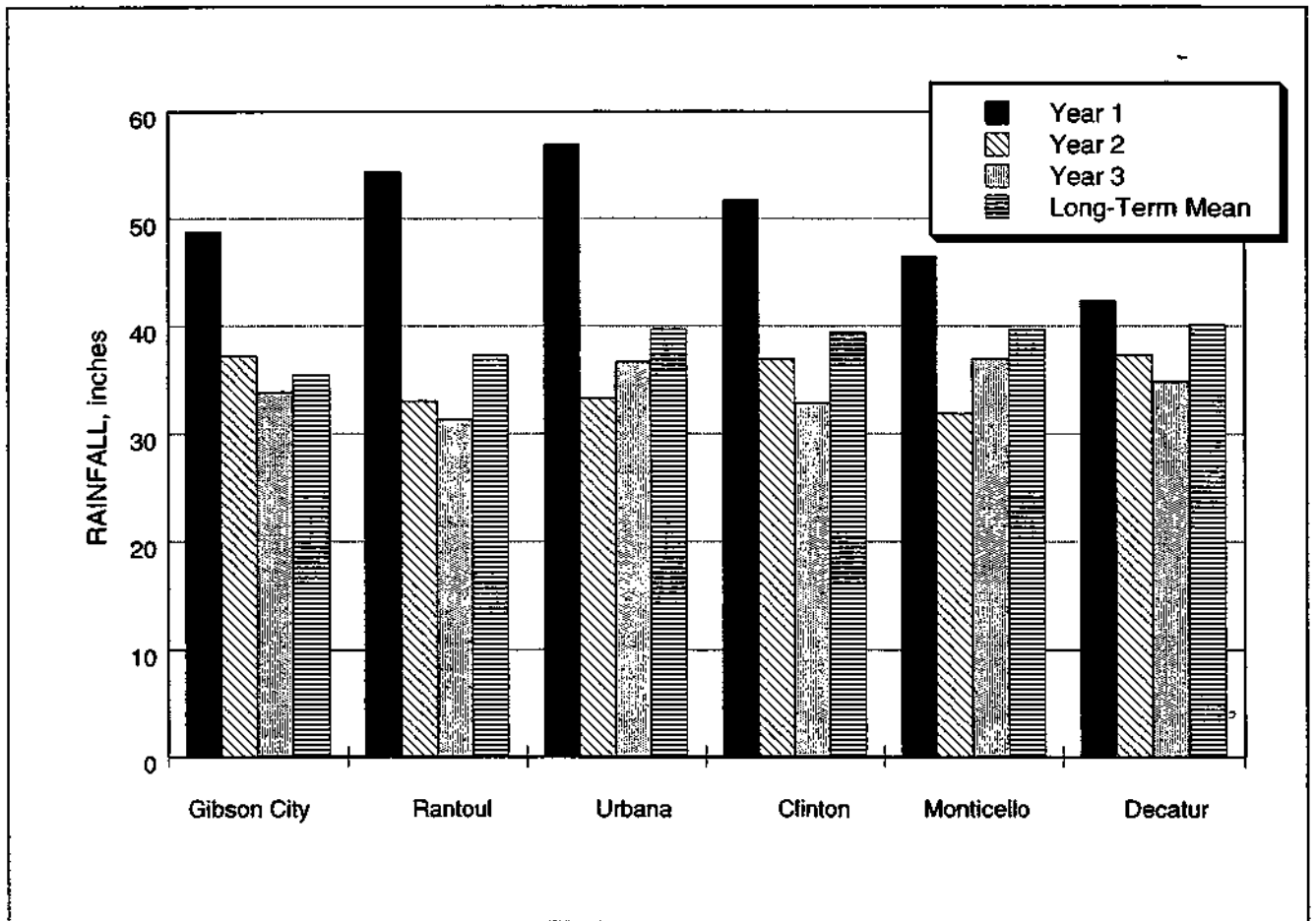


Figure 4. Annual precipitation during study period

Figure 3 shows the differences between each station as well as the changes in overall precipitation from month to month. The high precipitation in the summer and fall months of 1993 as well as April 1994, stand out in Figure 3a. The highest monthly precipitation was in Urbana during August of 1993 at 10.02 inches. More than half of the rain fell on August 12 with 5.32 inches. Figure 3b shows that the second year precipitation amounts vary from near normal to much below normal. Precipitation during February 1995 was more than 75 percent below normal. Precipitation was also much below normal in June, July, and December 1994. November 1994 was the only month above normal. Gibson City precipitation was above normal during August 1994, because of an isolated thunderstorm on August 2 with 3.8 inches of rain. Figure 3c shows May 1995 with by far the highest precipitation: Monticello was the highest at 11.4 inches, and Clinton and Urbana had 10.8 and 10.1 inches, respectively. August 1995 was the next highest month with the remaining months somewhat low.

Figure 4 shows the difference in rainfall between the three monitoring years. The first year of the study period is very much above the long-term mean, whereas the precipitation was below normal during the second and third years. It is also apparent that the stations in the northern region of the watershed have received nearly 40 percent more rainfall on the average compared to the southern region during the first year. Gibson City, Rantoul, Urbana, and Clinton received 12-17 inches above their long-term means of 35.50, 37.29, 39.67, and 39.41 inches, respectively. Decatur shows slightly above normal rainfall (2.18 inches above normal), with above average rainfall at Monticello (6.76 inches above normal). This gradient in precipitation amounts will be reflected in the streamflow runoff data that follow. Unlike the first year, there seems to be no clear tendency in rainfall variability among different regions of the watershed in the second and third year. Both years are below or near normal in precipitation compared to the long-term mean.

Streamflow

Streamflow data are generated from the stage record for each of the monitoring stations. Stage data are converted to streamflow data by applying a stage-to-discharge calibration curve. The stage-to-discharge calibration is developed by taking several detailed field measurements of the stream discharge at known stages throughout the monitoring period. The discharges are plotted with corresponding stages, and a stage-to-discharge curve is developed for each station. The calibration is continuously updated as more discharge field measurements are taken.

Streamflow Data. The streamflow data presented in this report are for the period from May 1993 through April 1996. The data were originally collected as stage data from continuous recording streamgaging instruments. The stage data are converted to discharge (streamflow) using discharge rating curves, as discussed in the preceding section. Rating curves were developed for Long Creek at Twin Bridge Road (station 101),

Friends Creek at Route 48 near Argenta (station 102), Goose Creek near DeLand (station 103), Camp Creek near White Heath (station 104), the Sangamon River at Shively Bridge near Mahomet (station 105), and Big Ditch near Fisher (station 106). Discharge data from the USGS continuous streamgaging stations already exist for the Sangamon River at Route 136 (station 112) and at Monticello (station 111). The discharge data from October 1995 to April 1996 for these two stations were retrieved from the USGS before being officially published and are therefore considered provisional. The USGS discharge data from October 1994 to April 1995 have been officially published since the ISWS Miscellaneous Publication 169 was written. There have been some minor changes in the monthly discharges, which will have little effect on the annual runoff calculations reported for the second year data.

The discharge data results are illustrated in figures 5 and 6. Figure 5 shows the monthly discharge for the stations located on tributaries of the Sangamon River (stations 101,102, 103, 104,106), and figure 6 shows the stations located on the Sangamon River (stations 111, 105, 112). In figure 5a, Friends Creek (station 102) shows the highest discharge during 11 of the 12 months presented, which is expected since it drains twice as much watershed (71,647 acres) as the other stations. Late summer to fall of 1993 (August-December) appears to be the wettest period of the year, and April and October 1993 and April 1994 were the wettest months. During the dry months, Long Creek (station 101) experienced the lowest flows and had almost zero flow in August. This would indicate that the extreme southeastern corner of the watershed was receiving much less rainfall during the first year of data collection. Figure 5b shows that the discharge amounts in the second year are significantly lower than those from the first year. Friends Creek produced the highest discharges due to its drainage area. The months of July through November 1994 suffered extreme low flow. April 1995 has very low flows compared to the first year. Figure 5c shows Friends Creek (102) with a significantly higher discharge than the other stations in May 1995. Again, this is expected because it has a larger drainage area. Several stations had precipitation for May 1995 (see figure 3c) at around 10 inches. The remainder of the third year monthly tributary discharges were similar to the second year discharges.

Figure 6a shows the same trends at the main river stations as the tributary stations for the first year of monitoring. The highest discharge months appear in July 1993, September through December 1993, and April 1994; and the driest months were August 1993, and January and February 1994. Most station sites, if not all, were frozen over in January and February 1994, and flows remained low. Monticello consistently had the highest discharges because it drains the largest watershed area at 347,747 acres (543.4 square miles). Figure 6b shows lower discharges during the second year of the study period compared with the first year. The summer and fall months were the lowest flow months, whereas May 1994 and January, March, and April 1995 were somewhat higher. Figure 6c shows May 1995 being a very high discharge month at the river stations. June

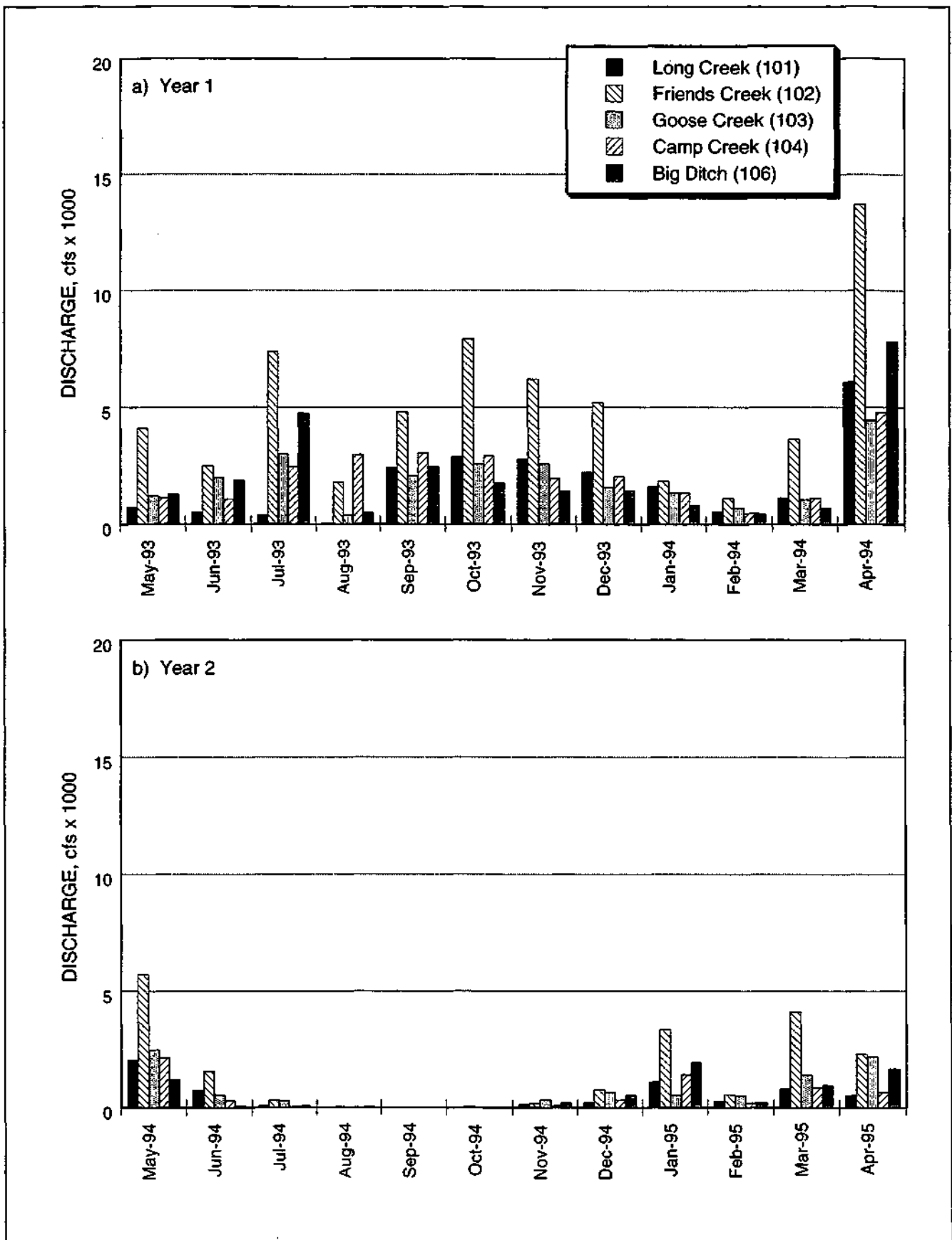


Figure 5. Monthly discharge for tributary stations

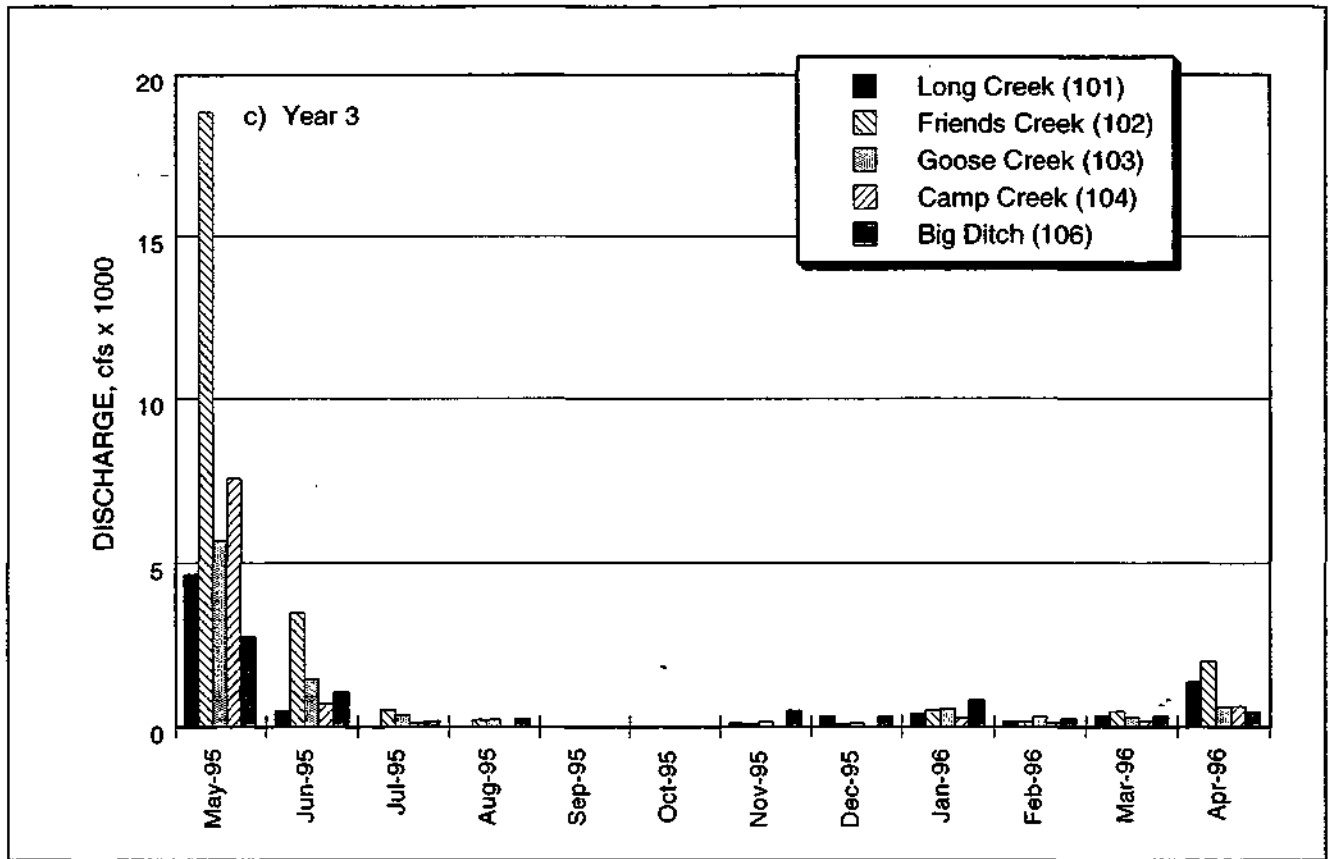


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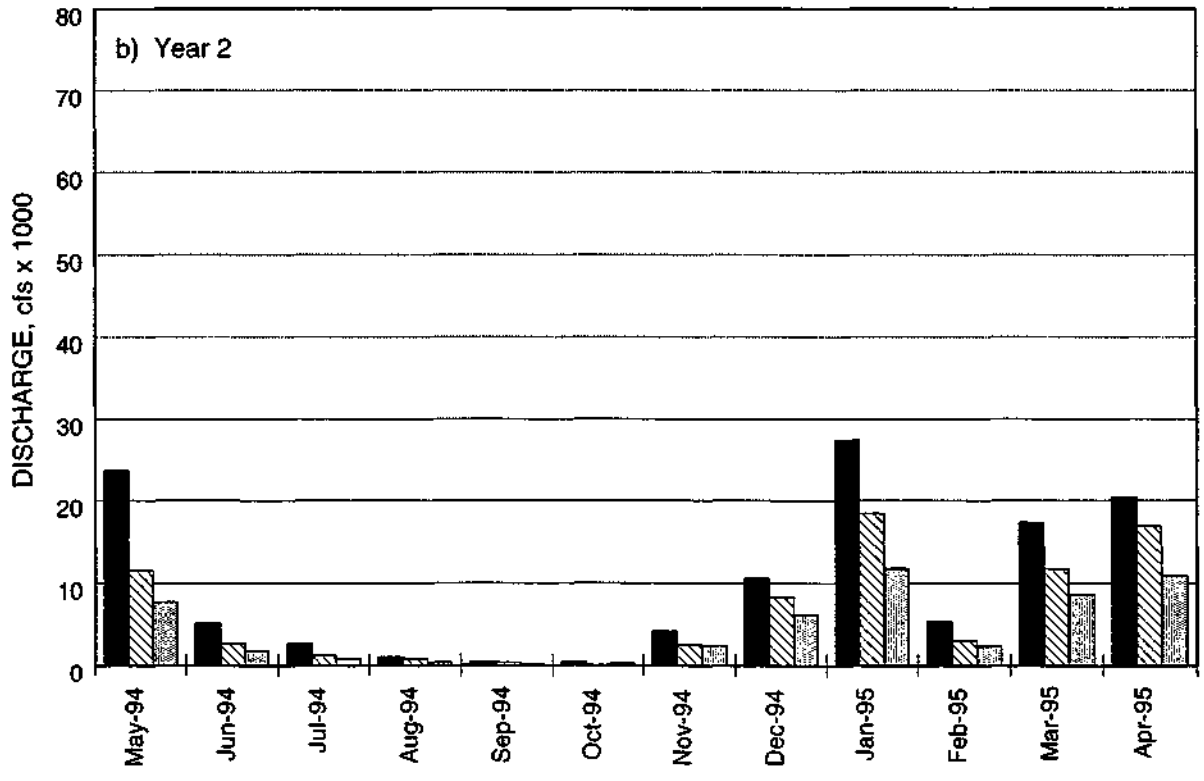
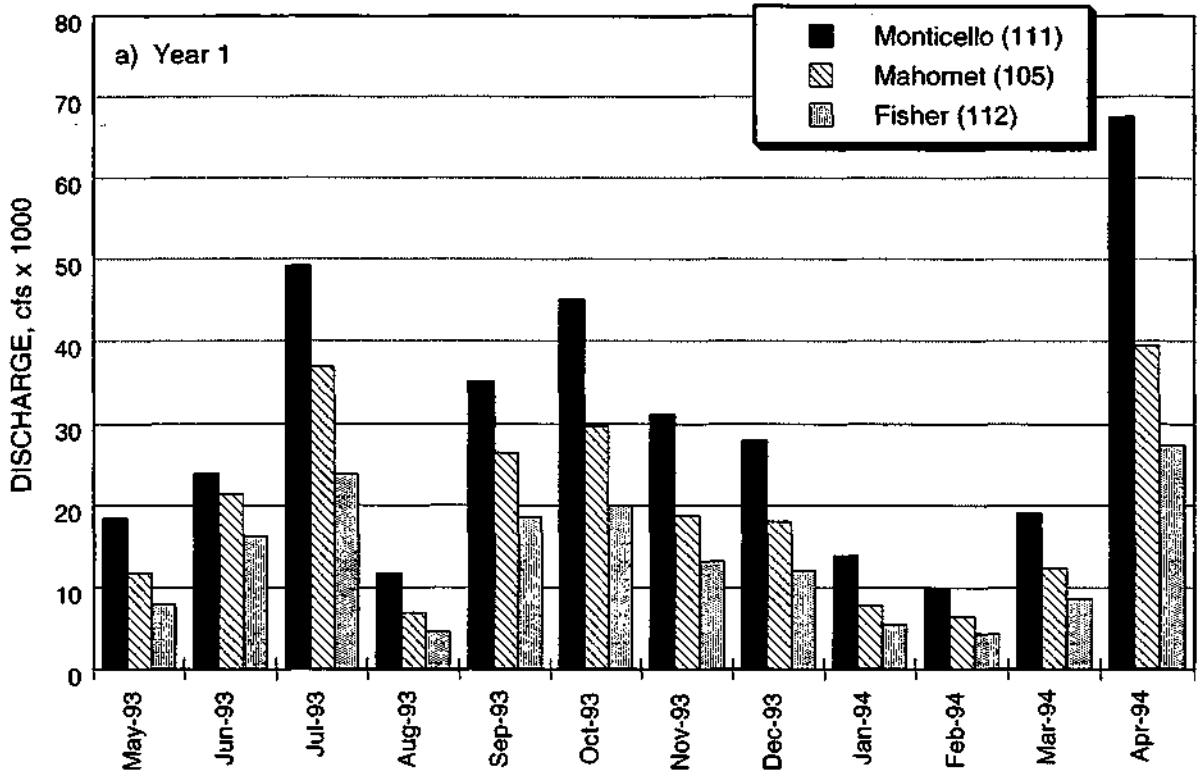


Figure 6. Monthly discharge for Sangamion River stations

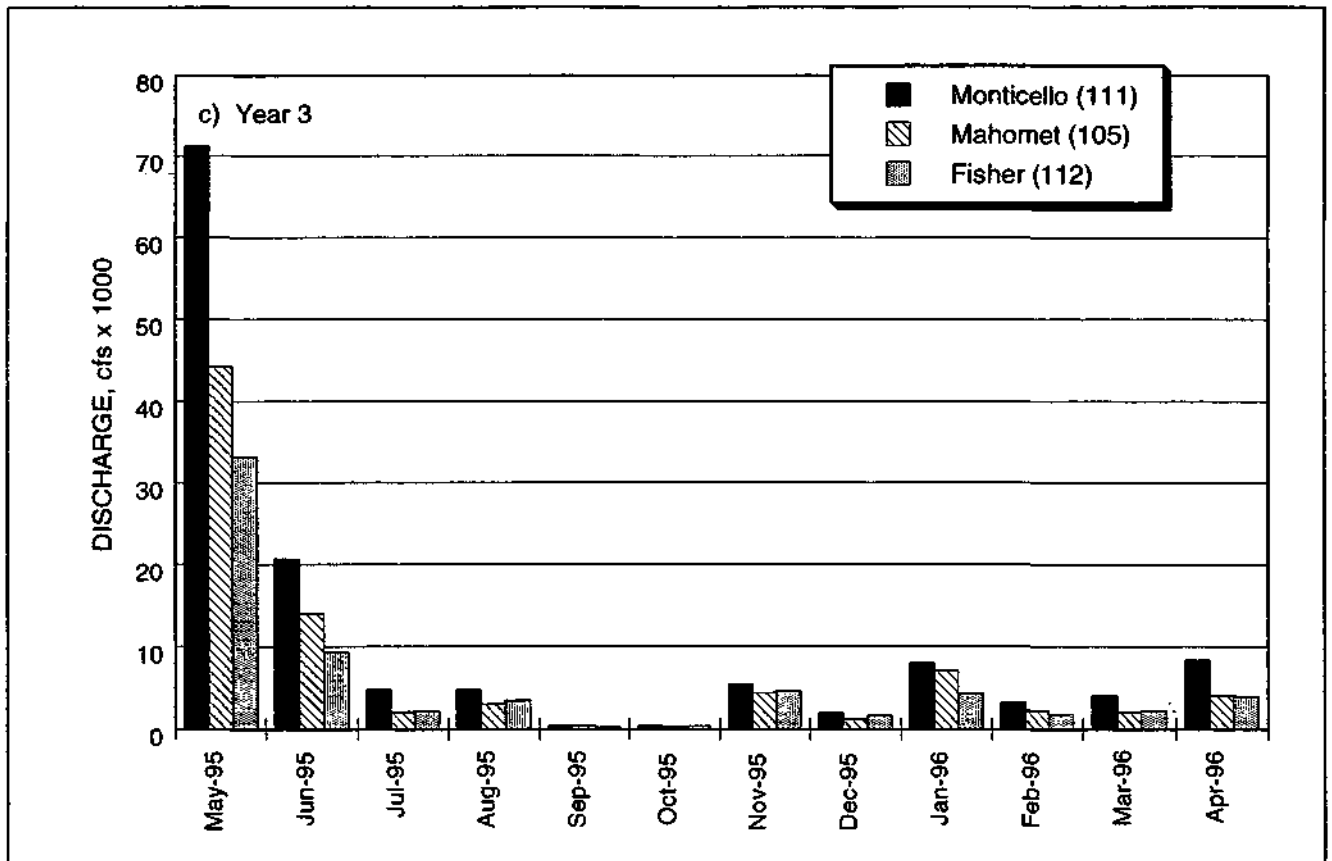


Figure 6. Concluded

1995 was the next highest month, September and October 1995 had almost no flow, and the fall and winter months were very low in comparison with the first two years.

Discharge is sometimes converted to inches for the purposes of comparing streamflow to rainfall. The monthly discharge is divided by the drainage area upstream of the streamgaging station to determine the streamflow in inches, which is termed "runoff". Figures 7 and 8 show runoff in inches for the tributary and Sangamon River stations, respectively. Runoffs vary between the stations due to the spatial variability of rainfall events throughout the watershed. Figure 7 shows the highest monthly tributary runoff for all three years was at the Big Ditch station in April 1994 with 7.68 inches (figure 7a). Figures 7b and 7c show that all tributary stations experienced severely low runoff to no runoff during the months of August through October of the second year and September through October of the third year. Figure 7c shows that May 1995 had the highest runoffs. Figure 8 reflects the same trends in runoff for the main river stations as in the tributary stations. The lowest runoff was experienced during July through October 1994 and September through October 1995. During the entire study period, 15 of the 36 months had stations that averaged 1 inch or greater runoff, half of those averaged 2 inches or more, and only three had more than 3 inches. May 1995 exhibited the highest runoff at 4.5 inches or more, with April 1994 being the next highest at about 4 inches.

Annual streamflow runoff for the tributary and Sangamon River stations is presented in figure 9. As can be seen in figure 9a, the runoff increases for each tributary as you move upstream through the watershed during the first year. This correlates very well with the rainfall measurements shown in figure 4. The rainfall deviation from the long-term mean increases when proceeding from the southernmost station at Decatur to the northernmost one at Gibson City. Big Ditch had the highest annual runoff during the first year at 24.7 inches and Long Creek had 17.2 inches, the lowest runoff. Runoff at the Sangamon River stations during the first year ranged from a high of 24.7 inches at Fisher to 23.9 inches at Mahomet.

Runoff the second year was considerably less than during the first year. The highest runoff was at Fisher (7.0 inches), and the lowest was at Camp and Long Creeks at 3.0 and 3.1 inches, respectively. The differences in runoff among the main river stations are a little more than 0.5 inch. Mahomet had the highest annual runoff at 7.7 inches. Third year runoffs were slightly higher than the second year runoffs. The highest runoffs were at Friends Creek (8.8 inches) and Fisher (10.3 inches). The lowest runoff for all stations was 6.4 inches at Long Creek. There is no indication of preferred spatial tendencies in the watershed during the second and third years as there were in the first year.

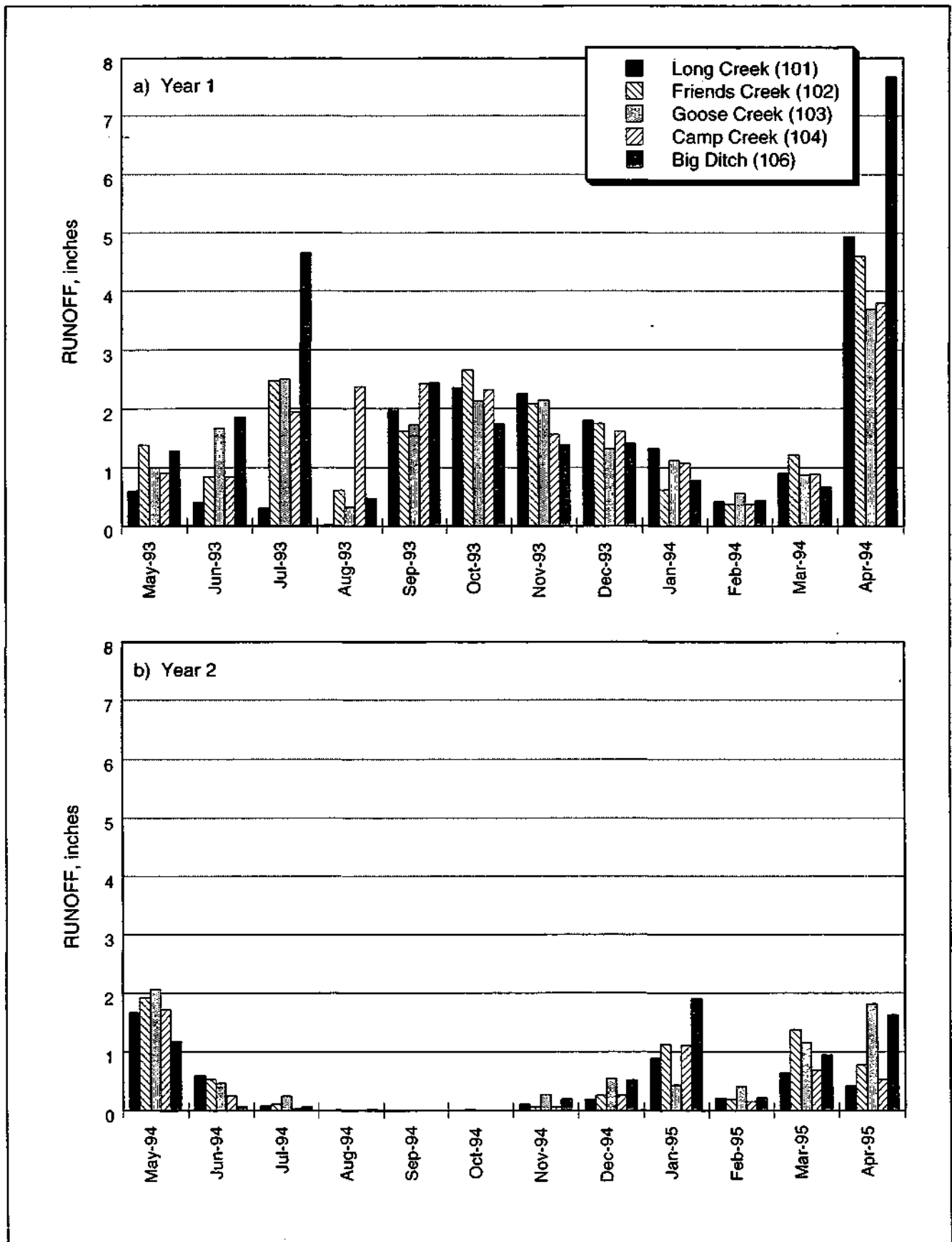


Figure 7. Monthly runoff for tributary stations

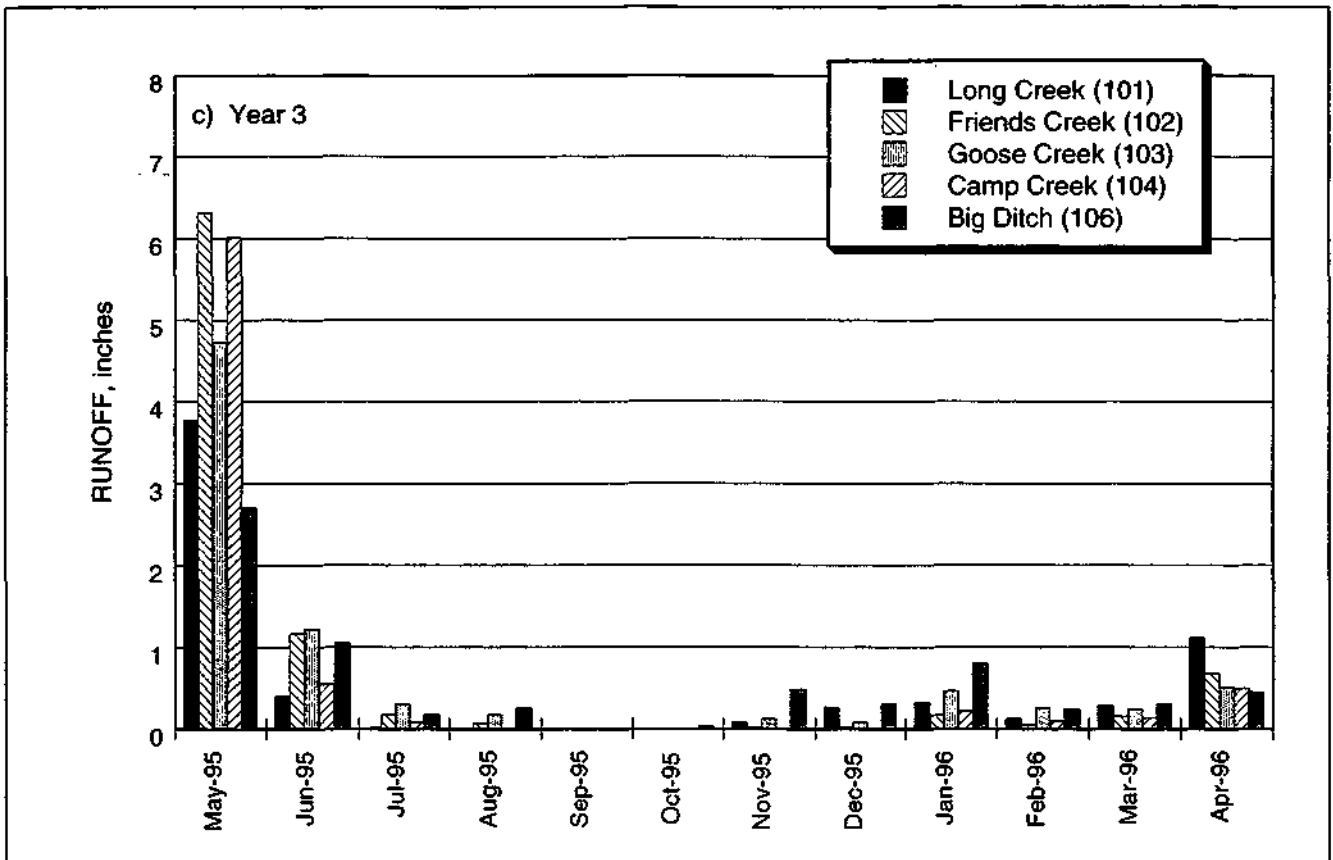


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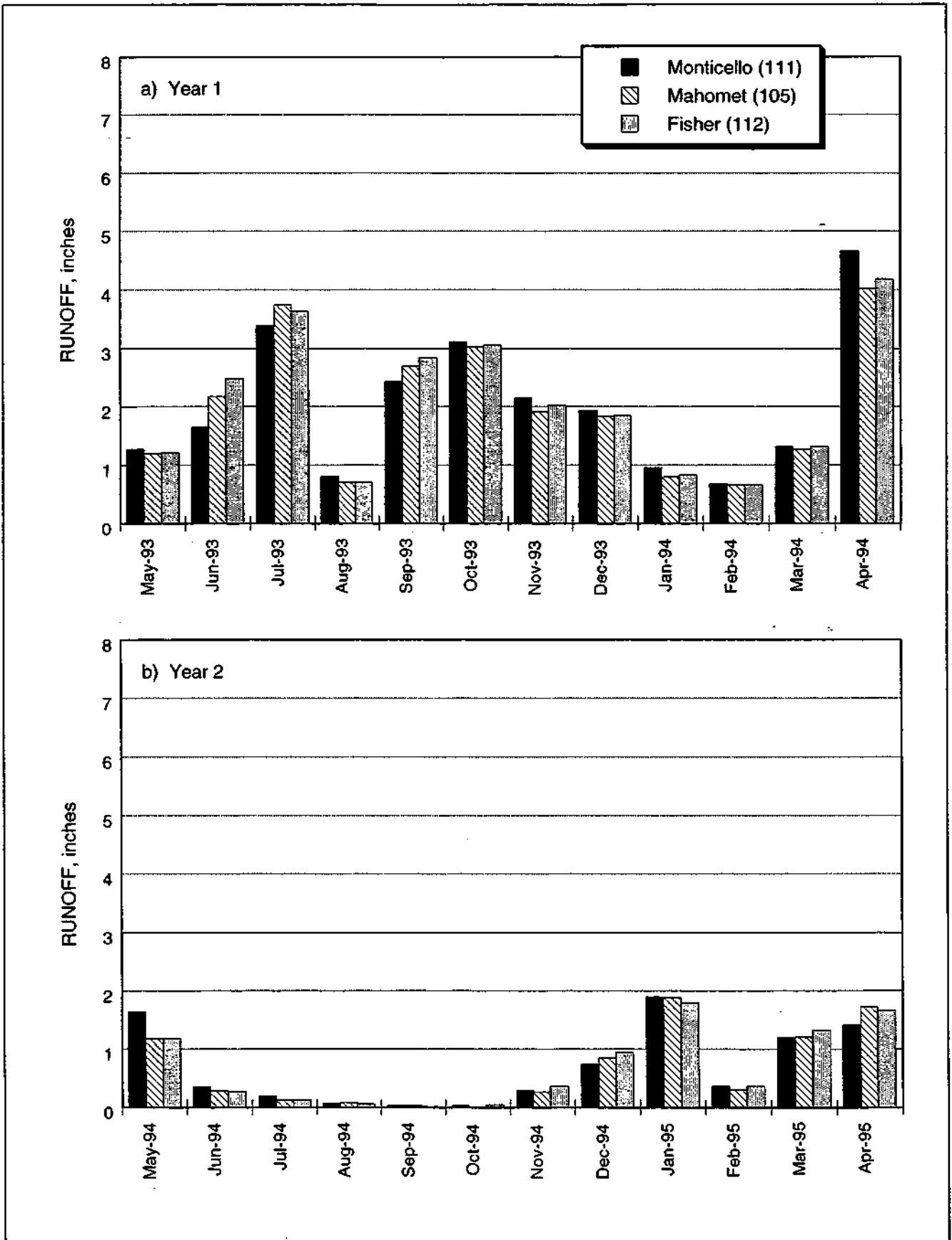


Figure 8. Monthly runoff for Sangamon River stations

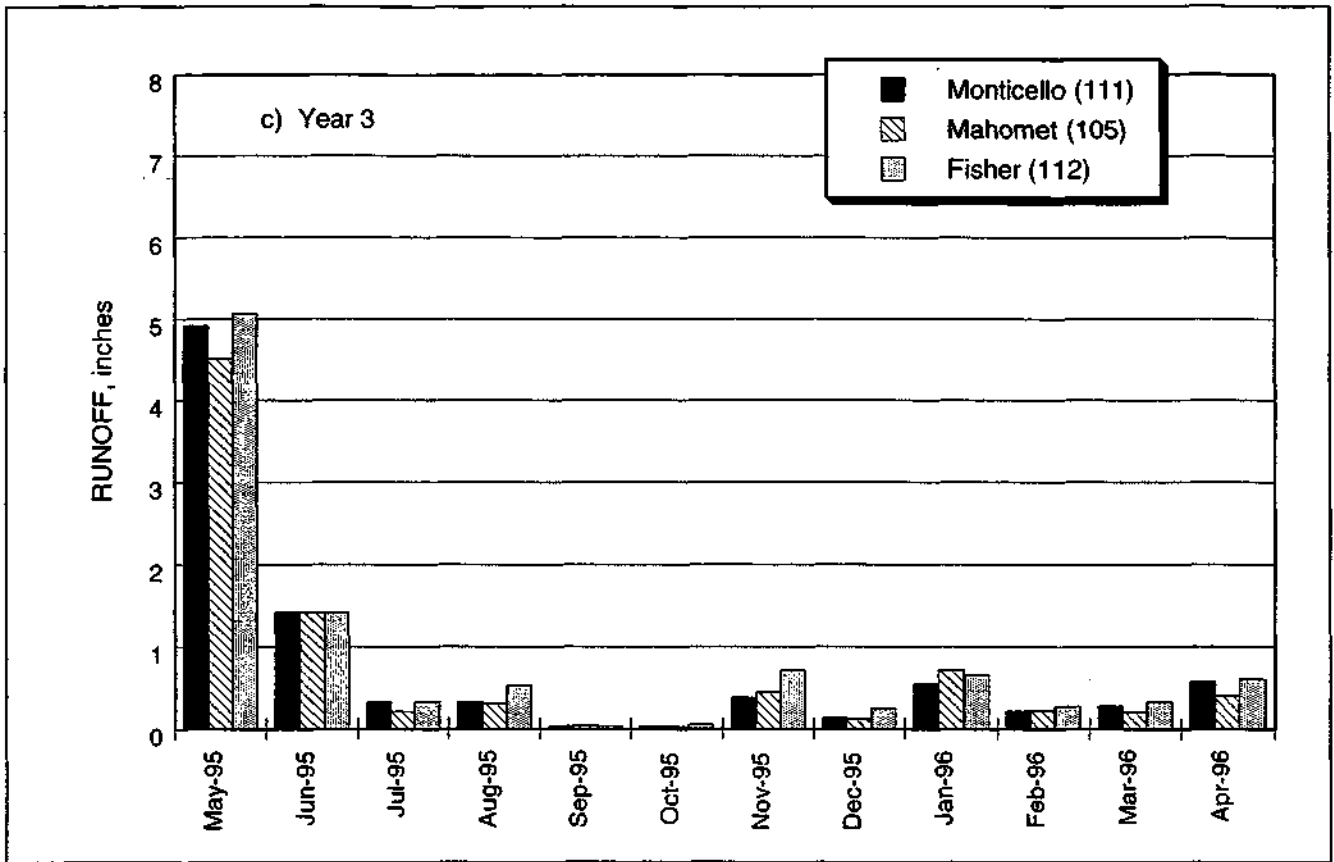


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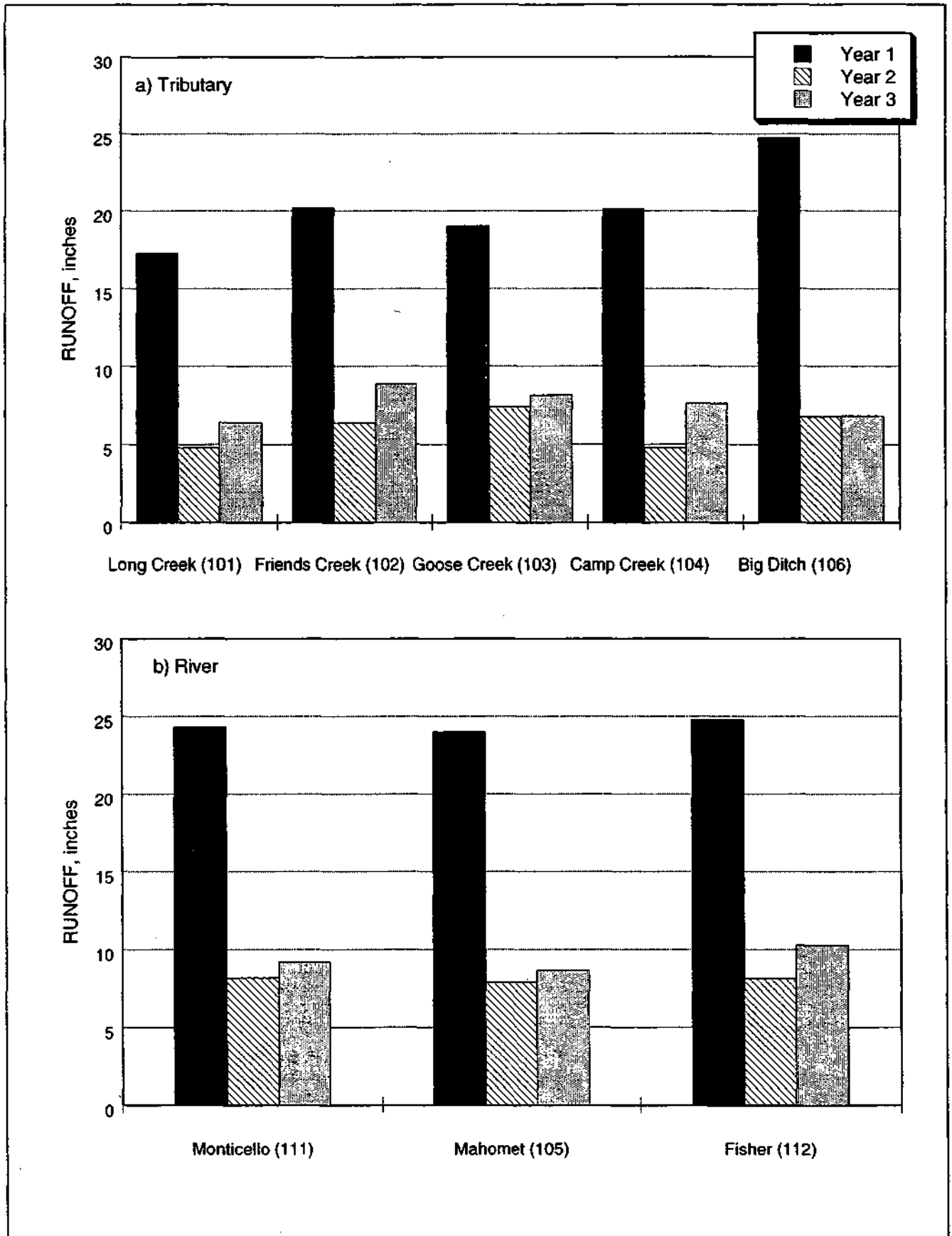


Figure 9. Annual runoff for tributary and Sangamon River stations

Water Quality Monitoring

Nitrate has been sampled at each of the eight monitoring stations for all three monitoring years. During the first two years, two additional parameters were analyzed: ammonium-nitrogen (ammonium-N) and total Kjeldahl nitrogen (TKN). Ammonium-N and TKN concentrations are reported in the ISWS Miscellaneous Publication 169 (Demissie et al., 1996).

Nitrate Concentrations

Nitrate-N concentration data for the three-year study period at the eight monitoring stations and the City of Decatur north and south treatment plants are presented in figures 10-12. Nitrate concentrations at the tributary stream stations for the three-year period are presented in figure 10. The first-year concentrations are presented in figure 10a, second-year in figure 10b, and third-year in figure 10c. The first major observation is the significant difference between the first year and the last two years of data collection. The first year was a wet year resulting in high nitrate concentrations throughout the year, even during the summer months. The second and third years were dry years, with near zero concentrations during the summer months. The significance of this difference in nitrate input into Lake Decatur will be discussed later in the section on nitrate loads.

The other major observation is how the data points from the different tributaries are closely clustered and generally follow similar trends even when the concentrations are different. This indicates the general similarities in climate, hydrology, and land use for most of the sub-watersheds in the region.

For the first year of data collection (figure 10a), the nitrate concentrations at all stations were generally above 4 mg/l except for Long Creek in August, two data points for Big Ditch in February and April, and one point for Camp Creek in September. The highest concentrations were in May and June 1993 when concentrations above 14 mg/l were measured. The highest concentration for the first year, 15.3 mg/l, was measured in Big Ditch on May 7, 1993. The lowest concentration, 0.74 mg/l, was measured in Long/Big Creek on September 1, 1993. For a period of almost nine months from August to April, nitrate concentrations at all the stations were generally between 4 to 10 mg/l. The concentrations stayed elevated even during the summer months when they were expected to have dropped significantly.

During the two months of high nitrate concentrations in May and June, the highest concentrations were measured at the Big Ditch station, while the lowest concentrations were measured at the Friends Creek station. For the rest of the year there was no consistent pattern except that Camp Creek tended to stay on the high side, while Long/Big Creek and Friends Creek tended to stay on the lower side. During the month of

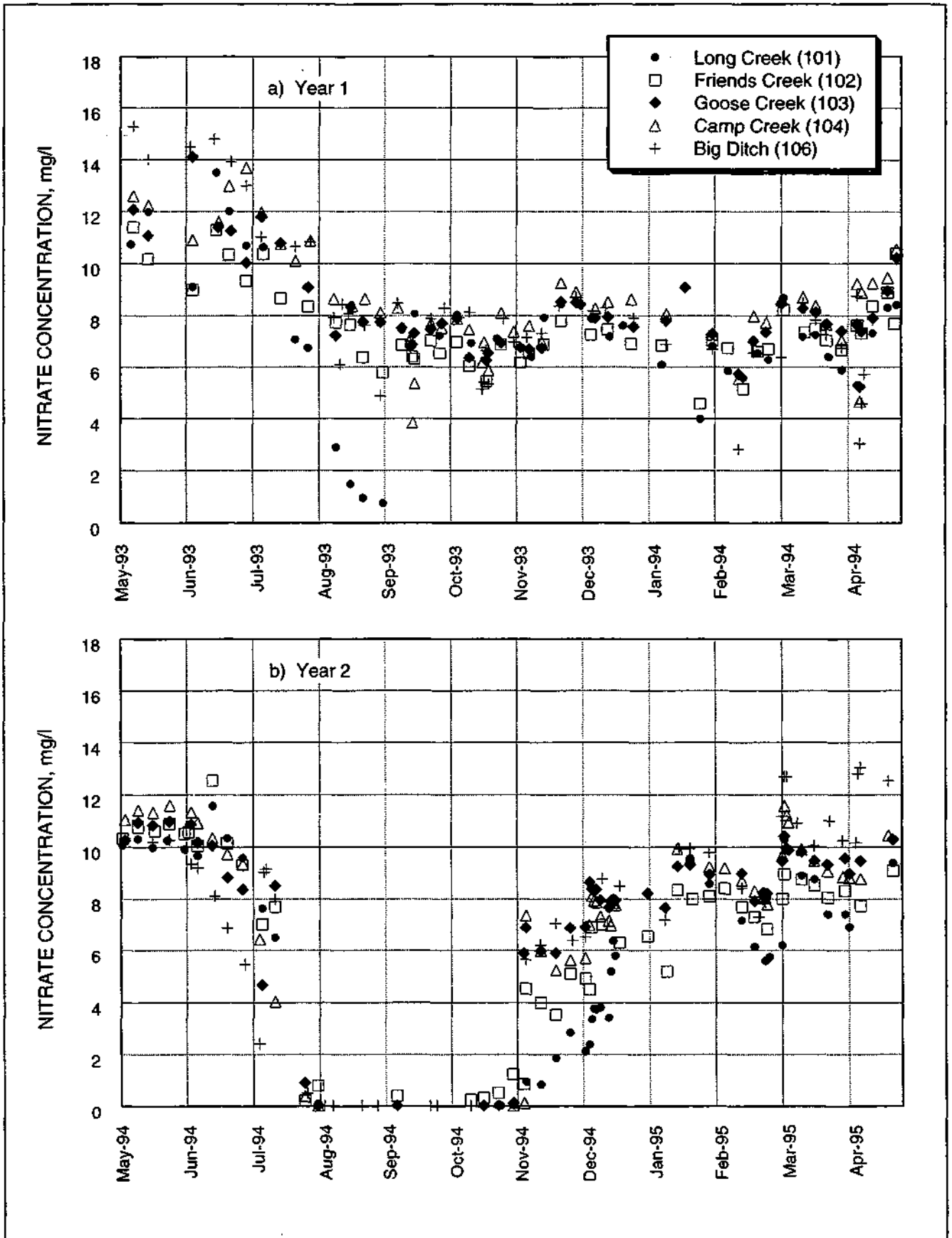


Figure 10. Nitrate-N concentrations for tributary stations

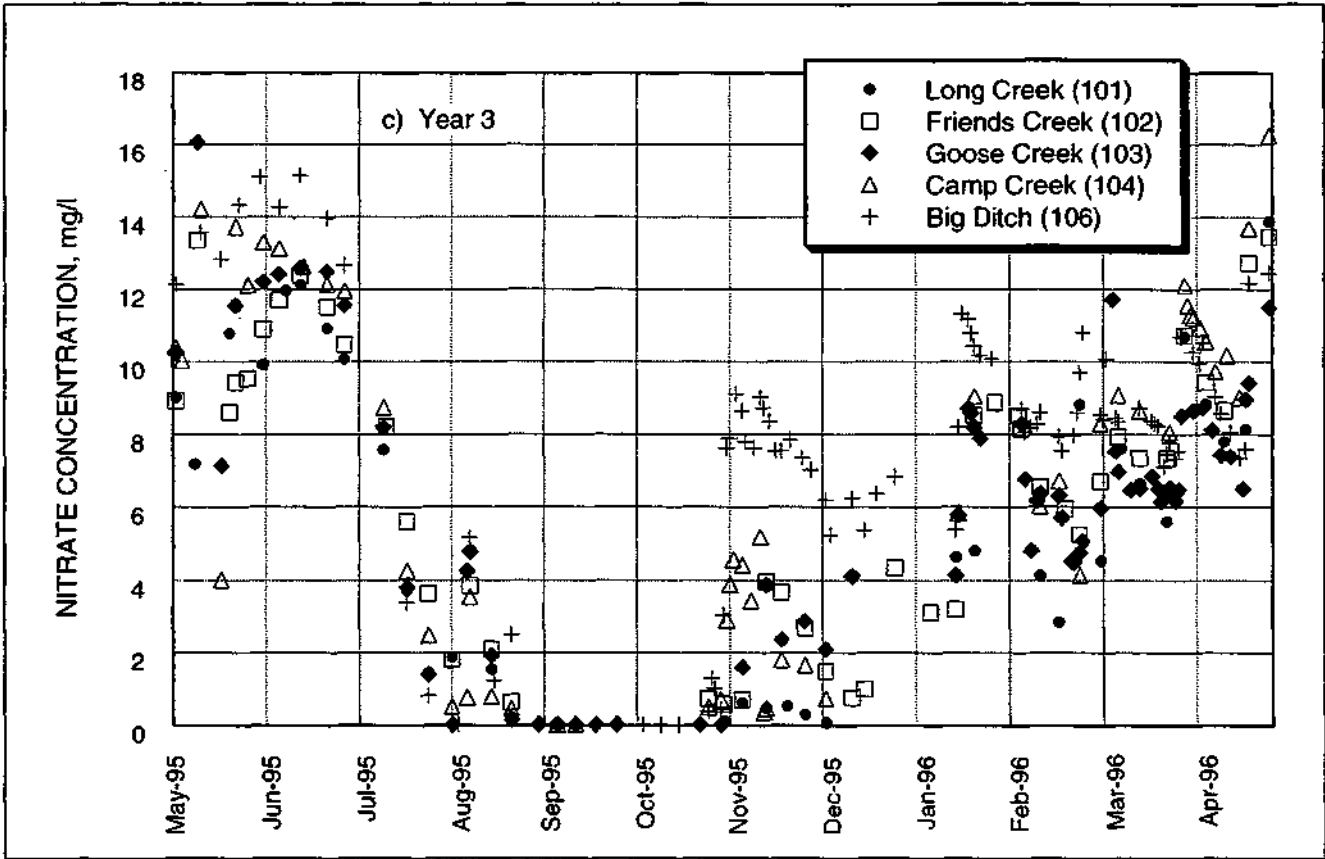


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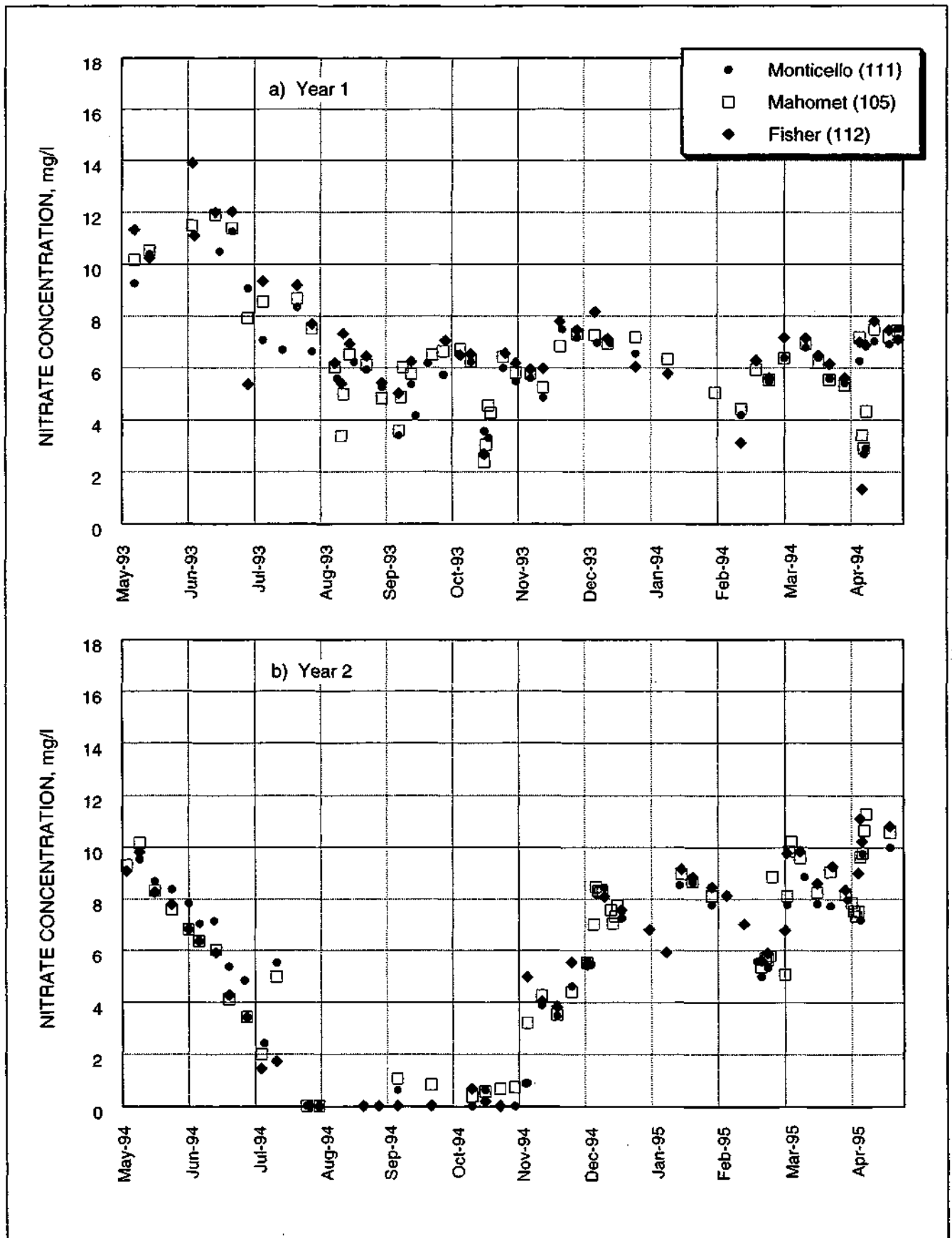


Figure 11. Nitrate-N concentrations for Sangamon River stations

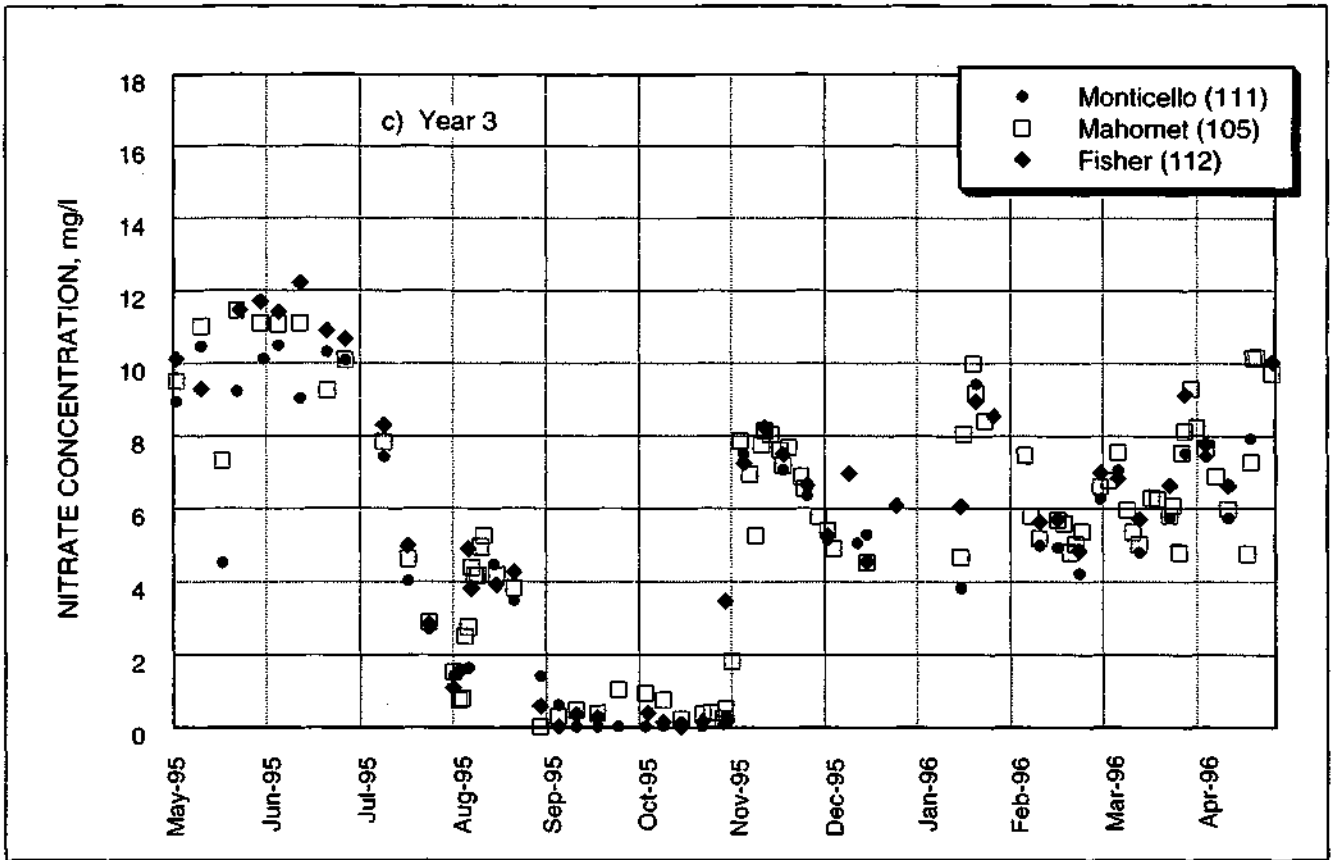


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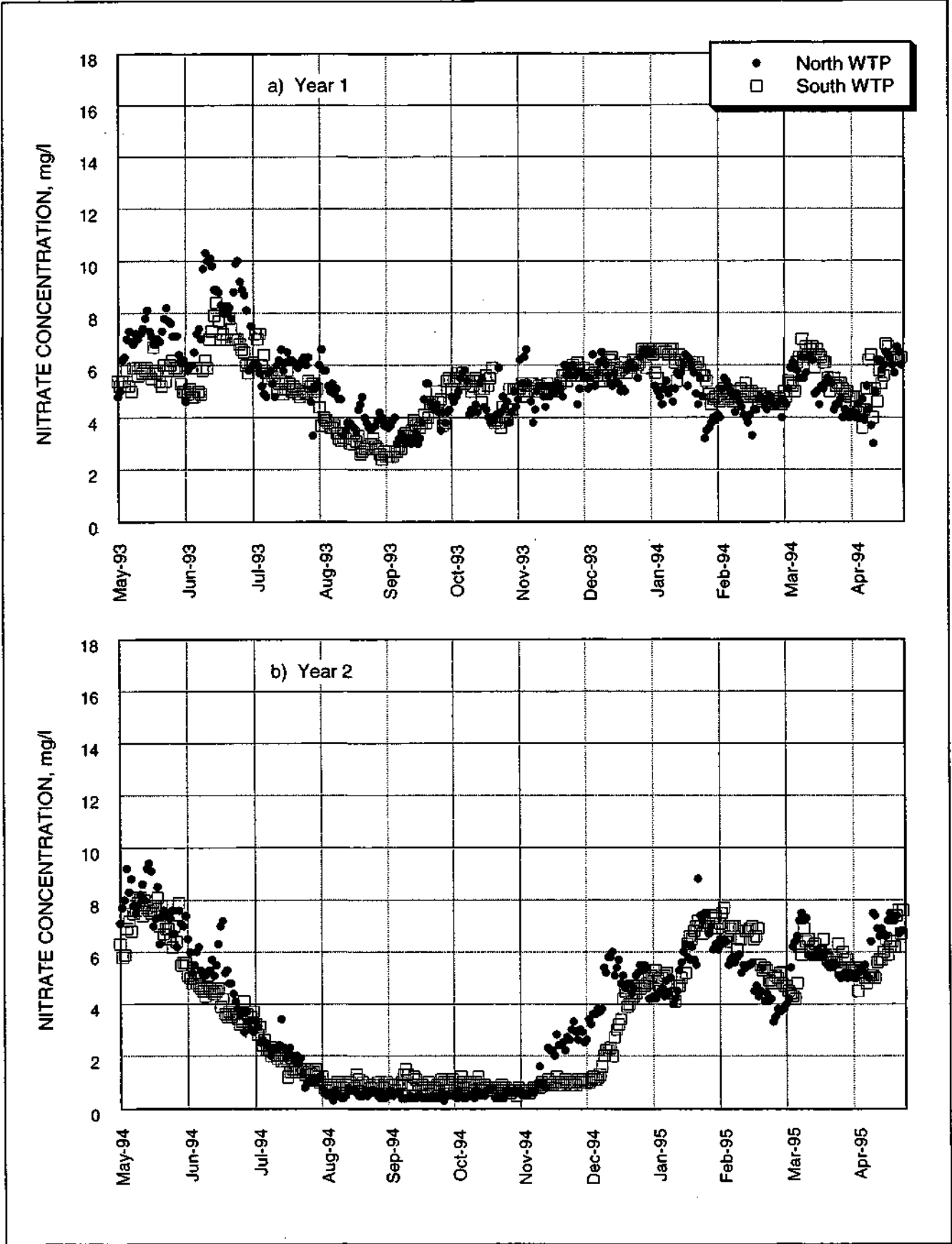


Figure 12. Nitrate-N concentration readings for north and south water treatment plants

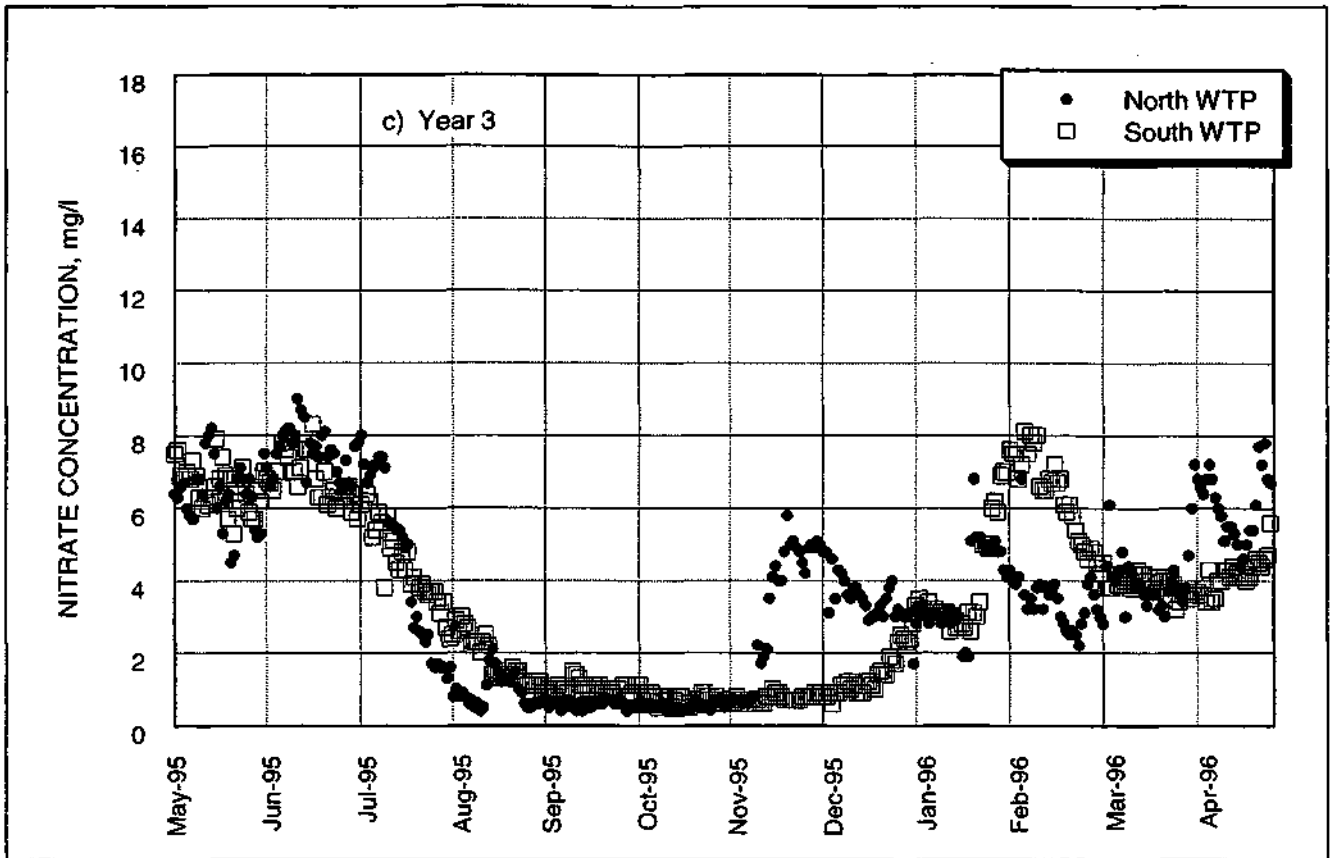


Figure 12. Concluded

August, nitrate concentrations at the Long/Big Creek station were consistently lower than at the other stations. This could be explained by the extreme low flow, only 0.04 inches runoff for the month (figure 7) in Long/Big Creek.

As previously mentioned, the pattern of nitrate concentrations monitored in the second year (figure 10b) was different than that of the first year. For three-and-a-half months, from mid-July to the end of October, nitrate concentrations were near zero at all of the monitoring stations. The low concentrations combined with the extreme low flows during the same period resulted in insignificant nitrate inflow into Lake Decatur. Nitrate concentrations were generally lower in the second year than the first year except during March and April when second-year concentrations were higher. The maximum concentration measured in the second year, 13.0 mg/l, was at the Big Ditch station on April 12, 1995. This is lower than the 15.3 mg/l measured during the first year at the same station. The period of relatively high nitrate concentration for the second year was longer (March to June) as compared to the months of May and June for the first year. The highest concentrations in the second year were measured in March and April as opposed to May and June for the first year. The highest concentrations were again measured at the Big Ditch station. Except for the months of May and June, the Big Ditch station tends to show higher concentrations and Long/Big Creek tends to show lower concentrations.

Figure 10c shows nitrate concentrations at the tributary stations during the third year of monitoring. The general seasonal trend exhibited historically (Demissie et al., 1996) and in the second year of monitoring (figure 10b) is also seen in the third year. The highest concentrations appeared in May and June 1995 and April 1996, where the period of the lowest concentrations extended for only two months (September to October 1995) as opposed to the three-and-a-half months during the second year of monitoring. The last three months of the monitoring year (February to April 1996) saw the greatest amount of fluctuation in concentrations which correlate to precipitation events. Similar to the second year, the third year had a steady rise in nitrate concentrations from the fall through spring months. The highest nitrate concentrations were encountered at Camp Creek (16.3 mg/l on April 30, 1996) and Goose Creek (16.1 mg/l on May 9, 1995). September and October 1995 had concentrations at the minimum detection level (MDL) of 0.02 mg/l.

Nitrate concentrations at the three Sangamon River stations for the three-year monitoring period are presented in figure 11. The three years of data are presented in figures 11a, 11b, and 11c, respectively. The first observation that can be made is the significant difference between the first-year and second- and third-year data, which is similar to the conditions observed at the tributary stations. During the first-year data collection, nitrate concentrations never fell below 2 mg/l except once at Fisher in April 1994. During the second year, nitrate concentrations were zero or near zero for three-and-a-half months from mid-July to the end of October. The third year was very similar to the second year but with a shorter period of low concentrations during the summer months.

During the first year (figure 11a), nitrate concentrations were high at all three stations for the months of May and June, started to drop in July, and essentially stayed between 2 and 8 mg/l for the rest of the year. The highest concentration, 13.9 mg/l, was measured at Fisher on June 3, 1993. The lowest concentration, 1.33 mg/l, was also measured at Fisher on April 12, 1994. The 10 mg/l level was exceeded only in May and June 1993. In general, the nitrate concentrations at Fisher, the upstream station, were higher than at Mahomet or Monticello and lower at Monticello than at Mahomet or Fisher. This is not, however, always the case, as indicated by the lowest concentration at Fisher in April.

Data for the second year (figure 11b) differ from data for the first year in several respects. The low concentrations in the summer during the second year have already been pointed out. Another major difference was the higher nitrate concentrations during the second year as compared to the first year for the period from December 1994 to April 1995. Nitrate concentrations were consistently higher in the Sangamon River during the second year from December 1994 through April 1995. During this period, concentrations were between 5 to 12 mg/l in the second year as compared to 2 to 8 mg/l for the first year. The highest concentrations were measured in April 1995 for the second year as opposed to in June 1993 for the first year. High concentrations were higher during the first year, while low concentrations were lower in the second year. In terms of comparing concentrations at the three stations for the second year, it is difficult to determine where the concentrations were consistently higher or lower because the pattern and the concentrations for all three stations were very similar.

The third year of data (figure 11c) is again very similar to the second year except for a shorter period during the summer of very low nitrate concentrations. The highest concentrations are in May and June 1995 with the highest concentration of 12.2 mg/l at Fisher on June 12, 1995. All three river stations had concentrations at the MDL. The river stations also had several fluctuations in concentrations during the last six months of monitoring. Closer inspection of precipitation and runoff records show that the only period of significant rainfall and runoff were during May to early June 1995. Runoff became very low from July through October 1995 in which September and October 1995 experienced almost no runoff. Runoff from November 1995 through April 1996 was at or below 0.5 inches. The nitrate concentration fluctuations in the Lake Decatur watershed correlate with precipitation events. Except for a major precipitation event (over 1 inch) in late October-early November 1995, precipitation totals roughly average around 0.5 inch. During this period, the nitrate concentrations in the watershed streams show a sensitivity to moderate rainfall events.

Figure 12 shows the nitrate concentrations from the north and south water treatment plants (WTPs) in Lake Decatur during the three years of monitoring in the watershed. The lake water shows the same trends in nitrate concentrations exhibited in the tributary and river stations. The concentrations in the lake are lower than those in the

river stations, just as the river stations are lower than the tributary stations. One noted observation shown in figure 12c is the appearance of the pulses of high nitrate concentrated water entering the lake. The north WTP is influenced by the pulses of nitrate coming into the lake from the Sangamon River due to its proximity to the mouth of the river. The pulses have a lag time and are dampened as they flow through the body of the lake and reach the south WTP.

Figures 13-15 show the maximum, average, and minimum concentrations of nitrate sampled at the eight main stations in the watershed during the study period. As illustrated by figure 13, out of all the tributary stations, Camp and Goose Creeks had the highest nitrate-N readings at 16.3 and 16.1 mg/l, respectively, while Goose Creek had the lowest maximum concentration of 11.0 mg/l. Fisher had the maximum river station nitrate-N concentration at 13.9 mg/l and Monticello had the lowest maximum at 9.9 mg/l. Figure 14 shows the average nitrogen concentrations for the study period. All eight stations average a nitrate-N concentration of 6.4, 7.6, and 6.1mg/l for the first through third years, respectively. The minimum nitrogen concentrations encountered appear in figure 15. Goose Creek had the highest minimum concentrations of 5.2 mg/l for the tributary stations, while Monticello read 2.7 mg/l. The lowest nitrate-N concentration was 0.02 mg/l for all stations except Friends Creek.

Nitrate Loads

Even though the main water quality concern at Lake Decatur is nitrate concentrations, the critical issue for watershed management is nitrate loads. It is impossible to reduce the nitrate concentration without reducing the nitrate load into the lake. Management alternatives are more easily understood in terms of load reduction than reduction in concentration.

The calculation of nitrate loads, or yields, is necessary to determine the contribution of different areas to the total nitrate input into the lake. Nitrate concentrations are used for regulatory purposes but are not sufficient to determine the relative contribution of nitrates from different areas. The nitrate load combines the effects of concentration and discharge and thus provides a more accurate picture of the relative contribution of different areas. For example, a tributary may have some of the highest nitrate concentrations, but if it is also one of the smallest sub-watersheds, its total delivery of nitrates to the lake could be quite small as compared to other sub-watersheds and thus not a significant contributor. Calculations of monthly nitrate loads have been made for all eight main stations and are presented in figures 16 and 17.

Figure 16 shows the monthly nitrate-N load in pounds per acre (lb/acre) for the five tributary stations. Since the loads are calculated as a product of the monthly discharges and the average nitrate concentrations, the loads presented in figure 16 show the combined effect of the streamflows and concentrations. Therefore because of the

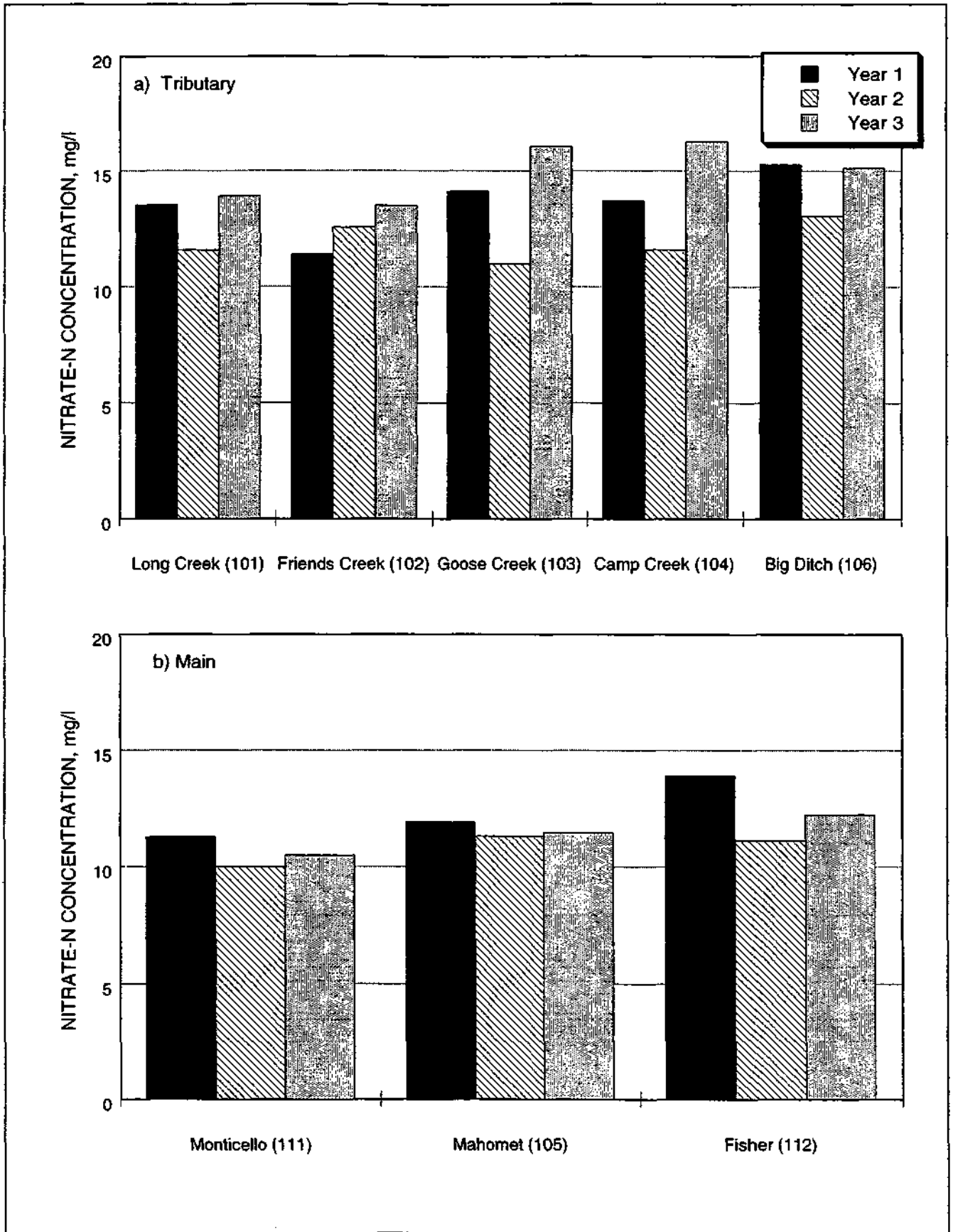


Figure 13. Maximum nitrate concentrations during study period

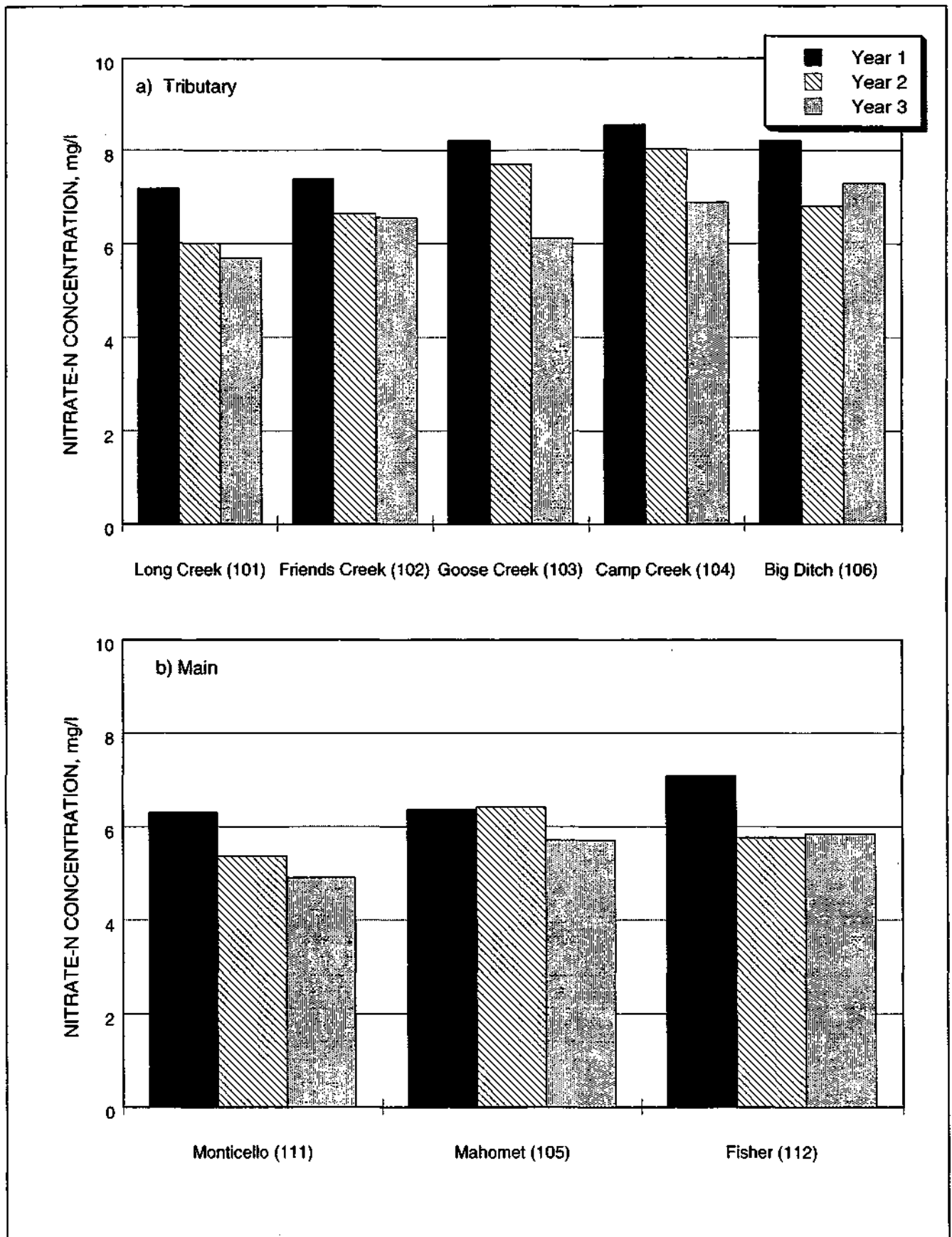


Figure 14. Average nitrate concentrations during study period

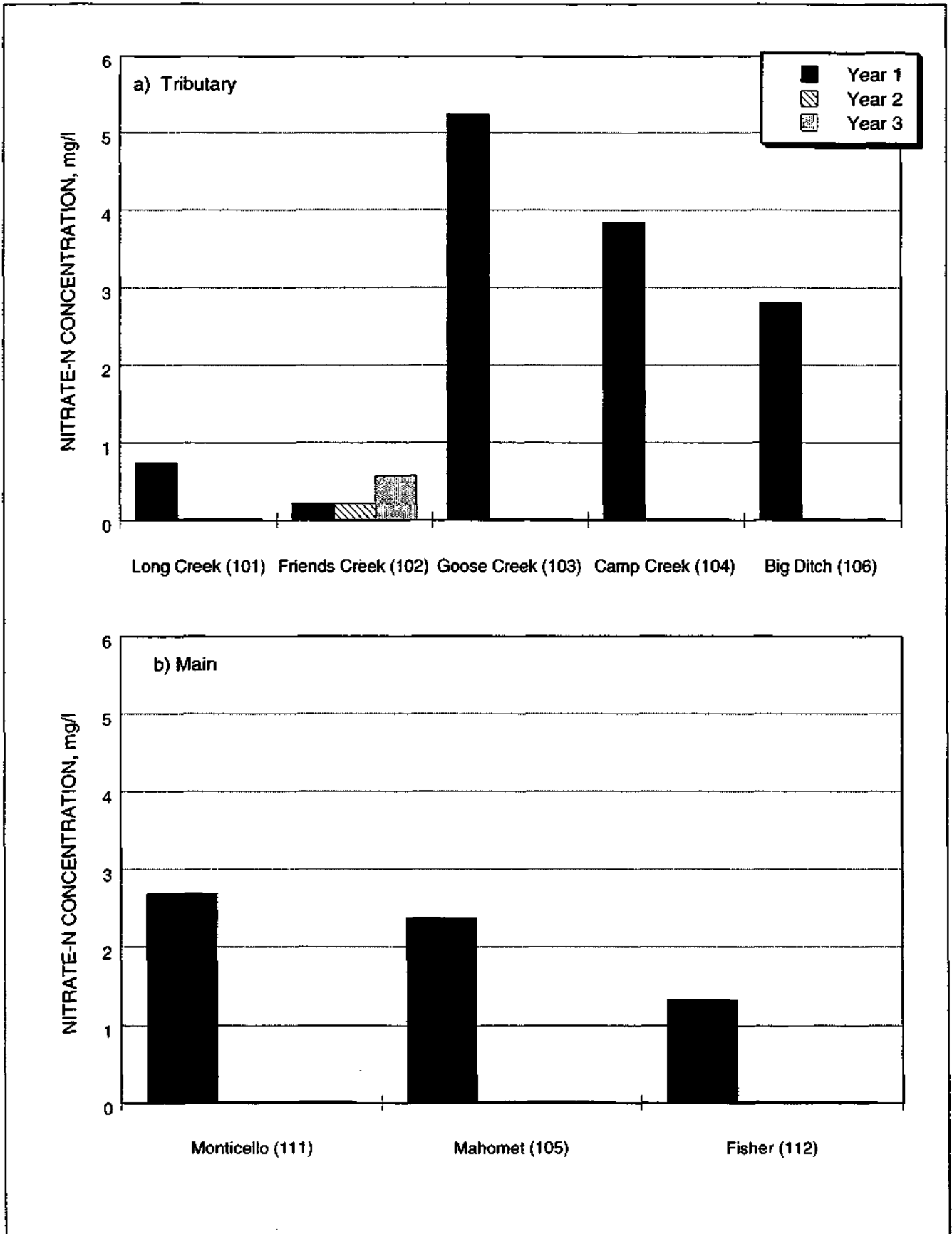


Figure 15. Minimum nitrate concentrations during study period

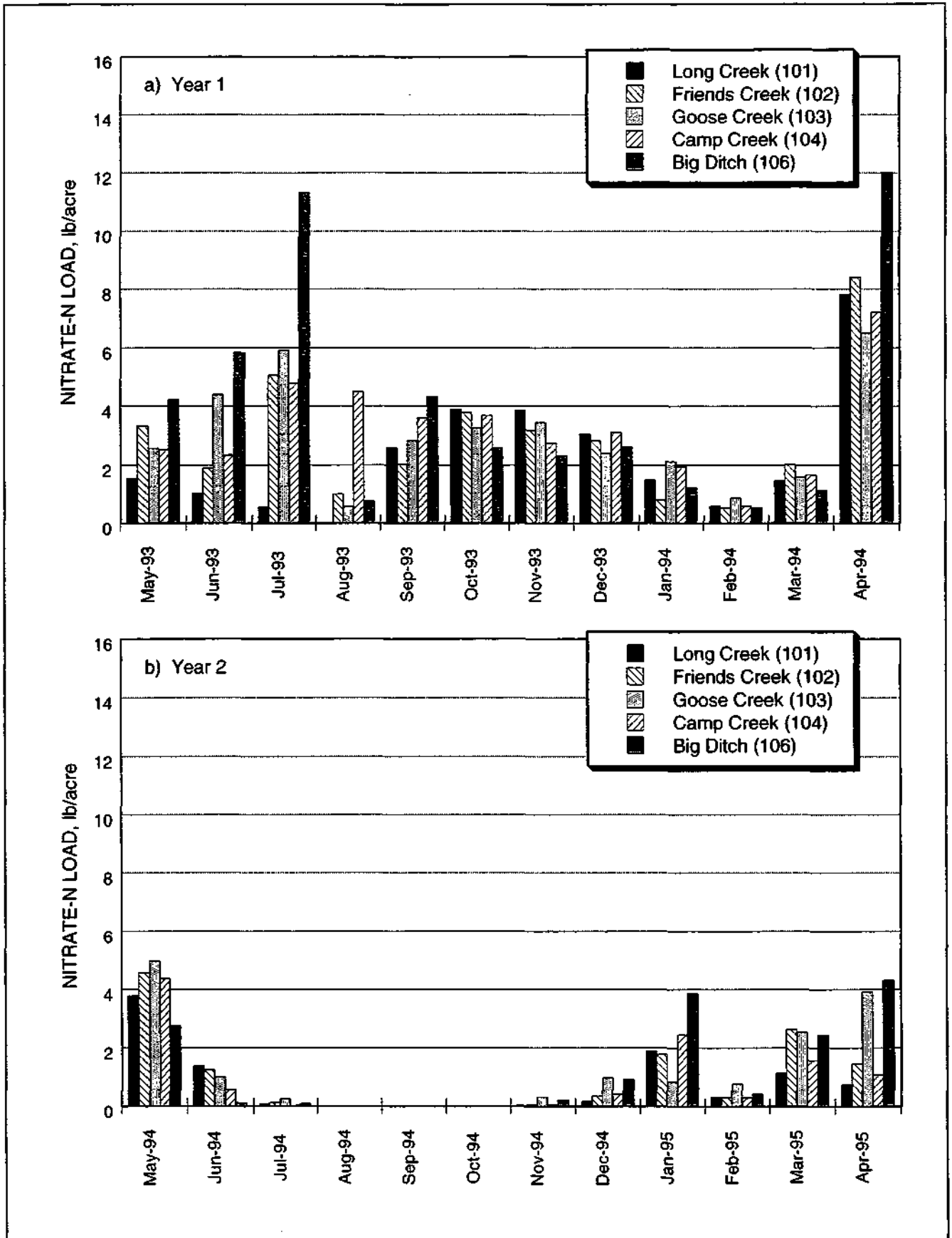


Figure 16. Monthly nitrate-N load for tributary stations

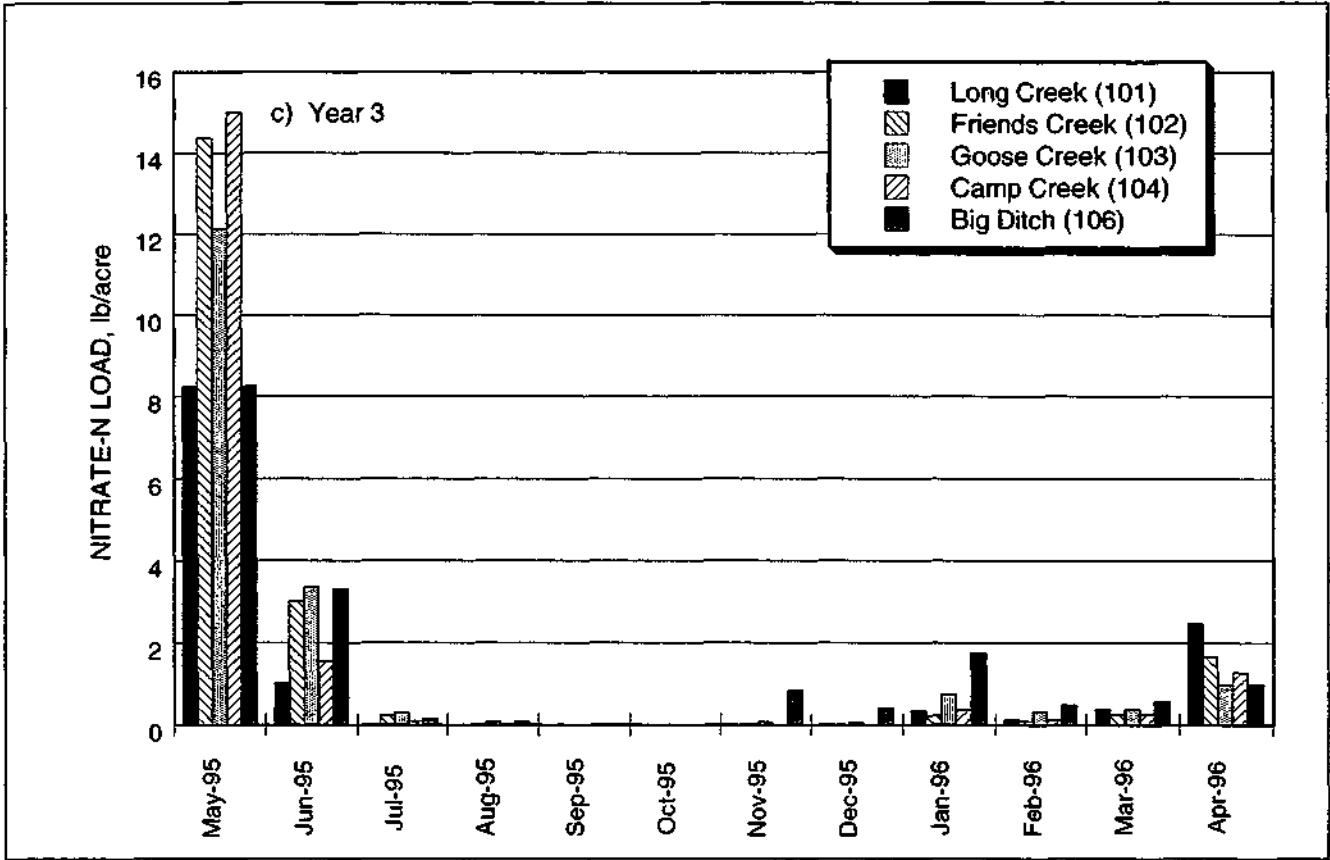


Figure 16. Concluded

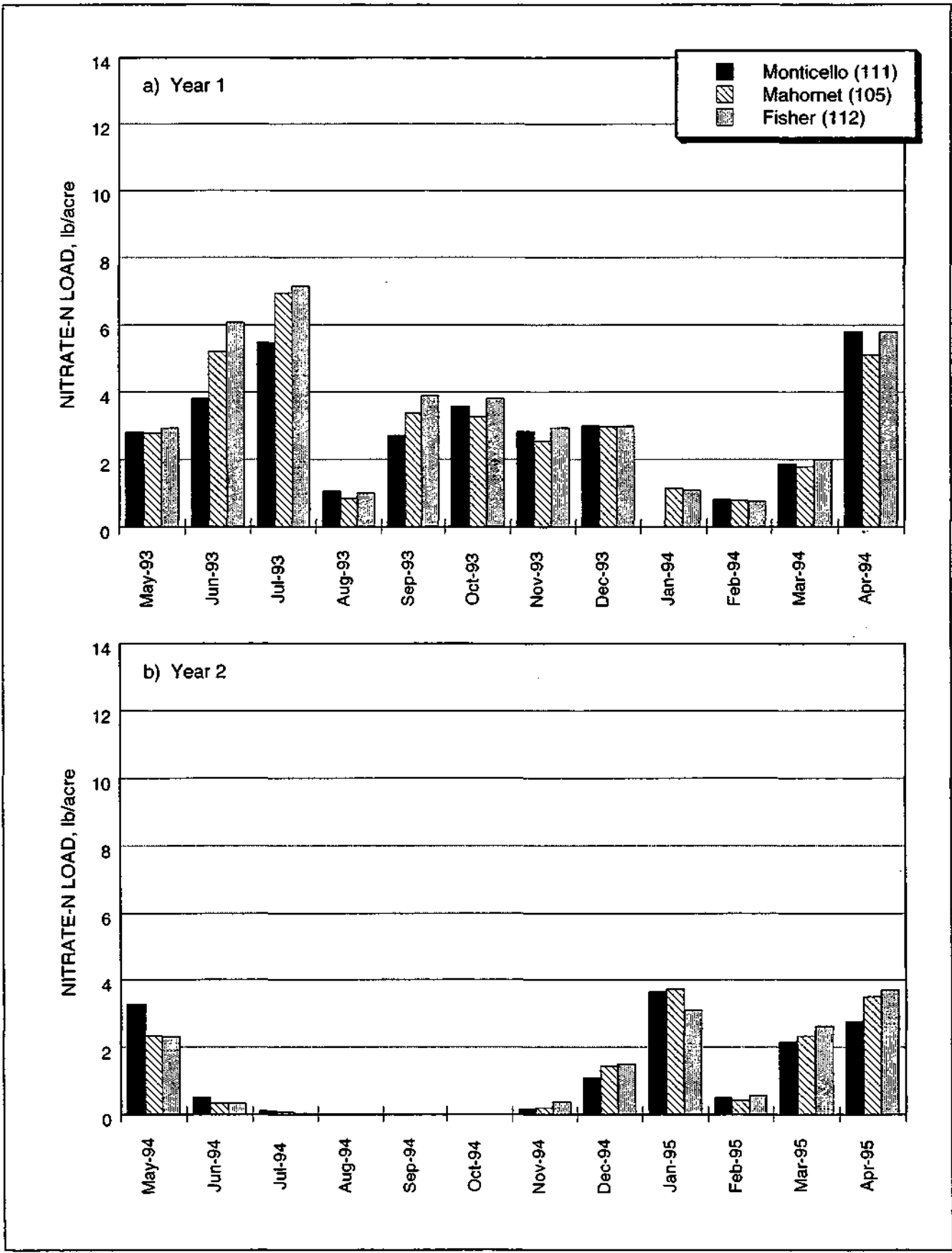


Figure 17. Monthly nitrate-N load for Sangamom River stations

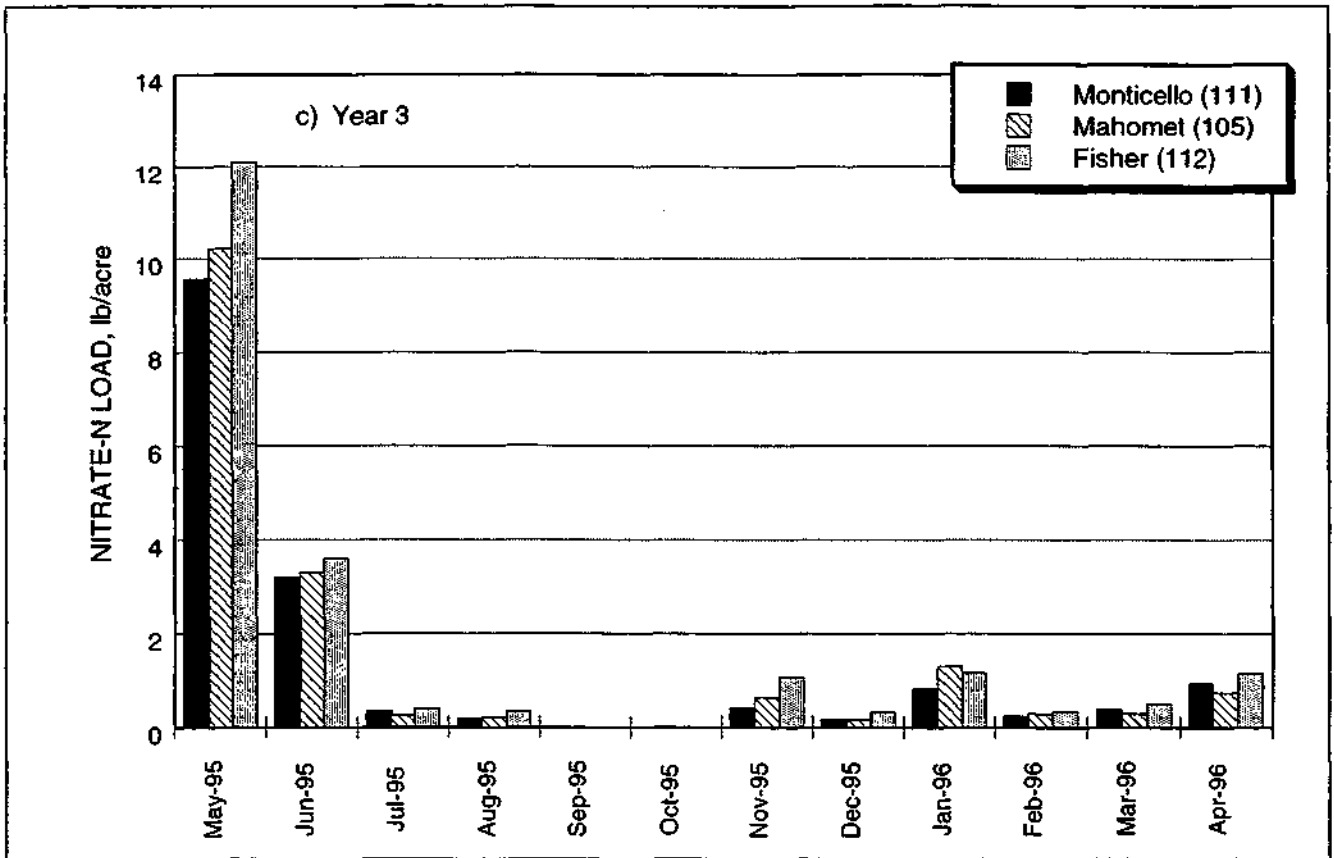


Figure 17. Concluded

higher streamflows during the first year, the monthly loads for the first year are significantly higher than for the second and third years. The overall average monthly nitrate load for all the stations was 3.1, 1.2, and 1.4 lb/acre for the three years, respectively. The main factor for the extremely low loads in the second and third years was the near zero monthly loads, which were a result of either no flow or near zero nitrate concentrations during the summer months. May 1995 was the month when all tributary stations exceeded 8 lb/acre nitrate loads. Extremely high flows combined with high concentrations resulted in loads ranging from 8.25 lb/acre for Big Ditch to 15.0 lb/acre for Camp Creek.

The monthly nitrate loads for the three Sangamon River stations are presented in figure 17. Similar to the tributary streams, the loads were consistently higher during the first year than the second and third years. The average monthly load for the three stations was 3.1, 1.2, and 1.5 lb/acre for the three years, respectively. This is because of the near zero loads for several months during the second and third years. The highest monthly loads at all stations occurred in May 1995. Monthly load values were 12.1, 10.2, and 9.6 lb/acre at Fisher, Mahomet, and Monticello, respectively. The lowest nitrate loads were in July through October 1994 and September through October 1995.

Annual Nitrate Loads. The annual nitrate loads at all the stations monitored are summarized in table 2 and presented in figure 18. The results are grouped into two figures for the purpose of comparing tributary streams separately from main river stations. For the tributary streams, the annual nitrate load for year 1 ranges from a low of 28 lb/acre for Long Creek to a high of 49 lb/acre for Big Ditch. The other tributaries, Friends Creek, Goose Creek, and Camp Creek, generated nitrate at almost a uniform rate of 35 to 39 lb/acre.

Table 2. Annual Nitrate Loads in the Sangamon River Basin

Station	Drainage area (acre)	Annual nitrate yield			Average (lb/acre)
		Year 1 (lb/acre)	Year 2 (lb/acre)	Year 3 (lb/acre)	
<i>Tributary stations:</i>					
Long Creek (101)	29,539	28	9	13	17
Friends Creek (102)	71,647	35	12	19	22
Goose Creek (103)	28,892	36	16	18	23
Camp Creek (104)	30,242	39	11	19	23
Big Ditch (106)	24,421	49	15	17	27
<i>Main river stations:</i>					
Sangamon River at Fisher	157,177	40	14	21	25
Sangamon River at Mahomet	235,653	37	14	17	23
Sangamon River at Monticello	347,747	34	14	16	21
Total inflow into Lake Decatur	586,868	32	12	16	20

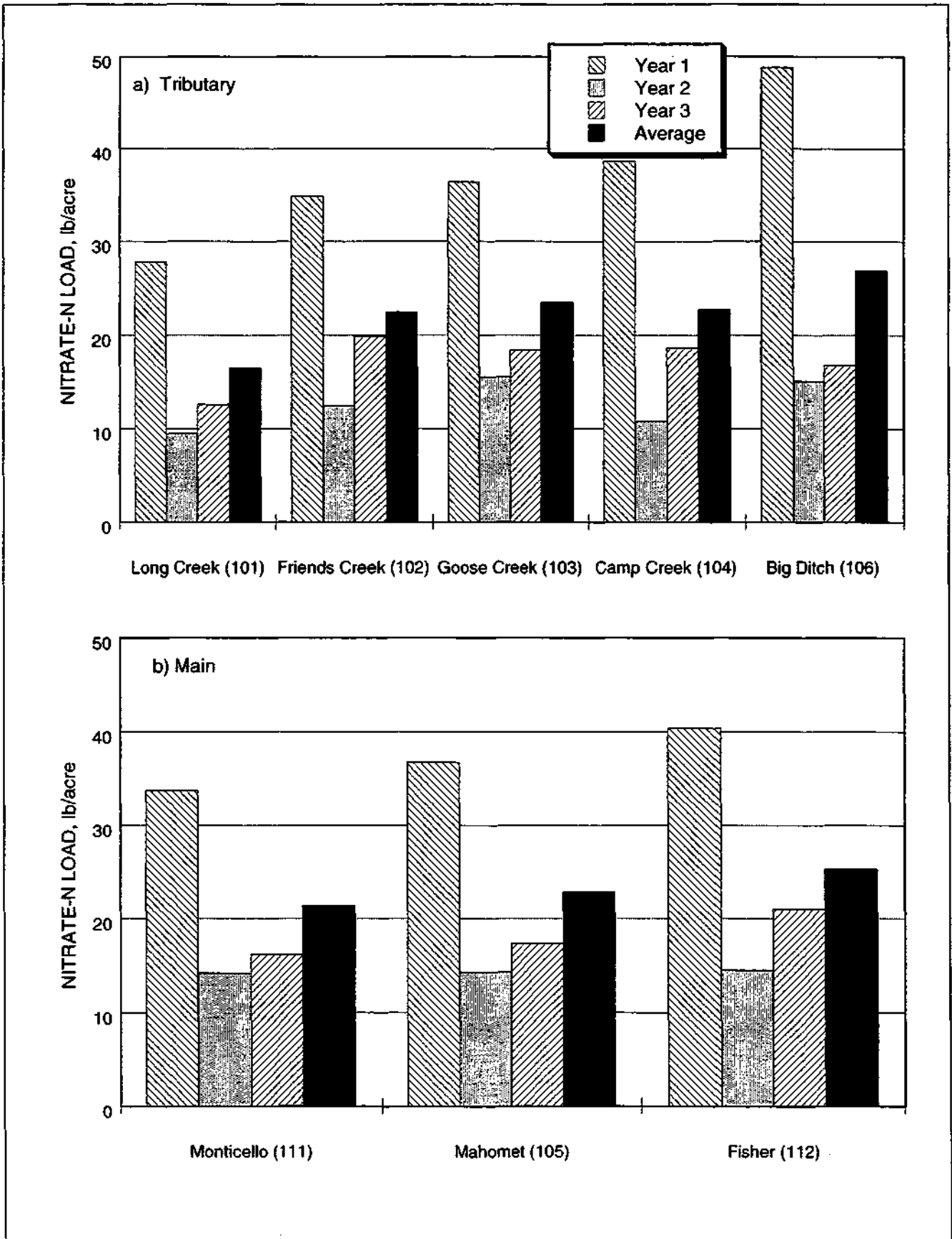


Figure 18. Annual nitrate-N load for tributary and Sangamon River stations

The average annual load for all the tributaries for the first year was 37 lb/acre. The annual nitrate loads for the tributary streams were much smaller the second and third years than the first year. The overall average annual load for the second year was 13 lb/acre as compared to the 37 lb/acre for the first year. First-year loads were almost three times greater than those of the second year. Loads for the second year ranged from a low of 9 lb/acre for Long Creek to a high of 16 lb/acre for Goose Creek. The average annual load for the third year was slightly higher than the second year at 17 lb/acre. The loads ranged from 13 lb/acre at Long Creek to 19 lb/acre at Friends and Camp Creeks.

The annual nitrate loads for the three Sangamon River stations are presented in figure 18b. Similar to the tributary streams, the loads during the first year are significantly greater than those for the second and third years. The overall average annual load for the main river stations for the first year was 37 lb/acre as compared to 14 lb/acre for the second year, more than double the second year loads, and the third year was 18 lb/acre. During the first year, the annual loads ranged from a low of 34 lb/acre at the Monticello station to a high of 40 lb/acre at the Fisher station. For the second year, all stations had uniform loads of 14 lb/acre. The annual loads during the third year ranged from 16 lb/acre at Monticello to 21 lb/acre at Fisher.

It should be noted that there are some differences between the nitrate loads reported here and in the previous technical report (Demissie et al., 1996). Due to the addition of several key discharge measurements made during the third-year monitoring period, modifications were made to the stage-discharge curves of the Friends Creek and Mahomet stations. These differences are due to the measurement of very high and very low streamflows for Friends Creek and Mahomet, respectively. The Friends Creek load values are now near the average annual nitrate loads for the tributary stations. Mahomet only experienced a slight change in the second year results. The nitrate load reported for Fisher in the second year changed from 15 to 14 lb/acre due to the final approval and publication of the USGS discharge values for the 1995 water year. None of the above modifications had an effect on the overall observations and conclusions of this study.

Based on the data, it can be concluded that as the drainage area increases, the unit load generally decreases similar to sediment yield. The nitrate load is the highest at Fisher and the lowest at Monticello. One process by which the unit load decreases with increasing drainage area is the mixing of runoff of higher concentrations with runoff of lower concentrations. For sediment, channel and floodplain storage account for the decrease in unit area yields as drainage area increases, but for nitrate there must be some losses in the stream channel and floodplain as the drainage area increases. Based on the nitrate load data calculated for the last three years, it can still be concluded that the source of nitrate in the Lake Decatur watershed is truly dispersed throughout the watershed. There are no "hot spots" generating most of the nitrate that flows into Lake Decatur.

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